REPORT

Summary of Select Historical Uranium Recovery Processes at In-Scope Mines in the Ambrosia Lake Valley

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Acronyms and Abbreviations

AdP	Arroyo del Puerto
AEC	Atomic Energy Commission
ALV	Ambrosia Lake Valley
ALW	Ambrosia Lake West
DP	discharge plan
DRS	documented release sampling
EPA	United States Environmental Protection Agency
g	gram
gpm	gallons per minute
IX	ion exchange
KMC	Kerr-McGee Corporation
KMNC	Kerr-McGee Nuclear Corporation
KNFC	Kermac Nuclear Fuels Corporation
L	liter
MDW	Mine discharge water
NMED	New Mexico Environment Department
NMEIA	New Mexico Environmental Improvement Agency
NMEID	New Mexico Environmental Improvement Division
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
pCi	picocuries
QMC	Quivira Mining Company
RAML	Rio Algom Mining LLC
RML	radioactive material license

1 Purpose and Scope

This report was prepared at the direction of Rio Algom Mining LLC (RAML) for the purpose of informing RAML discussions with United States Nuclear Regulatory Commission (NRC) regarding decommissioning[1] at the Ambrosia Lake West (ALW) mill and termination of radioactive materials license (RML) SUA-1473[2]. This report summarizes current understanding regarding environmental impacts at or near properties owned by RAML within certain portions of the Ambrosia Lake Valley (ALV) that derive from historical uranium recovery (i.e., mining and milling) processes and associated with historical permitting practices for which RAML has questions regarding regulatory jurisdiction. For simplicity, this report will refer to such processes as "mill or mill-like processes." NRC staff requested that RAML submit a list of its questions related to jurisdiction during a multi-agency call on 11 June 2021 and RAML provided its list to NRC on 3 September 2021 (RAML 2021). During a follow-up multi-agency call on 26 January 2022, NRC staff informed RAML that NRC would not be responding to RAML's questions and requested that RAML prepare a technical document summarizing currently available information regarding its understanding of the operational history of mill or mill-like processes (i.e., processes for which RAML has jurisdictional questions). This report is intended to fulfill that request by providing technical information to support a determination by NRC regarding the spatial extent of NRC's jurisdictional authority within the ALV. This report does not seek to make any legal determination as to jurisdiction. RAML looks forward to discussing next steps after NRC review of this document.

This report is based on a review of historical records readily available to RAML and field investigations conducted by RAML and others. As such, the scope of this document is necessarily limited. It identifies and describes four mill or mill-like historical uranium recovery practices that may have resulted in impacts at a subset of the uranium mines on RAML owned property in the ALV ("in-scope mines"). All in-scope mines were or are associated with prior or current versions of RAML's state and federal permits and licenses which are described in more detail in section 2. In-scope mines consist of the Section 17, 22, 24, 30, 30W, 33, 35, and 36 mines (Figure 1-1). In-scope mines produced uranium from the Westwater Canyon Member of the Morrison Formation via a combination of underground mining (1958-1985) and ion exchange (IX) recovery (1963-2003). The majority of uranium recovery infrastructure at in-scope mines is no longer in use and has been reclaimed. Decommissioning activities at the ALW mill have been ongoing since 1986; the ALW mill formally transitioned to decommissioning status in 2003 (NRC 2003). RAML has no plans to allow any uranium recovery to resume on its properties and so all historical facilities described in this document should be regarded as "former."

The four identified historical uranium recovery processes at in-scope mines described in this report are:

1. Mine water uranium recovery/treatment via IX (Section 2.1)
2. Mine stope leaching with chemically fortified mine water (Section 2.2)
3. Backfilling of stopes with classified or unclassified uranium mill tailings ("sandfilling") (Section 2.3)
4. Heap leaching (Section 2.4)

The potential spatial extent of environmental impacts that derive from mill or mill-like processes is summarized alongside the operational and permitting history in each of the above sections. Lastly, Section 2.5 identifies three additional areas where environmental impacts may derive from a mix of both mill or mill-like and mining process (i.e., impacts are potentially commingled). In these areas, jurisdictional status is not clear. Impacts to the three identified areas are the result

[1] 10 CFR 40.4

[2] The current radioactive materials license (RML) for the ALW mill is SUA-1473, which NRC issued on 23 September 1986. The first RML for the ALW mill, R-217, was issued by the Atomic Energy Agency (AEC) on 24 January 1958. The AEC changed the ALW mill license number to SUA-616 on 25 May 1959. The New Mexico Environmental Improvement Agency held the AEC license SUA-616 in timely renewal, with periodic amendments, from January 1976 through 1 June 1986.

of a set of complicated historical operational inputs that are described in detail in Sections 2.5.1 (Arroyo del Puerto), 2.5.2 (Section 4 Ponds area), and 2.5.3 (Section 2 drainage) and summarized in Table 3-1.

Any operational practices referenced in RAML's permits that occurred at locations outside the ALV are outside the scope of this document, as are RAML-permitted mines where currently available information suggests those mines are solely impacted by mining processes and RAML does not have questions regarding regulatory jurisdiction. Likewise, this document does not consider areas already undergoing decommissioning under the NRC's jurisdiction (i.e., areas described in the approved *Soil Decommissioning Plan* (Komex 2006) for SUA-1473 because the jurisdictional status of these areas is clear.

The geographic areas described in this report include parcels of land which have been impacted by operations historically conducted by several entities with no affiliation to RAML. This includes Tronox Worldwide LLC (formerly, Kerr-McGee Corporation [KMC]), which conducted operations at certain in-scope mines and the ALW mill beginning in the 1950s through the early 1980s, and several other uranium recovery facilities within the ALV historically operated by other third-party entities.

To respond to NRC staff's request, RAML and its consultants have reviewed thousands of documents and vast quantities of data. While some of this information has been developed from the investigations and closure activities conducted by RAML throughout the ALV, much of the information comes from historical sources uncovered by RAML and its consultants. These sources include documentation regarding KMC's historical operational and permitting practices at in-scope mines, which are included in this report for the purpose of supporting a jurisdictional determination by NRC. Where possible, this report identifies the corporate entity responsible for the operational or permitting practice at in-scope mines.

The information available to RAML and its consultants regarding historical operational practices in the ALV conducted by other third-parties is limited and generally out of the scope of this report, even though these operations may have impacted the same areas described in this report. This report is not intended to and should not be considered a fulsome recitation of all impacts or sources of impacts at the areas described within. Nor does this report seek to make any legal determination or admission regarding responsibility for those impacts.

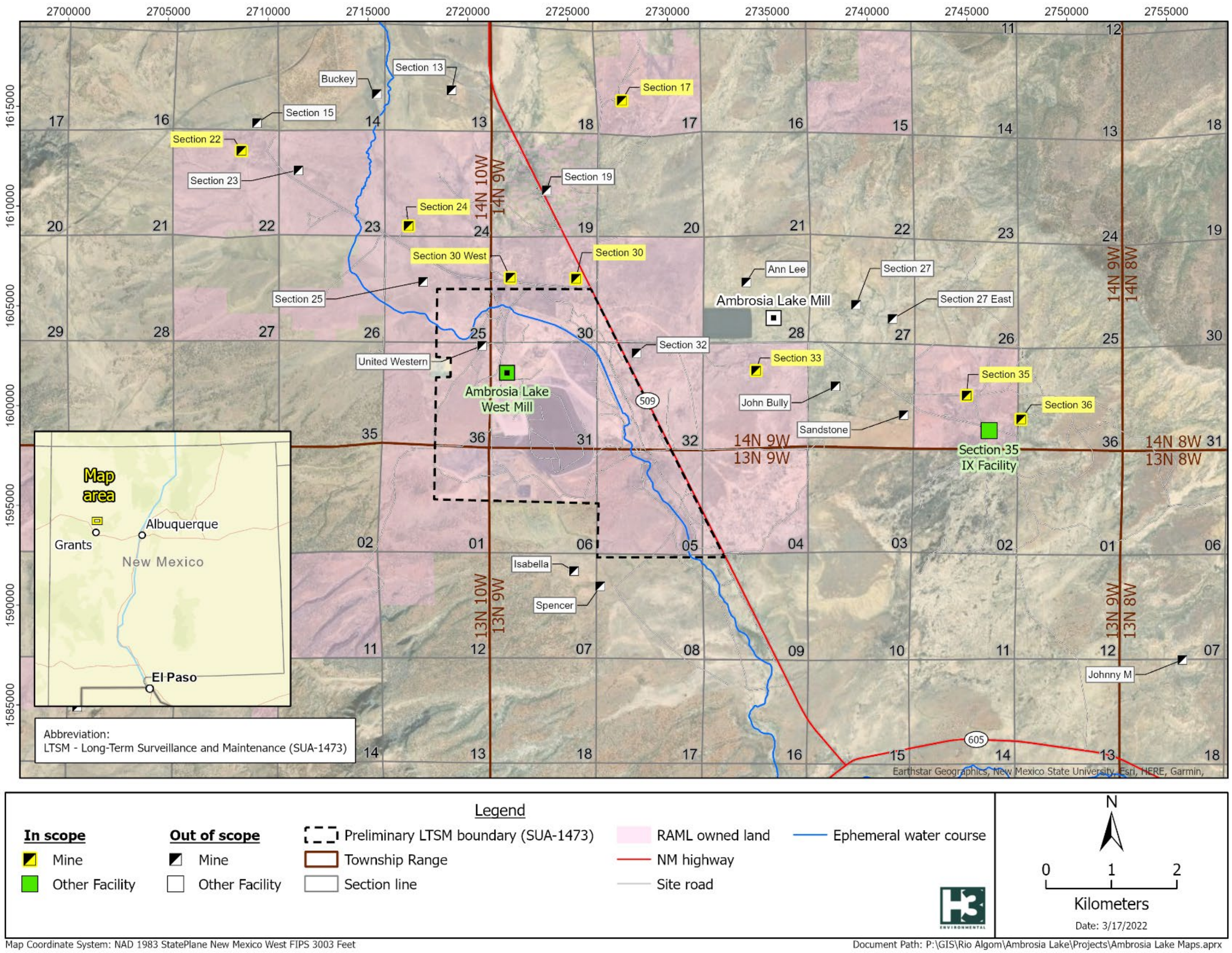

Figure 1-1 The Ambrosia Lake Valley, 25 miles north of Grants, New Mexico.

2 Description of Historical Mill or Mill-Like Processes at In-Scope Mines

This section summarizes four historical mill or mill-like processes, the permitting status of those processes, and potential impacts and affected areas associated with those processes.

Processes that do not generate waste which could potentially meet the definition of byproduct material in section 11.e(2) of the Atomic Energy Act and/or 10 CFR 40.4 are out of scope of this document. These sources are consistent in their definition of byproduct material as, in part, the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content. This definition includes wastes generated by mine water treatment for the primary purpose of recovering source material.

2.1 Ion Exchange Activities

IX facilities were operated at in-scope mines in the ALV. At different times during their operational history, the primary purpose of these facilities was either to meet discharge limits for uranium in water or to recover source material; these facilities were described in SUA-616 and SUA-1473 as "mine water uranium recovery treatment" facilities (NMEID 1986; NMEIA 1976b). Two IX facilities in the ALV were licensed via SUA-1473 and/or SUA-616[3], located at:

1. The ALW mill –This IX facility is outside of the scope of this document because it is already described in NRC-approved decommissioning documents for the ALW mill.
2. South of the Section 35 mine – This report refers to this in-scope facility as the "Section 35 IX facility", which consists an IX plant and up to nine earthen lagoons located on sections 35 and 36. Three of the nine lagoons and the IX plant were licensed via SUA-1473 and/or SUA-616. The Section 35 IX facility is described in sections 3.1.1, 3.1.2, 3.1.3, and 3.1.4 of this report.

2.1.1 Process

Beginning in July of 1976, mine water was pumped from the Section 35 and 36 mine shafts, clarified in settling ponds, and conveyed to a sump near the Section 35 IX plant (KMNC 1976d). At the sump, water from the Section 35 and 36 mines was mixed and passed through upflow cascade anion exchange resin columns for uranium removal (KMNC 1976d). Once loaded with uranium, the resin was transported by tank truck to the IX facility at the ALW mill for elution. The stripped resin was then trucked back to the Section 35 IX plant for reuse (KMNC 1976d). The process flow for the Section 35 IX is shown on Figure 2-1. Operational features associated with the Section 35 IX are identified on historical orthoimagery shown on Figure 2-2.

After uranium removal, water was released to a series of algae ponds, which were used to remove particulates from IX effluent; barium chloride was used to remove dissolved radium-226 prior to final discharge to an unrestricted area (KMNC 1976d). The treatment process was contained within a restricted area pursuant to SUA-616 (KMNC 1976d). The IX effluent treatment process is shown on Figure 2-3.

Following discharge to a ditch south of the IX plant (Figure 2-2), treated water was used by local ranchers for agricultural purposes (KMC 1971b).

On 28 August 1990 the Section 35 IX facility ceased operations (QMC 1991d); decommissioning of the Section 35 IX facility began in January 1994 (QMC 1994b) under an NRC-approved reclamation plan (QMC 1986f). Pond sediments were excavated and transported to the ALW mill for disposal in the west slope of tailings impoundment 1 (QMC 1994a).

[3] SUA-616 and SUA-1473 also authorized IX operations at the Quivira Church Rock Mines near Church Rock, New Mexico, which is outside of the geographic scope of this report.

The Section 35 IX plant was demolished in May 1995; parts were either released for salvage or transported to the ALW mill for disposal (QMC 1995).

2.1.2 Permitting

2.1.2.1 NPDES

A 1975 water quality investigation conducted by the EPA in coordination with New Mexico Environmental Improvement Agency (NMEIA) (EPA 1975b) concluded that radium-226 concentrations in water discharged from the Section 35 and 36 mines exceeded "the concentrations authorized by the AEC (Atomic Energy Commission)" and recommended enforcement action against the operator, KMC, for failure to file for a National Pollutant Discharge Elimination System (NPDES) permit (EPA 1975a).

In response, in March 1976 KMC submitted a NPDES permit application for mine water discharged from the Section 35 and 36 mines to the EPA (KMNC 1976a). The permit application stated that KMC believed a NPDES permit was not required because the discharged mine water did not reach navigable waters of the United States (KMNC 1976a). EPA issued NPDES Permit NM0028118 (EPA 1976) to KMC on 1 April 1976, which was adjudicated by KMC (KMNC 1976e). During adjudication, EPA concluded that water discharged from the Section 35 and 36 mines did not enter navigable waters of the United States and NPDES permit NM0028118 was discontinued and voided (EPA 1978).

2.1.2.2 Radioactive Material Licenses

In May 1976, Kerr-McGee Nuclear Corporation (KMNC) requested to amend SUA-616 to include operation of the Section 35 IX facility (KMNC 1976c, 1976b). On 1 July 1976, NMEIA amended SUA-616 by addition of condition 16, which authorized the operation of a mine water uranium recovery treatment facility on section 35 (NMEIA 1976b). The licensed facility consisted of an IX plant and three associated ponds. While SUA-616 condition 16 was amended again in April 1986 to include operation of two IX columns underground at the Section 35 mine (NMEID 1986), currently available records indicate that the underground IX facility on section 35 never operated.

SUA-616 condition 16, as amended in 1986, was incorporated verbatim into NRC license SUA-1473 amendment 0 (NRC 1986c); condition 16 became condition 13 in amendment 1 to SUA-1473 (NRC 1986a). Decommissioning of the Section 35 IX facility was included in the 1986 reclamation plan for the ALW mill tailings impoundments (QMC 1986f), which was incorporated by reference into conditions 21 and 27 of SUA-1473 by amendment 1. As described in Section 2.1.1, decommissioning of the Section 35 IX facility under NRC's authority ceased by 1995 and in 1997, the Section 35 IX facility was incorporated into New Mexico discharge plan (DP)-67; this transition is further described in section 2.1.2.3.

In 2003, amendment 52 to SUA-1473 updated condition 13 from authorization to operate mine water uranium recovery treatment facilities generally to an authorization to operate such facilities only in support of the SUA-1473 groundwater corrective action program (NRC 2003). This amendment removed authorization to operate the Section 35 IX facility because the facility was not involved in the ALW mill groundwater corrective action program. In 2020, amendment 62 administratively deleted condition 13 from SUA-1473 (NRC 2020).

2.1.2.3 New Mexico Discharge Plan

Discharge plan (DP)-67 for an unlined mine water settling pond on section 36 was submitted to the New Mexico Environmental Improvement Division (NMEID) on 2 March 1979 (KMNC 1979). The Section 35 IX facility was not explicitly identified as activities authorized by the original DP-67, which was approved on 19 August 1985 (NMEID 1985b). DP-67 was renewed in 1990; the only change associated with this renewal was the addition of a new requirement to conduct quarterly monitoring for uranium, selenium, total dissolved solids, and pH when the mine water settling pond on section 36 was in use (NMHED 1990).

In 1995, as part of another DP-67 renewal, the Quivira Mining Company (QMC) proposed that, in addition to the mine water settling pond on section 36, the entire Section 35 IX facility should be included in DP-67 (QMC 1995a). On 13 June 1997, the New Mexico Environment Department (NMED) renewed DP-67, including QMC's proposed expanded scope

(NMED 1997). Three of the earthen ponds and the IX facility were licensed by SUA-1473 at the time they were incorporated into DP-67. DP-67 remains open and the Section 35 IX facility, including the three licensed ponds, was administratively removed from SUA-1473 on 1 August 2003 with amendment 52 to SUA-1473 (NRC 2003).

2.1.3 Potential Affected Areas

In addition to the restricted area associated with the Section 35 IX facility (QMC 1983), the Section 2 Drainage is potentially affected by discharges from the Section 35 IX facility (Figure 2-2). This area is discussed in more detail in section 2.5.3.

2.1.4 Photos and Figures

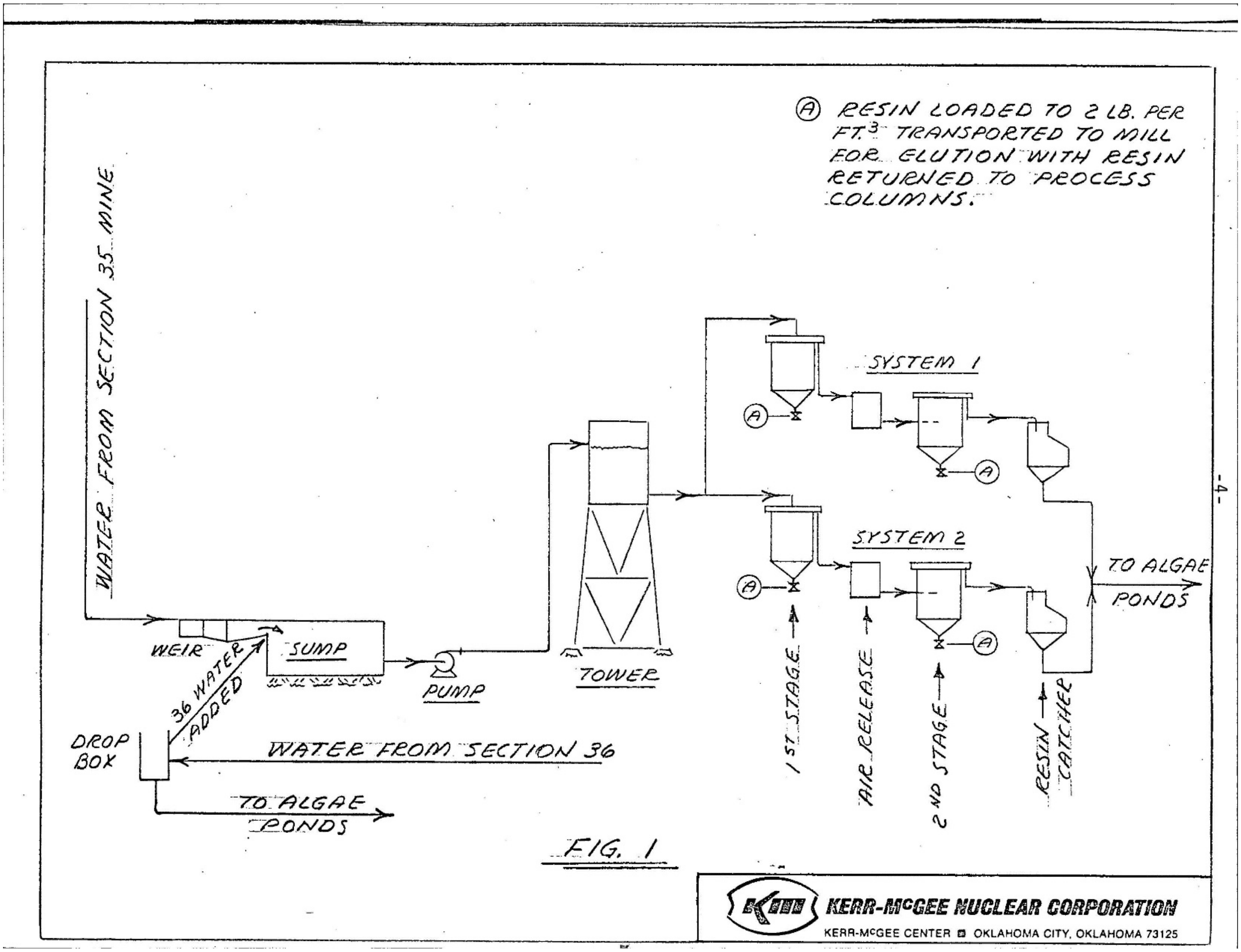

Figure 2-1 Process flow diagram of Section 35 IX plant from (KMNC 1976d).

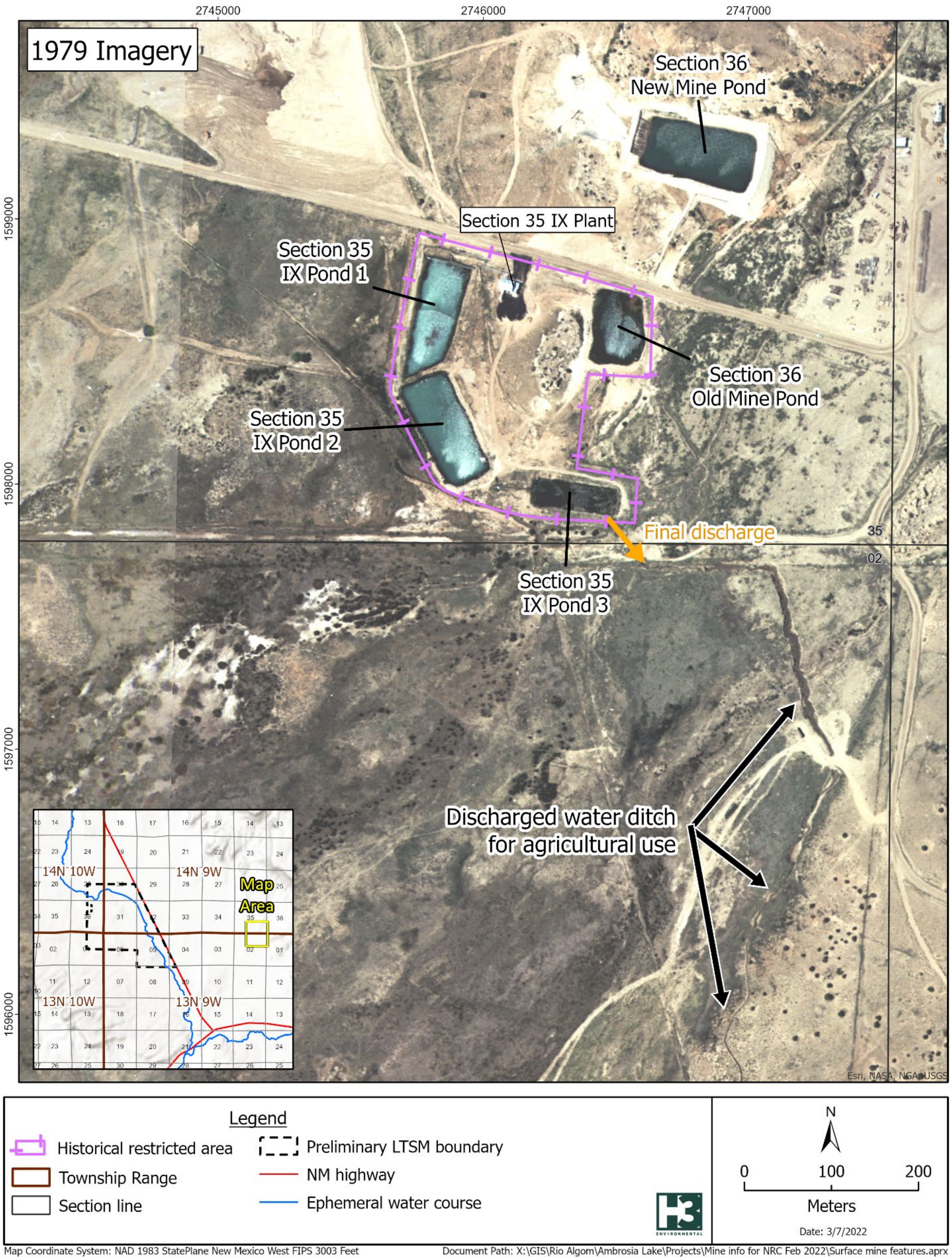

Figure 2-2 Section 35 IX facility (KMNC 1976d).

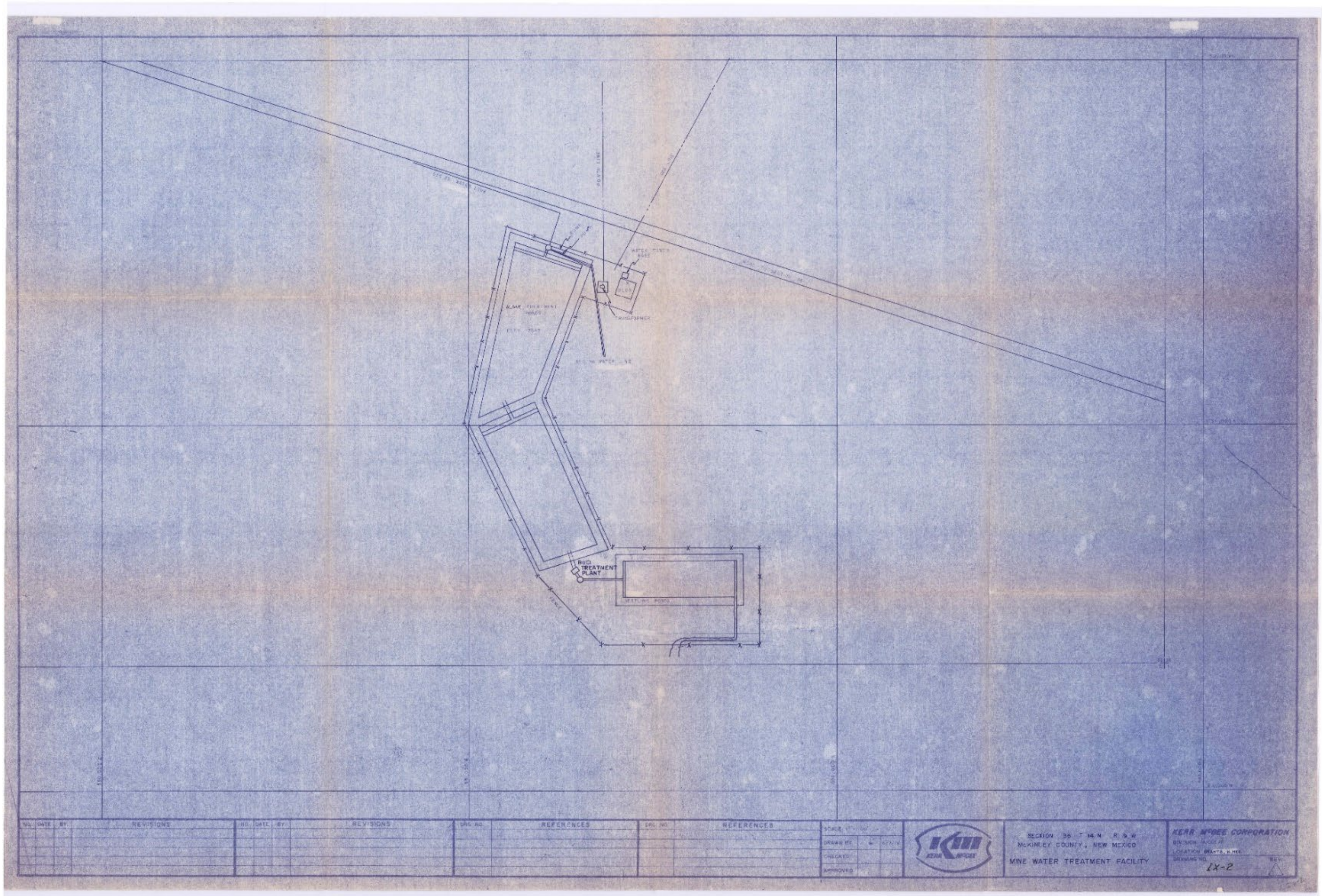

Figure 2-3 Schematic of pond treatment system at Section 35 IX facility (KMNC 1976d).[4]

[4] The fence line depicted in figure is described as the restricted area for the IX facility, this includes the three treatment ponds (KMNC 1976d).

2.2 Stope Leaching With Chemicals

Stope leaching with chemically fortified mine water to recover uranium from an orebody that has been previously conventionally mined is analogous to *in situ* recovery of uranium (NRC 2011), a process that is licensable. This is in contrast to passive "recirculation" of non-fortified mine water through an orebody, which historically was not licensable and did not generate byproduct material (NRC 1986b). This interpretation is consistent with previous regulatory clarifications (NRC and EPA 2020) and historical permitting/licensing actions, by both the State of New Mexico and the NRC, related to stope leaching with chemically fortified mine water at in-scope mines, which are discussed section 2.2.2.

2.2.1 Process

Kerr-McGee began a research and development program to evaluate the feasibility of leaching reserve uranium from previously mined areas (stopes) in 1962 (KNFC 1963). The stated purpose of this program was to recover a fraction of the approximately 35% of uranium reserves that could not be recovered via conventional mining (KNFC 1963).

Records reviewed regarding the program indicate that favorable leach tests of ore, in the laboratory and underground, with both chemically fortified and unfortified water as the leaching solution, influenced the decision to construct the IX plant at the ALW mill in 1963 (KNFC 1963). Early testing demonstrated that most of the uranium in the exposed stopes could be effectively leached using recirculated mine water without need for chemical fortification (KNFC 1965). In 1966, recirculation efforts progressed from research and development to production-scale at the Section 17, 22, and 24 mines (KMC 1966). Starting in 1970, production scale recirculation was expanded into the Section 30, 30W, 33, 19, and 35 mines (KMC 1971a). Because recirculation does not generate byproduct material, a detailed description of uranium recovery via mine water recirculation is out of scope for this document.

Stope leaching with chemicals such as sulfuric acid or sodium bicarbonate is known to have occurred at some in-scope mines; Table 2-1 lists the in-scope mines where currently available records indicate that stope leaching with chemicals was tested or used for uranium recovery. The process for stope leaching with chemicals was identical to the process for recirculation, except that chemical fortification occurred prior to the introduction of recycled mine water into mine stopes or the surrounding formation.

By 1965, two methods were used to introduce leaching solution (chemically fortified or otherwise) into stopes for the purpose of recovering uranium. If stopes were accessible, a sprinkling system within the stope was used; otherwise, leaching solution was introduced into a stope or the surrounding formation via a perforated or slotted tube that ran into the stope or formation via a hole drilled from the surface. Sprinkler systems were identified as the more effective method to introduce leaching solution, but were of limited use because these systems required that inactive areas of the mine remained open and ventilated (KMC 1969).

Regardless of the method used to introduce leaching solution, the uranium-laden solution drained into and was collected by small ditches (Photo 2-1) located within mined stopes. Here, the leachate solution mixed with the formation water that seeped continuously into the mine's stopes from the Westwater. The small ditches conveyed water from across a mine into a sump at the bottom of the mine shaft. Water from the sumps at most in-scope mines was pumped to the ALW mill IX facility for recovery of uranium, although in the case of the Section 35 and 36 mines, water was sent to the IX facility on section 35 beginning in 1976 (NMEIA 1976b). Figure 2-4 depicts the general process for stope leaching with chemicals.

Stope leaching with chemicals ceased by 1991 (NMED 2001; QMC 1992).

Table 2-1 Former mines in Ambrosia Lake valley known to have been leached with chemically fortified solutions.

Mine	Chemical	Description	Reference
Section 22	Water treated with oxygen	In 1979 gaseous oxygen was injected into leach water to increase uranium recovery.	(KMNC 1980b)
	Sulfuric acid	In mid-November 1983 an experiment was run using sulfuric acid added to an 80 gpm flow of recirculated mine water and sprayed into an open stope. pH of solution was 1.5-2. Sulfuric acid was used as chemical amendment for all of 1986. pH of leach solution ranged from 1.7 to 5.7	(QMC 1984a) (QMC 1986e, 1986c, 1986d, 1987)
Section 24	Sodium carbonate	In 1972, soda ash was added to leach solution used for two months. 44,000 pounds of soda ash was consumed.	(KMC 1973)
	Sodium bicarbonate	Sodium bicarbonate was used as a chemical amendment to leach water in 1986, 1989, 1990, and 1991. pH of leach solution ranged from 7.6 to 8.3.	DP-362 quarterly reporting (QMC 1986c, 1986d, 1987, 1989, 1990a, 1990b, 1991a, 1991b, 1991c, 1992)
Section 17	Hydrogen peroxide with sodium bicarbonate	Mine water fortified with bicarbonate was used in the north decline area in May and June 1982 as part of a feasibility test.	(KMNC 1982b)
Section 33	Hydrogen peroxide with sodium bicarbonate	Mine water fortified with bicarbonate was used in 1981 extending into 1982 as part of a feasibility test.	(KMNC 1982b; QMC 1984a)

DP – discharge plan
gpm – gallons per minute

2.2.2 Permitting

On 18 April 1985, the Uranium Licensing Section of the New Mexico Environmental Improvement Division (NMEID) notified QMC (NMEID 1985e) that stope leaching with chemicals must be authorized by SUA-616. The NMEID issued DP-362 on 29 July 1985 (NMEID 1985c), which initially authorized stope leaching with chemically fortified solutions (sulfuric acid or sodium bicarbonate) at the Section 17, 19, 22, 24, 30, 30W, 33 and 35 mines. Quarterly reports to NMEID describing leach location, period of leaching, leaching rate, and pH were required from the time of issuance of DP-362 (NMEID 1985c). Prior to issuance of DP-362 the practice of stope leaching with chemically fortified solutions does not appear to have been regulated.

On 19 August 1985, NMEID issued condition 39 to SUA-616 (NMEID 1985a), which authorized stope leaching with chemicals and referenced DP-362.

Condition 39 was retained when NRC issued SUA-1473 amendment 0 on 23 September 1986 (NRC 1986c). Authorization to stope leach with chemically fortified solutions was removed from SUA-1473 with amendment 1 on 21 November 1986 (NRC 1986a). On 11 August 1988, amendment 8 (NRC 1988) to SUA-1473 authorized injection of chemically fortified mine water (bicarbonate and carbonate only) at the Section 24 mine via the addition of condition 33. As described in Table 2-1, chemically fortified mine water was introduced into the Section 24 mine from 1989-1991. DP-362 reports confirm that chemically fortified water was not injected between December 1991 and June 1999. Condition 33 was administratively removed from SUA-1473 by amendment 52 in 2003 (NRC 2003).

On 7 August 1999, the State of New Mexico renewed and expanded DP-362 (NMED 1999) to authorize the recirculation of 7,200,000 gallons per day of mine water fortified with sodium bicarbonate or sulfuric acid. The 1999 permit renewal and modification expanded the area authorized to receive chemically fortified mine water to the former Section 13, 15, 17, 19, 22, 23, 24, 25, 30, 33, and 35 mines. However, conditions 7 and 8 of the permit renewal required the submission of updated groundwater monitoring prior to 1) injection of fortified mine water or 2) mine water recovery of uranium from the expanded area. RAML has no records of these materials being submitted to the State of New Mexico and records suggest that the expanded activities described in the 1999 DP-362 renewal never occurred.

Citing the discontinuation of site operations, in 2004, RAML requested that the State amend DP-362 to "eliminate the operational aspects and solely include elements associated with closure and possible post closure activities" (RAML 2004).

2.2.3 Potential Affected Areas

Figure 2-5 shows the locations of leach holes associated with each in-scope mine. A subset of leach holes known to have been used for stope leaching with chemicals based on DP-362 quarterly reports are specifically identified on Figure 2-5.

RAML is not aware of evaluation of potential surface impacts associated with leach hole construction and operation at in-scope mines having been conducted. Stope leaching chemicals may have altered the groundwater chemistry of the Westwater formation, however the impact is likely small and indistinguishable from the surrounding impacts related to uranium mining. Additionally, dewatering of the Westwater to access the ore body resulted in a hydraulic cone of depression which will persist in the Westwater for more than 1,000 years, thereby containing water quality changes resulting from uranium recovery operations in the ALV (INTERA 2017, 2018).

2.2.4 Photos and Figures

Photo 2-1 Typical mine with dewatering ditch to the left side of the photograph.

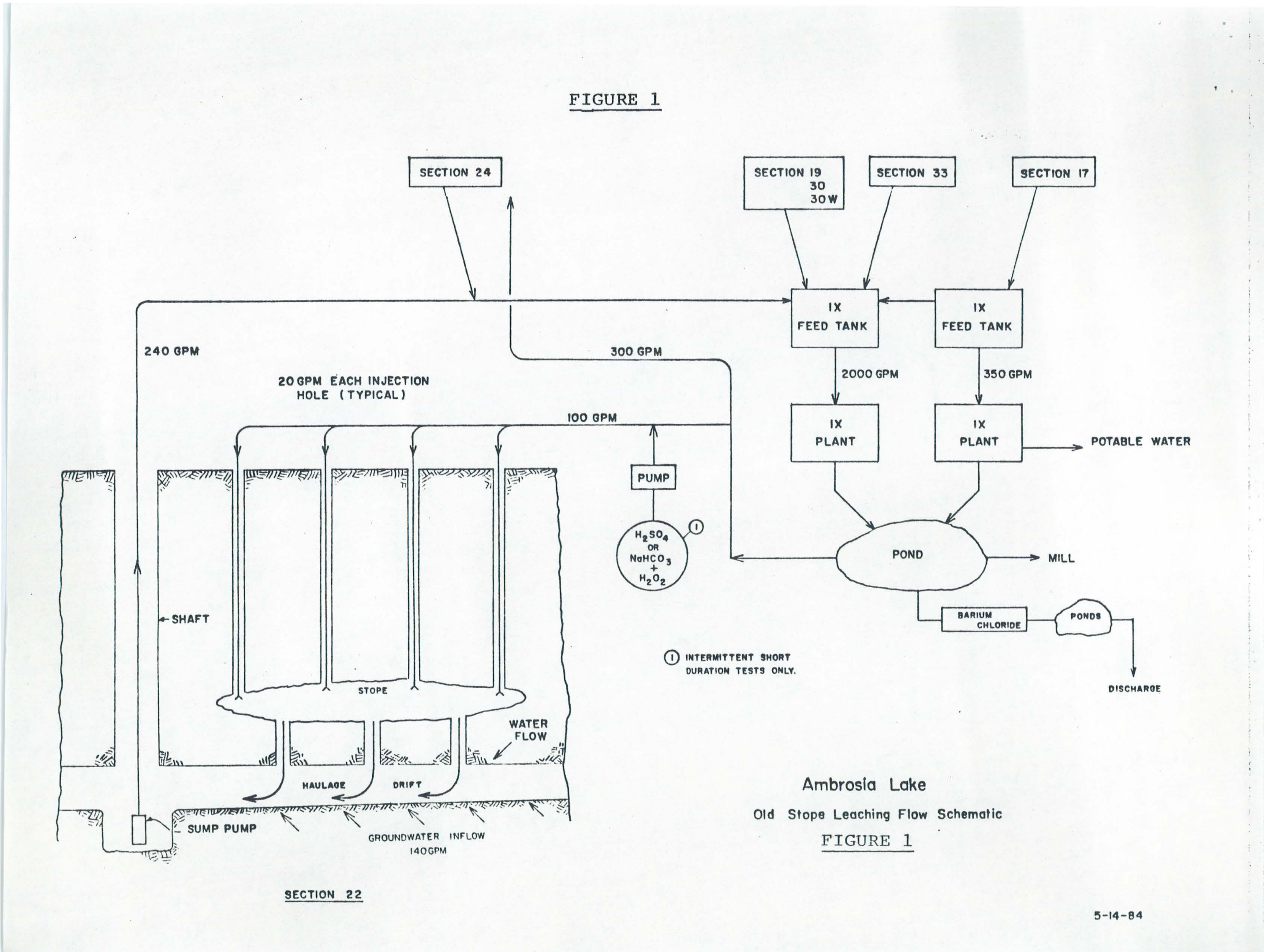

Figure 2-4 Generalized process diagram for stope leaching with chemicals (QMC 1984a).

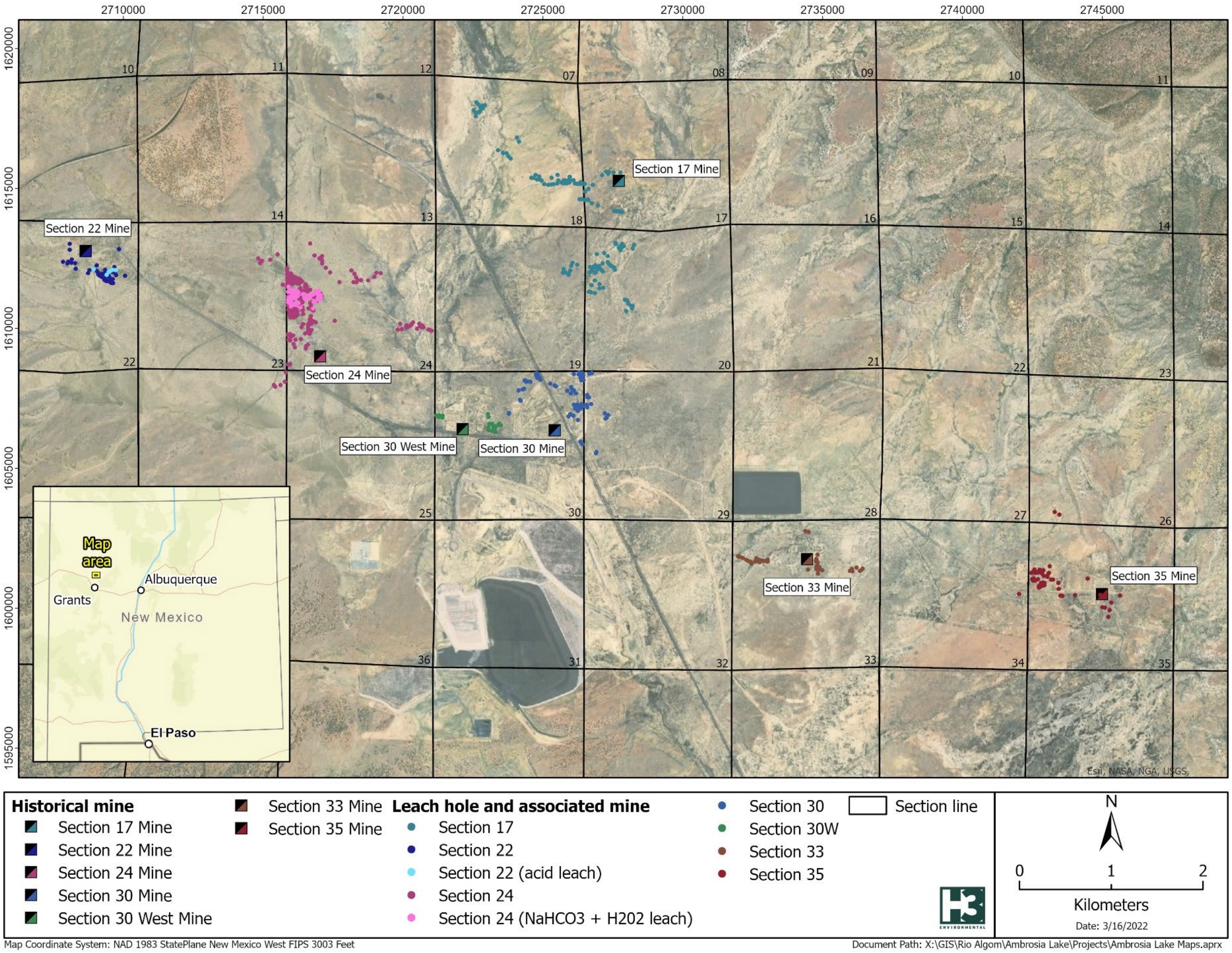

Figure 2-5 Known leach holes at in-scope mines.

2.3 Sandfilling

Hydraulic transport of solids into mines to improve underground support of mine workings has been practiced since 1864 (McNay and Corson 1975). Classification of mill tailings and the hydraulic transport of coarse tailings fraction into underground workings has been used in metal mines since the early 1900s (McNay and Corson 1975) and the practice has been colloquially referred to as sandfill or backfill (McNay and Corson 1975). In this document, the practice of hydraulic placement of classified or unclassified uranium mill tailings into mine voids or stopes is referred to as sandfilling.

Sandfilling of certain in-scope mines began by 1962 (KNFC 1963), when uranium mill tailings were regulated only while inside of the license boundary of a uranium mill. Uranium mill tailings outside of a mill's license boundary first became regulated in 1978 via the passage of the *Uranium Mill Tailings Radiation Control Act*. Sandfilling ceased by 1985; in 1986, QMC (1986a) estimated that the total mass of classified uranium mill tailings placed in in-scope mines was 1,333,742 dry tons, which is approximately 4 percent of the tailings generated at the ALW mill. The Section 22, 30, 30W, 35, and 36 mines are the only in-scope mines known to have received sandfill (KMC 1983). Approximately 45 percent of the total volume of ALW mill tailings used for sandfilling was produced prior to 1 December 1969 (598,217 dry tons), the period during which all uranium was produced under contract with the Atomic Energy Commission (AEC) (QMC 1986b).

Some of the backfill placed in in-scope uranium mines in the ALV was native alluvial material; mine backfill with alluvial material is not a mill or mill-like process and is therefore out of scope of this document.

2.3.1 Process

Sandfilling was a method of ground support to prevent subsidence above shallow mines and to prevent caving of rock above deeper mines. It was also shown to reduce radon-222 concentrations in uranium mines by reducing the stope void space by more than 90 percent with a material containing less radium-226 than the host rock, thereby reducing radon-222 emanation (Black 1980). An NMEID study in the ALV (NMEID 1985d) identified the following benefits associated with sandfilling:

- Prevention of roof fracturing, which may result in increased hydrological connection between the ore zone and overlying aquifers.
- Providing support to mine additional ore (i.e., ore in or near pillars).
- Control of land surface subsidence.
- Disposal of mill tailings.
- Improved worker safety.

Sandfill in the ALV consisted of either classified or unclassified uranium mill tailings. Classified mill tailings were preferred because the coarser grain size improved drainage and the geotechnical stability of sandfill material following placement in mined out stopes (Thompson and Heggen 1982).

The sandfilling process began with hydraulic separation (classification) of tailings sand greater than 200 mesh (74 micrometers) from the mill tailings slurry (KMC 1982). Following separation, classified tailings sand was dewatered and trucked to outlying in-scope mines. Most commonly, hydraulic separation occurred at the ALW mill (KMC 1982). However, ALW mill tailings were also classified at the former Section 35 mine (Golder 1974; KMNC 1976d) and 620,000 tons of classified sandfill was slurried and piped directly to the Section 30 mine from the ALW mill (KMNC 1980a).

Typically, after reaching the mine site, classified tailings sand was slurried with mine water and gravity fed by a pipeline from the surface into a stope prepared with a bulkhead or dam constructed to retain the sandfill in the desired location (KMC 1982). Sandfill was piped into the stopes through the mine shaft, a vent hole, or other vertical penetration drilled from the surface. Following placement, the mixture of mine water and remaining tailings liquid drained from the sandfill and was collected in small ditches (Photo 2-1) located within mined stopes and drifts. In these ditches, the mine water/tailings solution mixed with the formation water that seeped continuously into the mine's stopes from the Westwater.

The small ditches conveyed water from across a mine into a sump at the bottom of the mine shaft. Water from the sumps of in-scope mines was pumped to an IX facility for recovery of uranium, as described in section 2.1.

Figure 2-6 and Figure 2-7 illustrate the general sandfilling process. Table 2-2 presents typical concentrations of radium-226 in sandfill. In stopes where sandfilling occurred, up to 80-90 percent of the stope void space was filled (KMC 1982).

Table 2-2 Typical concentrations of radium-226 in classified tailings sand, classified tailings slimes, and sandfill slurry solution.

Material	Concentration (pCi g^{-1})	Reference
Classified Tailings	60	(KMNC 1978)
Tailings Slimes	1600	(KMNC 1978)
Tailing Solutions[1]	8	(KMNC 1978)

[1]units are picocuries per milliliter
g – gram
pCi – picocuries

2.3.2 Permitting

Sandfilling of in-scope mines was first permitted at the Section 35 and 36 mines by DP-264 on 27 May 1983. The 22 April 1983 application materials for DP-264 state that sandfilling had previously occurred at the former Section 22, 30, 30W, 35, and 36 mines (KMNC 1982a). The same submission states that sandfill was never used in the former Section 24, 17, 19, or 33 mines. Because sandfilling was initiated as early as 1962 and the State of New Mexico first required a discharge plan regulating this activity in 1982, most sandfilling at in-scope mines was not regulated by DP-264. The NMEIA did not act on the KMC's 1977 (KMC 1977b) license amendment request to incorporate sandfilling of in-scope mines into SUA-616.

2.3.3 Potential Affected Areas

Stopes in the Section 22, 30, 30W, 35, and 36 mines were sandfilled as part of mining operations.

Kermac Nuclear Fuels Corporation (KNFC) reported that placement of sandfill in mined-out stopes improved the fraction of uranium recovered (sandfill slurry water has pH of 6-6.3 and upgrades uranium in mine water by 0.003 ppm during sandfilling) via stope leaching (KNFC 1963). Thompson and Heggen (1982) evaluated the effects of sandfilling on groundwater quality and concluded that short-term (defined as while the mine was operating) impacts on water quality were negligible and that theoretical long-term (i.e., after dewatering ceases) impacts would also be negligible. However, KMC suggested to the U.S. Department of Energy (KMC 1982) that tailings sands, produced as a result of AEC contracts, used to backfill mines should be subject to reimbursement under Title X of the Energy Policy Act, then under development, because "backfill may become a problem under future groundwater regulations" (SAIC 1994) (SAIC 1994) (SAIC 1994) (SAIC 1994) (SAIC 1994) (SAIC 1994) (SAIC 1994).

Surface impacts from sandfill operations have been documented at the Section 35 and 30 mines and are discussed in sections 2.3.3.1 and 2.3.3.2 respectively.

2.3.3.1 Section 35 Mine Area

Beginning on 23 October 1975 unclassified mill tailings from the ALW mill were trucked to the Section 35 mine for use as sandfill (KMNC 1975). Mill tailings were required because the existing source of native alluvial backfill material at the Section 35 mine had been depleted (KMNC 1975). Classification of mill tailings occurred at a sandfill plant on section 35 that had been previously used to classify alluvial material for use as backfill; it appears that the waste fraction generated from the classification process (i.e., fine grained material) was discharged without treatment. KMNC's internal correspondence from the spring of 1976 identifies that "nothing has been done to clean up the slime fractions separated at the [section 35] sandfill plant and discharged" (KMNC 1976g).

On 5 October 1976, KMNC performed a gamma survey of the area potentially affected by the fine grain slimes discharged from the Section 35 sandfill plant (KMNC 1976f). During this survey, an ongoing discharge of about 20 gpm of fine grain slimes was observed. Gamma readings in the 41-acre survey area ranged from 0.04 to 5 milliroentgen per hour (KMNC 1976f).

Photographs of the tailings slime discharge are provided on Photo 2-2. A map of the Section 35 sandfill plant infrastructure and likely tailings slime discharge point is provided on Figure 2-9. Figure 2-10 shows the location of the tailings slime discharge; the area completely covered by tailings slime was approximately 6.5 acres (KMNC 1976f). Figure 2-10 depicts the affected area on contemporary historical orthoimagery. Figure 2-11 depicts downgradient areas potentially affected by the tailings slime discharge, which are discussed further in section 2.5.3.

Records reviewed by H3 on behalf of RAML do not precisely estimate the quantity of tailings slimes discharged or when the discharge of tailings slimes from the section 35 sandfill plant was abated. By 20 July 1977, 90 percent of the tailings discharge from the Section 35 sandfill plant had been removed and transported to a pit near the sandfill plant (KMNC 1977). The discharge was likely discontinued by this time and gamma radiation levels were reduced to less than 100 microroentgen per hour in most affected areas (KMNC 1977). Tailings used for sand fill were removed from section 35 to the ALW mill site by contractors in April 1992 (RAML 2012).

The Section 2 Drainage, which was potentially affected by sandfilling operations, is described in section 2.5.3.

2.3.3.2 Section 30 Mine

In the spring of 1984 QMC conducted a soil survey around the Section 30 mine (QMC 1984b). QMC concluded that up to 42 of the 66 samples collected during the survey exceeded 5 picocuries per gram radium-226 in part because of sandfill-related processes at or near the Section 30 mine. Sample locations and results are shown on Figure 2-12.

In February 2013, the EPA conducted documented release sampling (DRS) near the Section 30 mine (EPA 2013). The DRS included gamma survey and soil sampling. The DRS sampling occurred in areas previously identified as being impacted by sandfill or a mix of sandfill and mining activities. This report identifies some samples as having much higher concentrations of radium-226 than uranium, suggesting a potential sandfill-related impact.

2.3.3.1 Section 22, 30W, and 36 Mines

RAML has not evaluated surface impacts from sandfilling at other in-scope mines, which may include discrete impacts associated with infrastructure used to convey and place sandfill (e.g., leaks or spills from pipes used to slurry sandfill) and more widespread, homogeneous impacts associated with aeolian or waterborne transport of sandfill material (e.g., classified tailing sands blown from open-top trucks during transport of sandfill for placement at in-scope mines).

RAML has noted discrete gamma anomalies present on the ground surface above mines known to have received sandfill (e.g., parts of the Section 36 mine) that *may be* related to sandfilling operations. Further historical research and soil characterization *could* be used as lines of evidence to support the classification of such gamma anomalies as the result of sandfilling operations (Figure 2-13). However, the observed gamma anomalies are of little significance (in terms of spatial extent and total radionuclide inventory) when compared to the surrounding mine-related impacts.

2.3.4 Figures and Photos

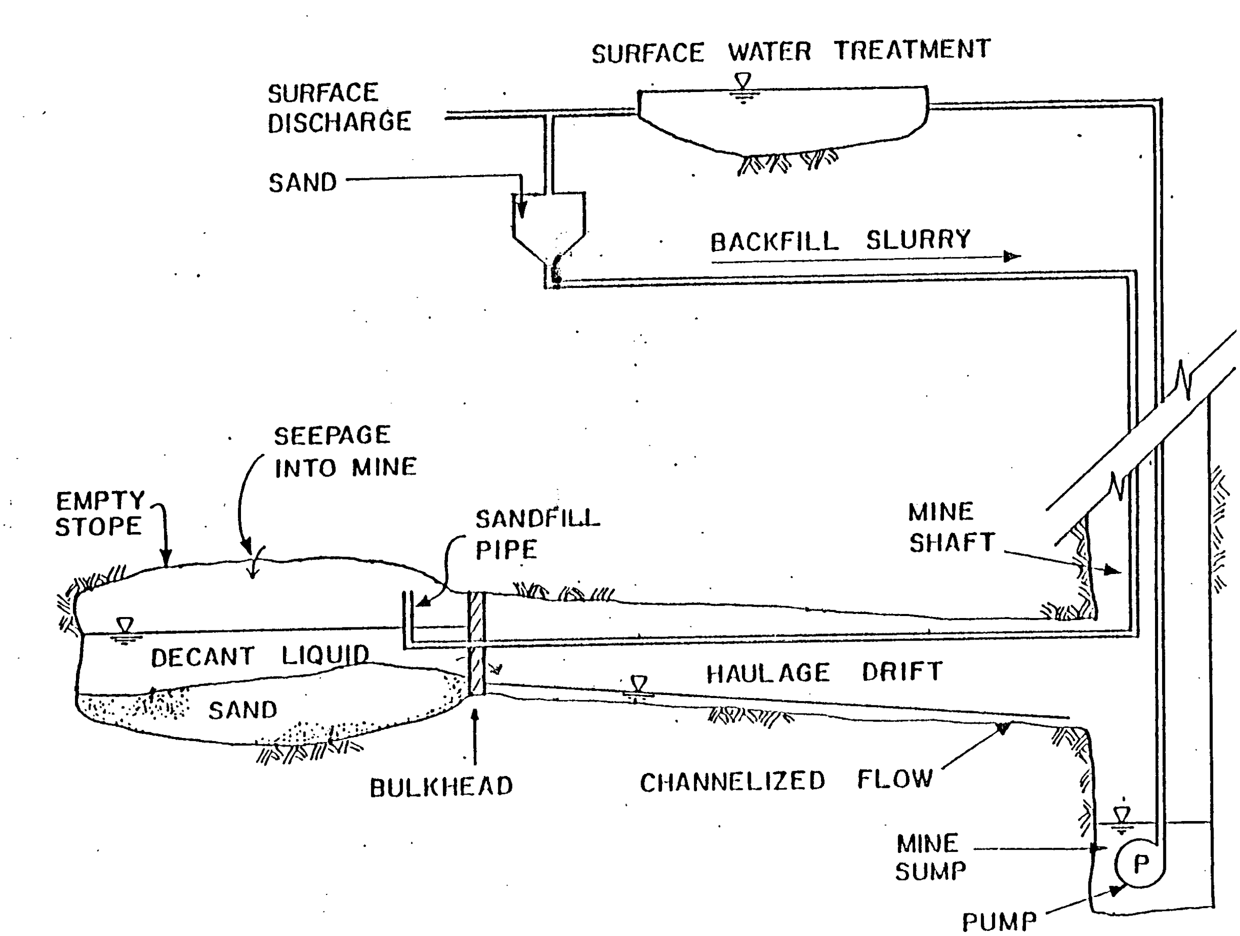

Figure 2-6 Generalized process of sandfilling operation (NMEID 1985d).

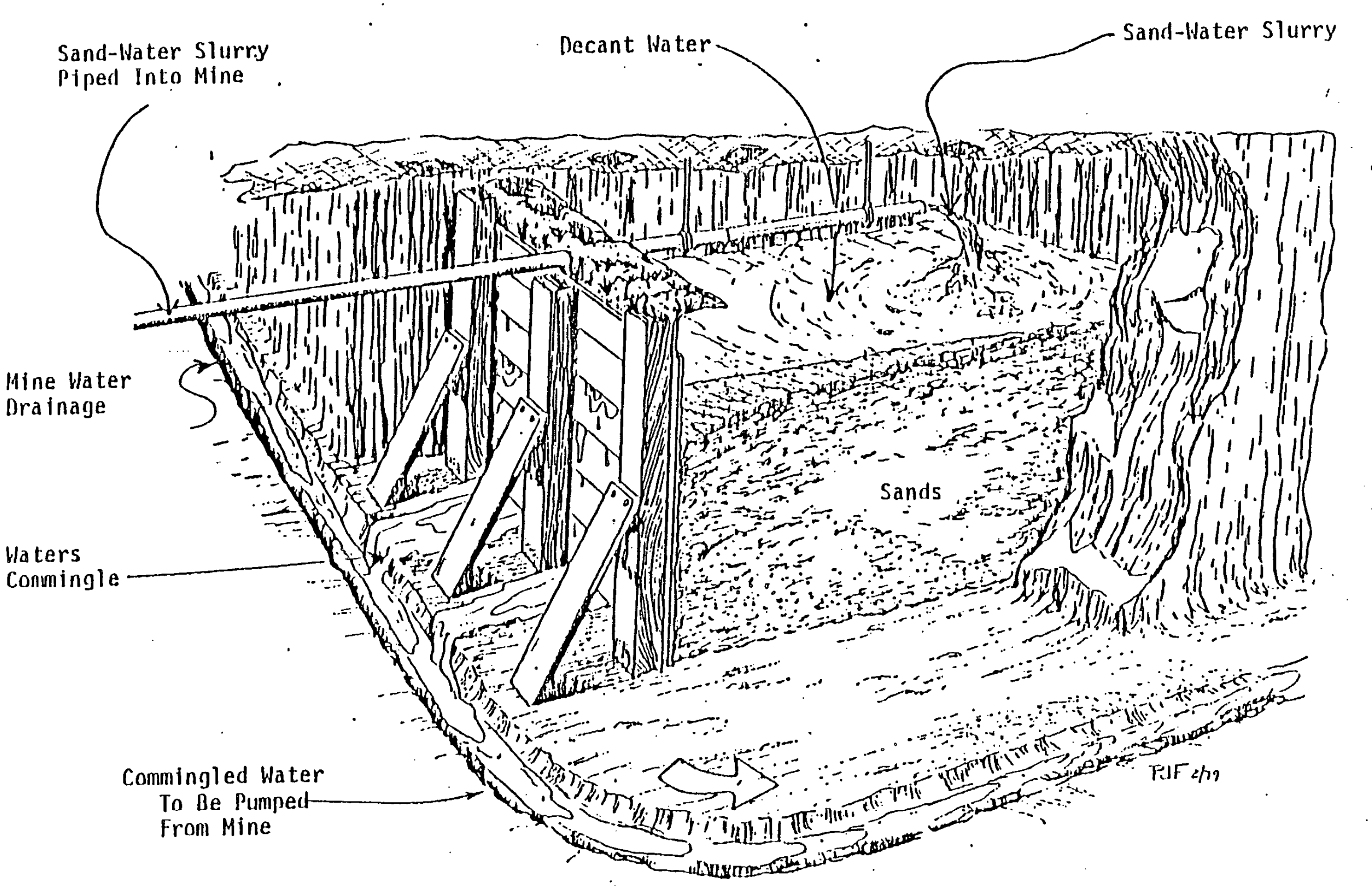

Figure 2-7 Generalized diagram of sandfilling in mines (NMEID 1985d).

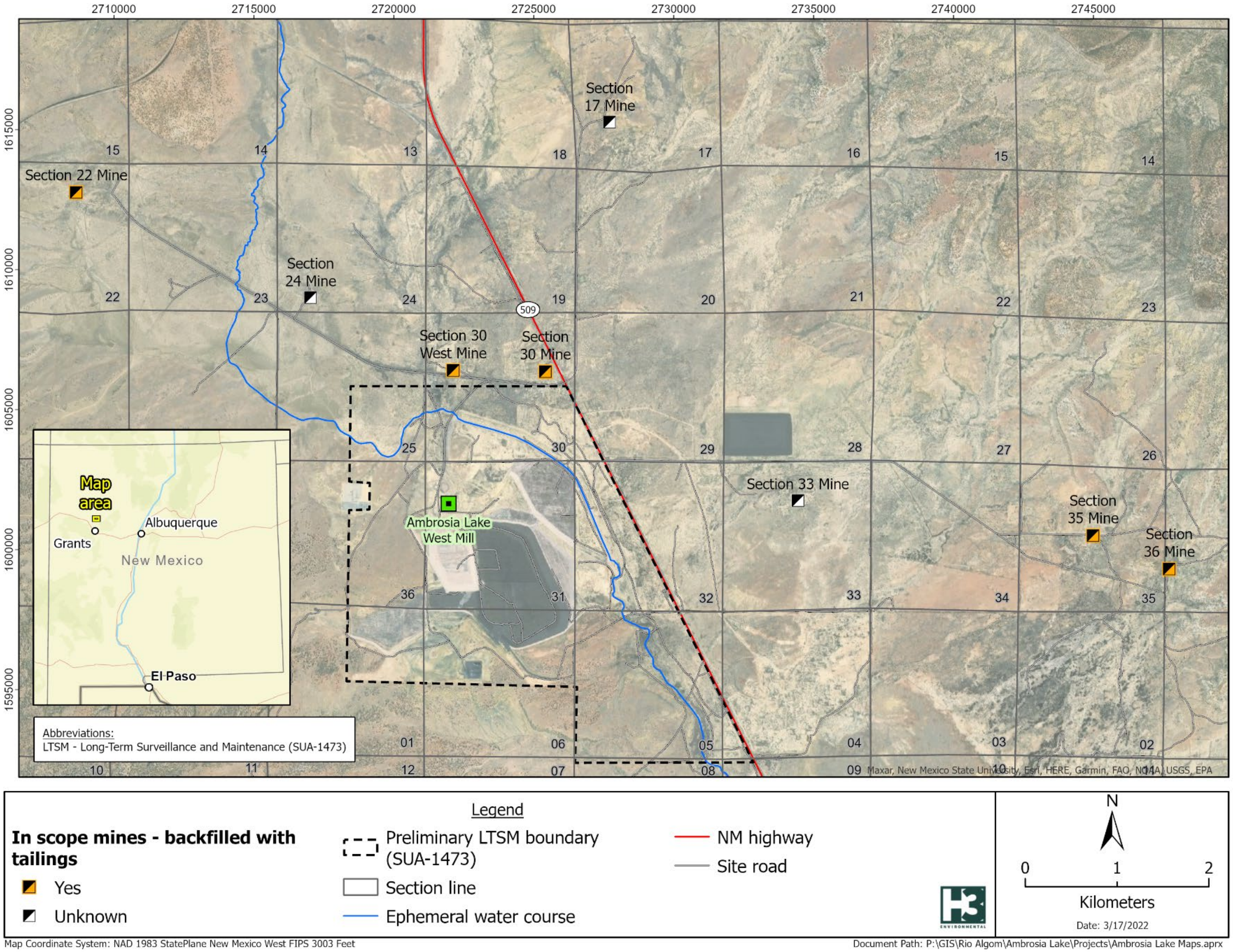

Figure 2-8 In-scope sandfilled mines in the Ambrosia Lake Valley.

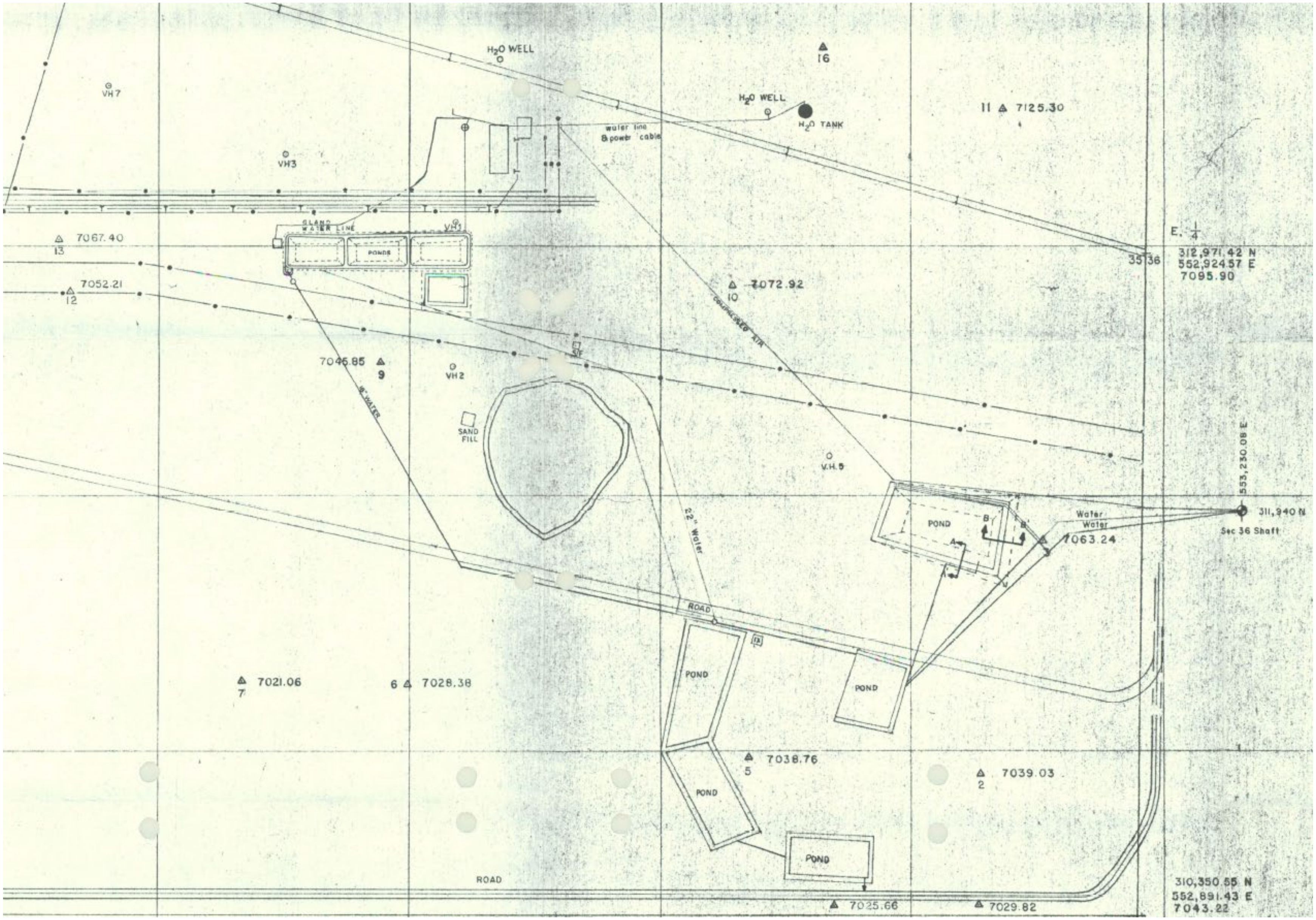

Figure 2-9 Sandfill infrastructure as of 1978 at the Section 35 mine.

a) Discharge point from slimes pond. Discharge travels southward under road finally joining Sec. 35-36 pond system final discharge.

b) Immediately east and south of the Sec. 35-36 outfall showing discharge channel from slimes pond.

c) End of Sec. 35 sandfill slimes pipeline discharging toward slimes pond 750 feet downhill

d) Sandfill slimes channeling toward pond.

Photo 2-2 August 1976 photographs of sandfill slimes discharge from the Section 35 sandfill plant.

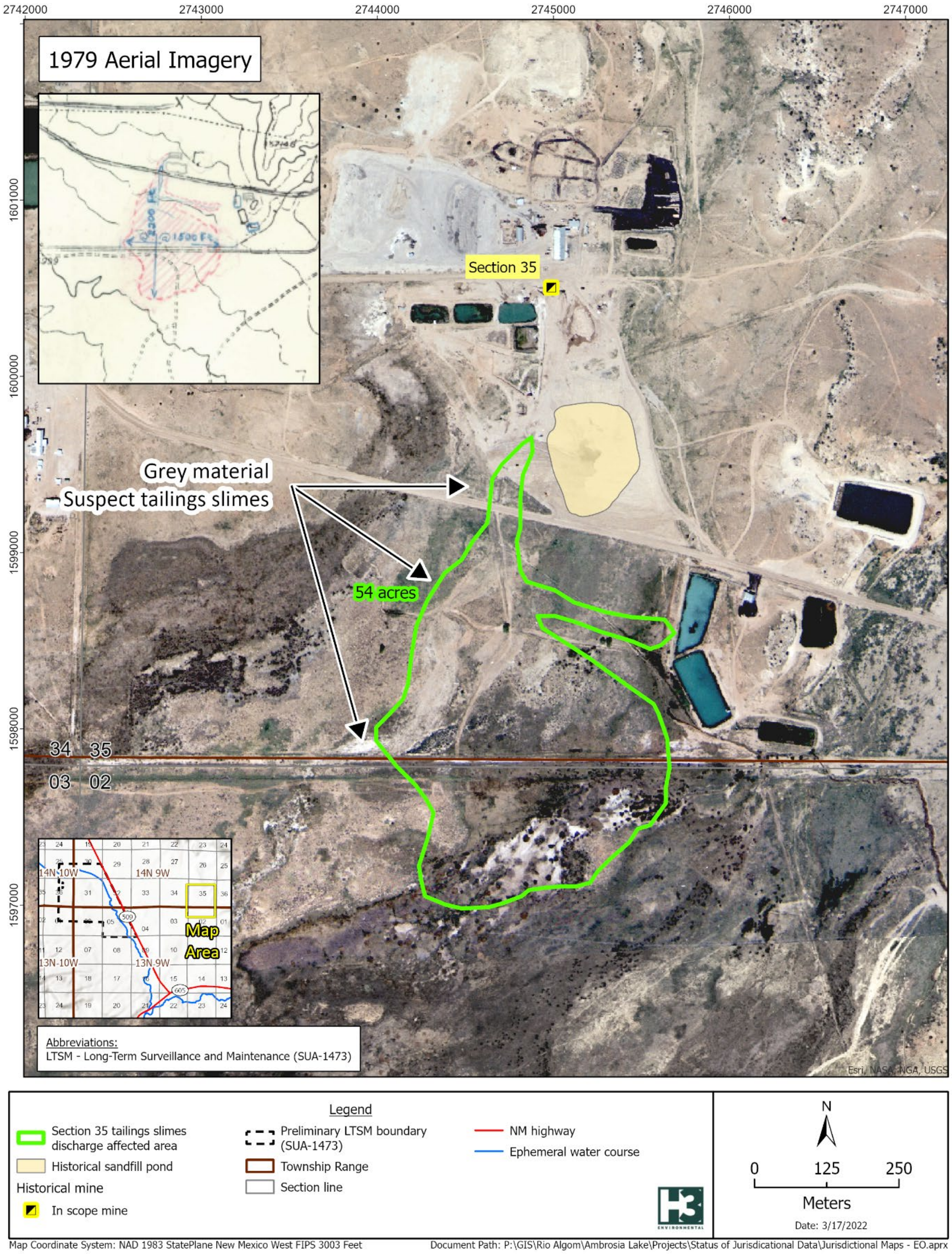

Figure 2-10 Section 35 mine features and sandfill impact areas (KMNC 1976f).

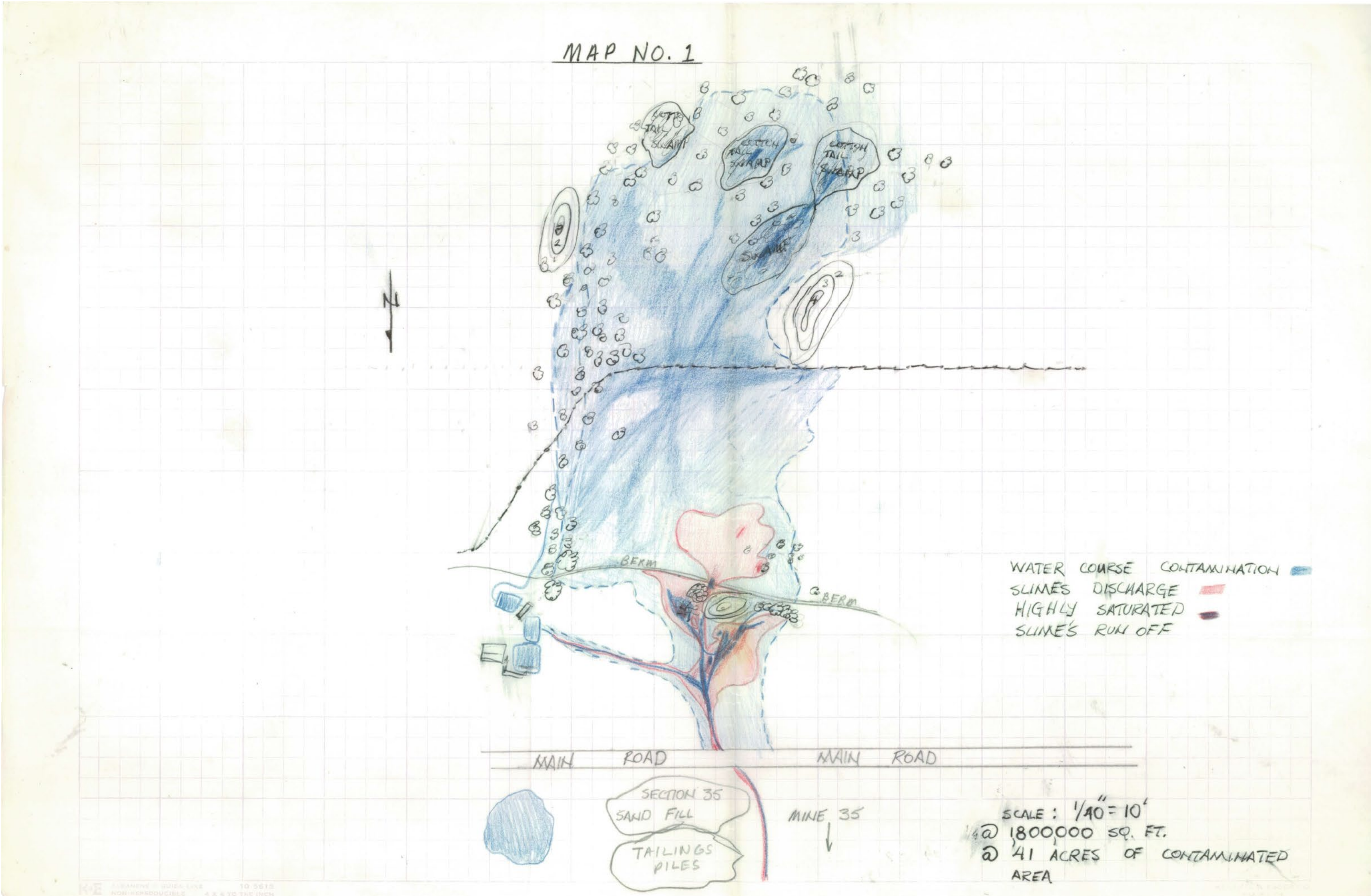

Figure 2-11 Hand drawn map of tailing slime affected area from Section 35 sandfill plant discharge (KMNC 1976f).[5]

[5] North is to the bottom of the page.

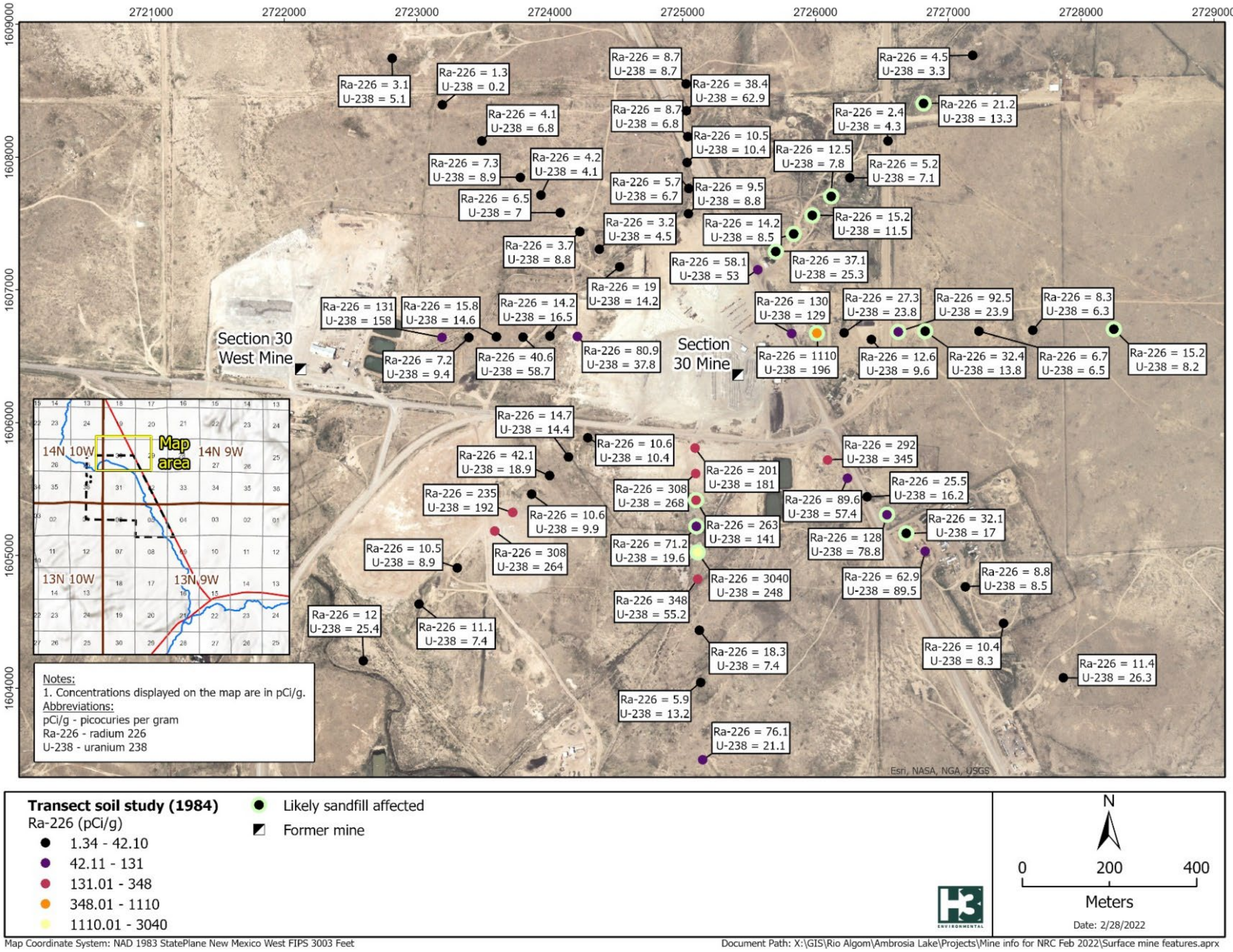

Figure 2-12 Characterization data for section 30 and QMC-identified sandfill-affected areas (QMC 1984b).

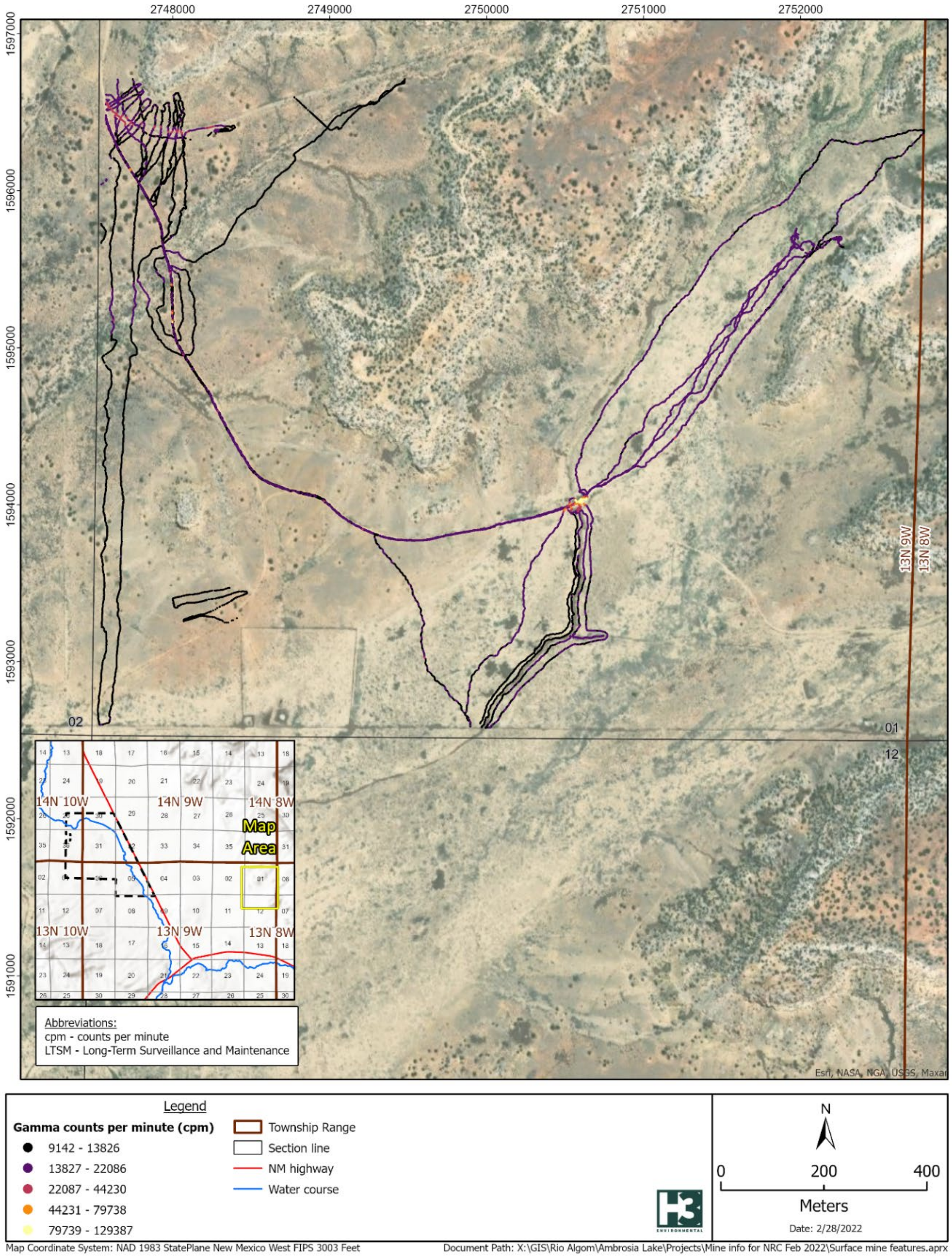

Figure 2-13. Discrete gamma anomaly in section 1 of T13N R09W suggesting presence of potential sandfill-related impact. Gamma data collected by EPA in 2017.

2.4 Heap leaching

Heap leaching of uranium ore occurred near the ALW mill and at the Section 17, 24, 30, and 33 mines between 1966 and 1972 (Petersen 1979). A heap leach was also constructed at the Section 30W mine, but never operated (Petersen 1979). Heap leaching is a method to extract minerals from low-grade ore by percolating a leaching solution through heaped ore-bearing rock. The mineral-laden leach solution is collected beneath the heaped rock for recovery.

2.4.1 Process

Heap leaching at in-scope mines consisted of the following steps:

1. Small pieces of low-grade uranium ore were placed in a pile (heap) on an impervious material such as clay or plastic, either at a location near a mine or at a location near the ALW mill (Petersen 1979).
2. Leach solution (acid, water, or ALW mill raffinate) was percolated through the pile where it solubilized uranium (Petersen 1979).
3. Perforated pipes under the heap collected the uranium-laden leach solution, which was transferred to the ALW mill IX facility (for water leach solution) or directly into the ALW mill counter current decantation circuit (for acid/raffinate leach solution) (KMC 1967).

Figure 2-14 depicts a generalized process flow for an acid heap leach system.

2.4.2 Permitting

During the period of heap leach uranium recovery at in-scope mines (1966 to 1972), heap leaching was not regulated by the Atomic Energy Commission. RAML's currently available records indicate that heap leaching was never incorporated into any license associated with the ALW mill.

2.4.1 Potential Affected Areas

Areas potentially affected by heap leaching are described below.

All environmental impacts from heap leaching, water or acid, are likely insignificant compared to and indistinguishable from collocated impacts from other uranium recovery processes.

2.4.1.1 Section 31 (ALW Mill)

In June 1966, uranium recovery began from an acid heap leach built of low-grade ore sourced from the Section 22 mine and located near the ALW mill (Figure 2-15). The leaching solution was ALW mill raffinate (Petersen 1979). Uranium production from the Section 22 acid heap leach ceased in October 1969 (KMC 1971c). Total production from the Section 22 acid heap leach was 38,610 pounds of uranium oxide, which is 0.03 percent of the uranium oxide milled at the ALW mill.

In November 1966, uranium recovery began from a second acid heap leach built of low-grade ore sourced from the Section 33 mine and located adjacent to the Section 22 acid heap leach (Figure 2-15). The leaching solution for this second acid heap leach included both ALW mill raffinate and sulfuric acid at varying concentrations and ratios (Petersen 1979). Uranium production from the Section 33 acid heap leach ceased in 1969 (KMC 1971c). Total production from the Section 33 acid heap leach was 26,175 pounds of uranium oxide, which is 0.02 percent of the uranium oxide milled at the ALW mill.

Leached ore from the Section 22 and 33 acid heap leaches was most likely processed by the ALW mill in 1973 (KMNC 1974).

2.4.1.2 Section 33 mine

A water heap leach was constructed at the Section 33 mine by February 1968 (Petersen 1979). A second water heap leach began operating at the Section 33 mine by the end of 1971 (Petersen 1979). The location of the Section 33 water heap leaches is shown on Figure 2-16. Heap leach operations at the Section 33 mine ended in 1972; leached ore was shipped to the ALW mill in 1973 and processed (KMNC 1974). Total production from the water heap leach facilities on section 33 was 18,122 pounds of uranium oxide, which is 0.01 percent of the uranium oxide milled at the ALW mill.

2.4.1.3 Section 24 Mine

A water heap leach was constructed at the Section 24 mine beginning in October 1966 (Petersen 1979). The location of the Section 24 water heap leach is shown on Figure 2-17. Due to suboptimal uranium recovery from the Section 24 water heap leach, 116 tons of sulfuric acid were added to the leaching solution, which did not adequately improve heap leach performance (KMC 1967). Heap leach operations at the Section 24 mine ended in 1972; leached ore was shipped to the ALW mill in 1973 and processed (KMNC 1974). Total production from the heap leaches on section 24 was 16,230 pounds of uranium oxide, which is 0.01 percent of the uranium oxide milled at the ALW mill.

2.4.1.4 Section 17 Mine

Water heap leaching was tested near the Section 17 mine in 1965 with favorable results (KMC 1966). A commercial-scale water heap leach began operating near the Section 17 mine in February 1968 (Petersen 1979). The location of the Section 17 water heap leach is shown on Figure 2-18. Heap leach operations at the Section 17 mine ended in 1972; leached ore was shipped to the ALW mill in 1973 and processed (KMNC 1974). Total production from the water heap leach on section 17 was 35,674 pounds of uranium oxide, which is 0.03 percent of the uranium oxide milled at the ALW mill.

2.4.1.5 Section 30 Mine

A water heap leach began operating at the Section 30 mine in 1968 (KMC 1966). The location of the Section 30 water heap leach is shown on Figure 2-19. The Section 30 water heap leach was treated with batch additions of sulfuric acid in 1969 (Petersen 1979). Heap leach operations at the Section 30 mine ended in 1972; leached ore was shipped to the ALW mill in 1973 and processed (KMNC 1974). Total production from the heap leach on section 30 was 18,122 pounds of uranium oxide, which is 0.01 percent of the uranium oxide milled at the ALW mill.

2.4.1.6 Section 30W Mine

A heap leach pad was constructed at the Section 30W mine in 1968 but never operated (KMC 1969). The pad and heap are shown on Figure 2-19. Stockpiled ore was shipped to the ALW mill in 1973 and processed (KMNC 1974).

Because the Section 30W heap leach never operated, there is no potential for heap leach related impacts at the Section 30W mine.

2.4.2 Figures and photos

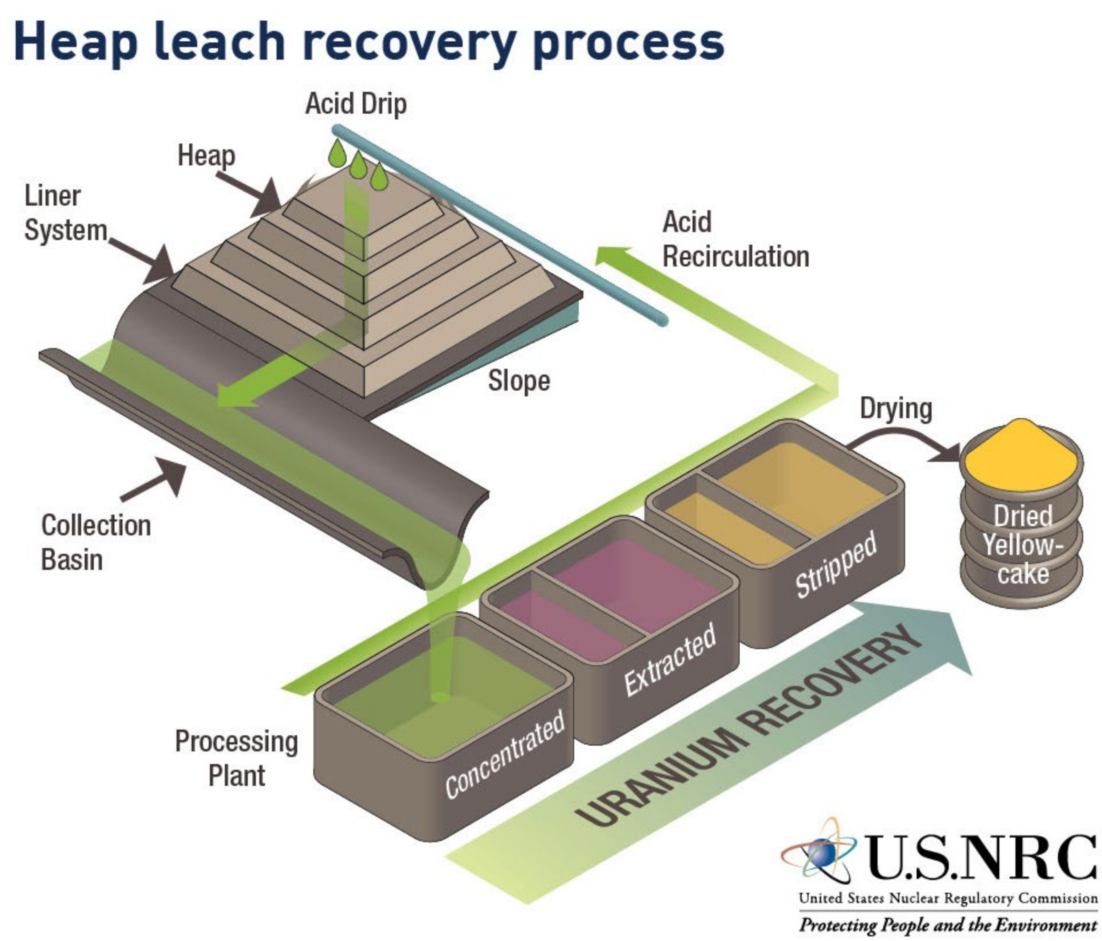

Figure 2-14 Generalized process diagram of a uranium acid heap leaching system.
This image is a work of a Nuclear Regulatory Commission employee, taken or made as part of that person's official duties. As a work of the U.S. federal government, the image is in the public domain in the United States.

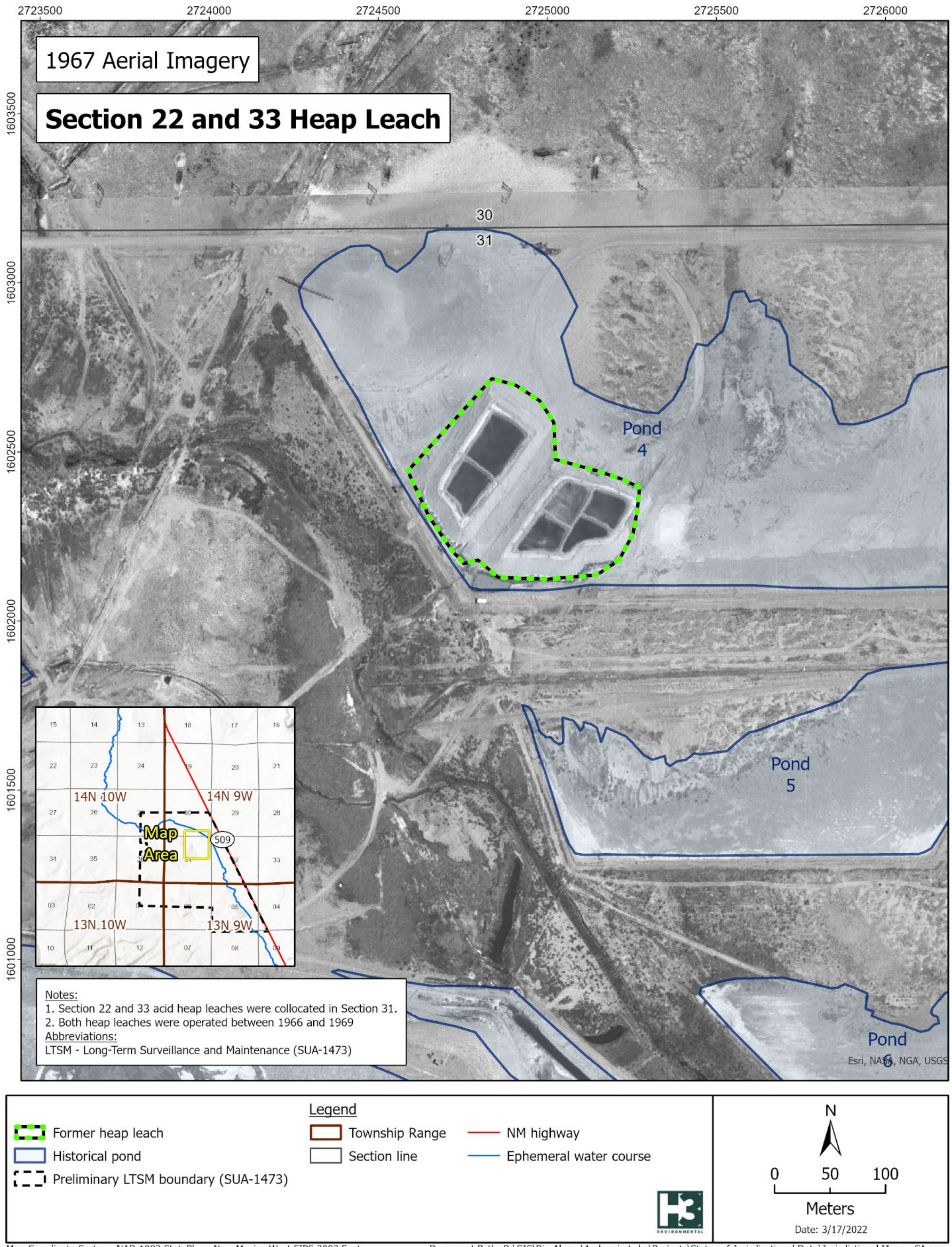

Figure 2-15 Location of acid heap leaches constructed with ore from the Section 22 and 33 mines.

Figure 2-16 Location of heap leach constructed at the Section 33 Mine.

Figure 2-17 Location of heap leaches constructed at the Section 24 Mine.

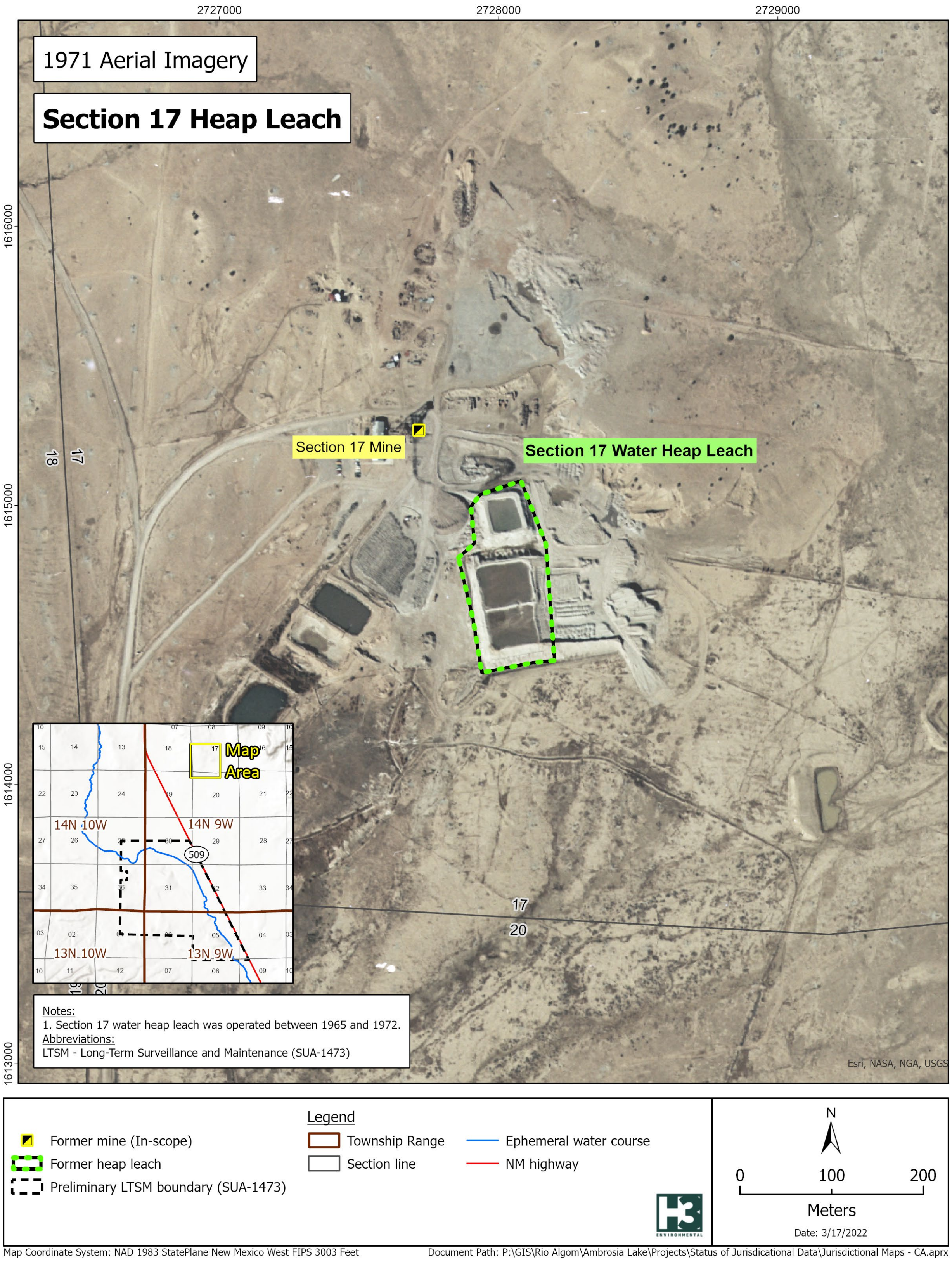

Figure 2-18 Location of heap leach constructed at the Section 17 Mine

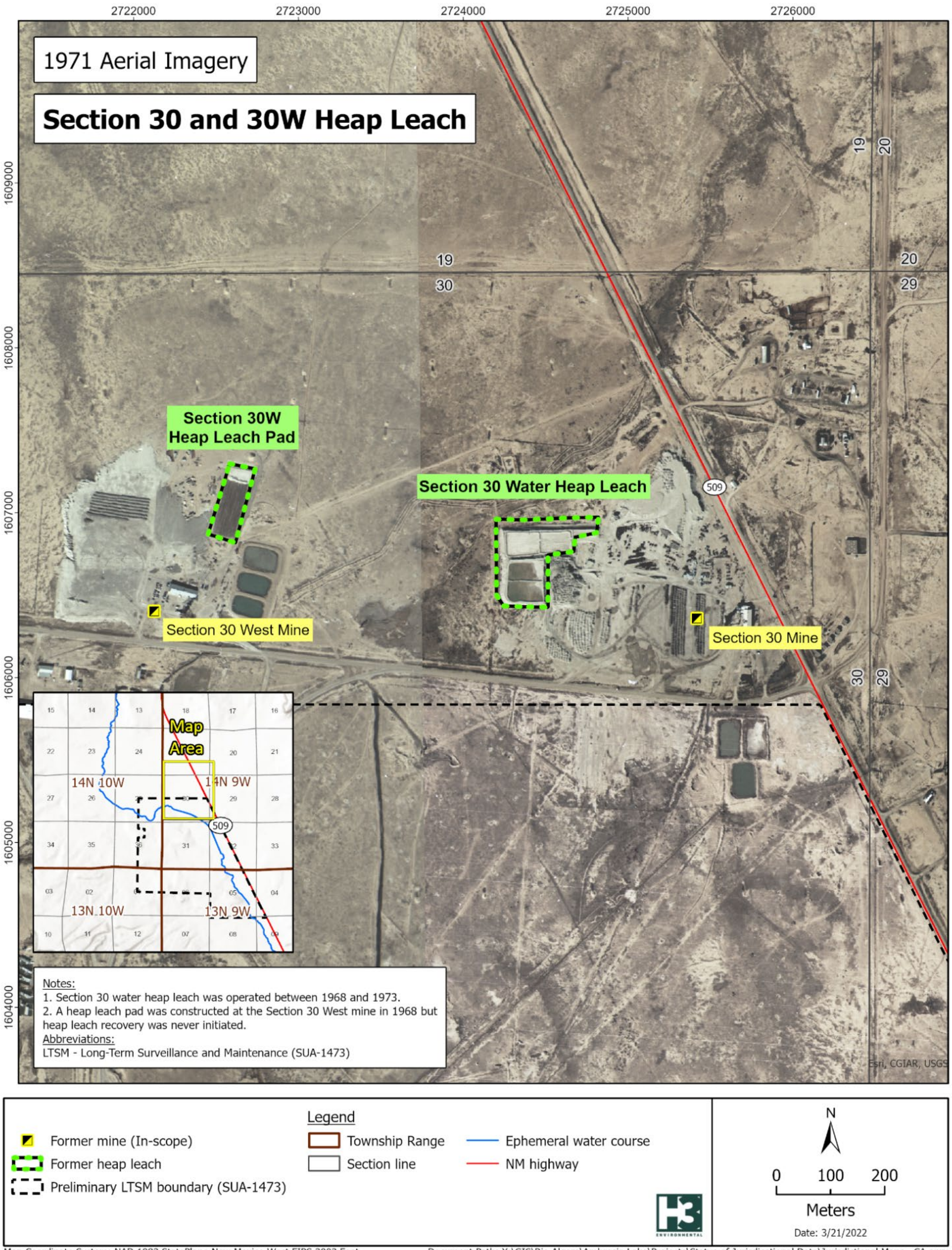

Figure 2-19 Location of heap leaches constructed at the Section 30 and 30W Mines.

2.5 Other Commingled Areas

This section describes areas within the ALV where environmental impacts that derive from mill and mill-like processes from in-scope mines may be spatially commingled with mine impacts. This section does not discuss areas where concentrations of radionuclides that derive from mill or mill-like processes are likely too low to distinguish from a surrounding mine impact (e.g., areas that outlie the ALW mill that are not already described in the SUA-1473 *Soil Decommissioning Plan* (Komex 2006) and may be minimally affected by windblown tailings from the ALW mill).

2.5.1 Arroyo del Puerto

The Arroyo del Puerto (AdP) is an ephemeral water course that runs roughly northwest to southeast across the ALV (Figure 2-20). All natural surface water drainage in the ALV is toward the AdP and prior to uranium recovery operations, the AdP was a dry wash with intermittent flow in response to significant rainfall events and prolonged periods of snowmelt (Ganus 1980). Aquifer testing (pump testing) in the ALV began in 1957; the discharges from these tests resulted in periodic flow in the AdP (Ganus 1980). Mine discharge water (MDW) reached the AdP following the initiation of uranium mining, and MDW in the AdP became a source of recharge to otherwise dry alluvial sediments (Ganus 1980).

Discharges (other than those related to weather) to the AdP upgradient of the ALW mill were either associated with mining processes or with licensed processes, performed by other entities, for which decommissioning has been previously approved by NRC. Therefore, this report regards the AdP upgradient of the ALW mill as solely mine-affected and out of scope. However, in 1975, greater than 55 gpm of water from upgradient sources, with radium-226 concentrations greater than 100 picocuries per liter, flowed through the AdP (EPA 1975b) into ALW mill restricted area, where the water mixed with ALW mill-related discharges. As such, impacts within the AdP south of the ALW mill discharge points likely derive from both mill or mill-like and mine related processes.

Discharges to the AdP from the ALW mill consisted of:

- **ALW Mill Reservoir** – ALW mill IX effluent was discharged to the ALW mill reservoir where it was stored and used as mill process water, non-potable water, or recirculated back to the mines for stope leaching (EPA 1975b). A fraction of ALW mill reservoir water was also discharged into the AdP through the mill reservoir outfall (Figure 2-20), as permitted by NPDES permit NM0020532 (EPA 1975a; EPA 1983). The mill reservoir outfall discharge continued periodically until the completion of the ALW mill groundwater corrective action program in 2006 (NRC 2006).
- **Seepage from ALW Mill Ponds 1-8** – Unlined mill Ponds 1 through 8 (Figure 2-20) were used to evaporate liquid process waste from the ALW mill. EPA (1975c) observed that water seeped from ponds 1-8, collectively, into the alluvium and that a portion of the seeped liquid later appeared as flow in the AdP (EPA 1975c). Discharges to unlined mill Ponds 1 through 8 were authorized by SUA-616, SUA-1473, and DP-169 (NMEID 1984a).

  DP-169 required monitoring of discharges to the unlined ponds at the ALW mill. DP-169 was not referenced in SUA-616 or SUA-1473 and remains open as of 2022.

The *Soil Decommissioning Plan* for the ALW mill (Komex 2006) identifies one historical out-of-scope MDW discharge into the AdP on section 32, just north of lined Ponds 9 and 10. Further south of the ALW mill, on sections 8 and 9 of T13N R09W, additional out-of-scope, mine-related discharges flowed into the AdP, suggesting the likely presence of commingled impacts which derive from mine, mill, and mill-like processes within the AdP at- and south- of the ALW mill.

RAML has performed surface and subsurface characterization studies in the AdP. Gamma data for the south AdP is presented on Figure 2-21, while soil/sediment concentrations of radionuclides from systematically placed boreholes are provided on Figure 2-22, Figure 2-23, and Figure 2-24. Some boreholes/depth intervals have low ratios of uranium to radium-226, suggesting a potential impact from a mill-related process, while others contain ratios closer to one, or even greater than one. This mixture of isotopic ratios is consistent with a complex set of historical operational inputs. Regardless of the sources, soil/sediment impacts in the south AdP appear to end within two miles of the southern boundary of the ALW mill preliminary long-term surveillance and maintenance boundary.

2.5.2 Section 4

The Section 4 ponds consisted of lined ALW mill Ponds 11-21. Construction of lined Ponds 11-15 was completed in the spring of 1977 (KMC 1977a) and lined Ponds 16-21 were constructed in 1979 (NMEID 1979). Discharge to lined Ponds 11-21 was authorized by DP-71 (NMEID 1984) and SUA-616 (NMEIA 1976a; NMEID 1980). The restricted area associated with lined Ponds 11-21 is shown on Figure 2-20 (QMC 1983).

Lined Ponds 11-21 were constructed on an area historically impacted by discharges from out-of-scope uranium recovery operations east and northeast of section 4 (Figure 2-25). Prior to construction of lined Ponds 11-21, this mixed discharge flowed from the unlined Vought Tank (Figure 2-20, Figure 2-25) and also from section 3, onto and across section 4. To prevent discharges from the Vought Tank entering lined Ponds 11-21, a ditch and berm (Figure 2-20, Figure 2-26) were constructed to the east and south of lined Ponds 11-21 at the time the ponds were built. The purpose of the ditch and berm was to divert existing surface water flow around lined Ponds 11-21 (KMC 1979).

Surface and subsurface soil in areas east or south of the diversion ditch and berm have been potentially impacted by in- and out of- scope discharges from uranium recovery facilities located northeast and east of lined Ponds 11-21. Figure 2-27 presents soil sample data collected by RAML in the drainages coming on to section 4. The ratio of radium-226 to uranium is variable, however, concentrations generally diminish with the gradient of surface water features, indicating that the source of this impact is likely topographically upgradient of section 4. Surface soil in areas west of the lined Ponds 11-21 and east of Highway 509 has most likely been impacted by ALW mill activities.

Conceptually, potential groundwater and subsurface soil impacts on section 4, if present, mostly derive from out-of-scope uranium recovery facilities to the northeast and east of section 4. Four tears in the ponds' liner have been documented (RAML 2019), however, the quantity of ALW mill process water discharged to section 4 as a result of tears is small compared to the quantity of water discharged from other uranium recovery facilities that passed over section 4 during the 15 years of uranium recovery operations that occurred prior to construction of lined Ponds 11-21. Because impacts within section 4 derive from multiple commingled sources, environmental sampling is unlikely to definitively identify the nature of impacts to groundwater or subsurface soil on section 4.

2.5.3 Section 2 Drainage

The Section 2 drainage and downgradient areas have potentially been affected by mill, mill-like, and mine processes from both in-scope and out-of-scope mines. EPA's characterization activities in the Section 2 drainage show variable ratios of radium-226 to uranium in the Section 2 drainage area.

Systematic data regarding surface and subsurface soil concentrations of radionuclides in the section 2 downgradient affected area are anticipated to be available by June 2022 as RAML completes analysis and reporting of data collected in 2021.

2.5.4 Figures and photos

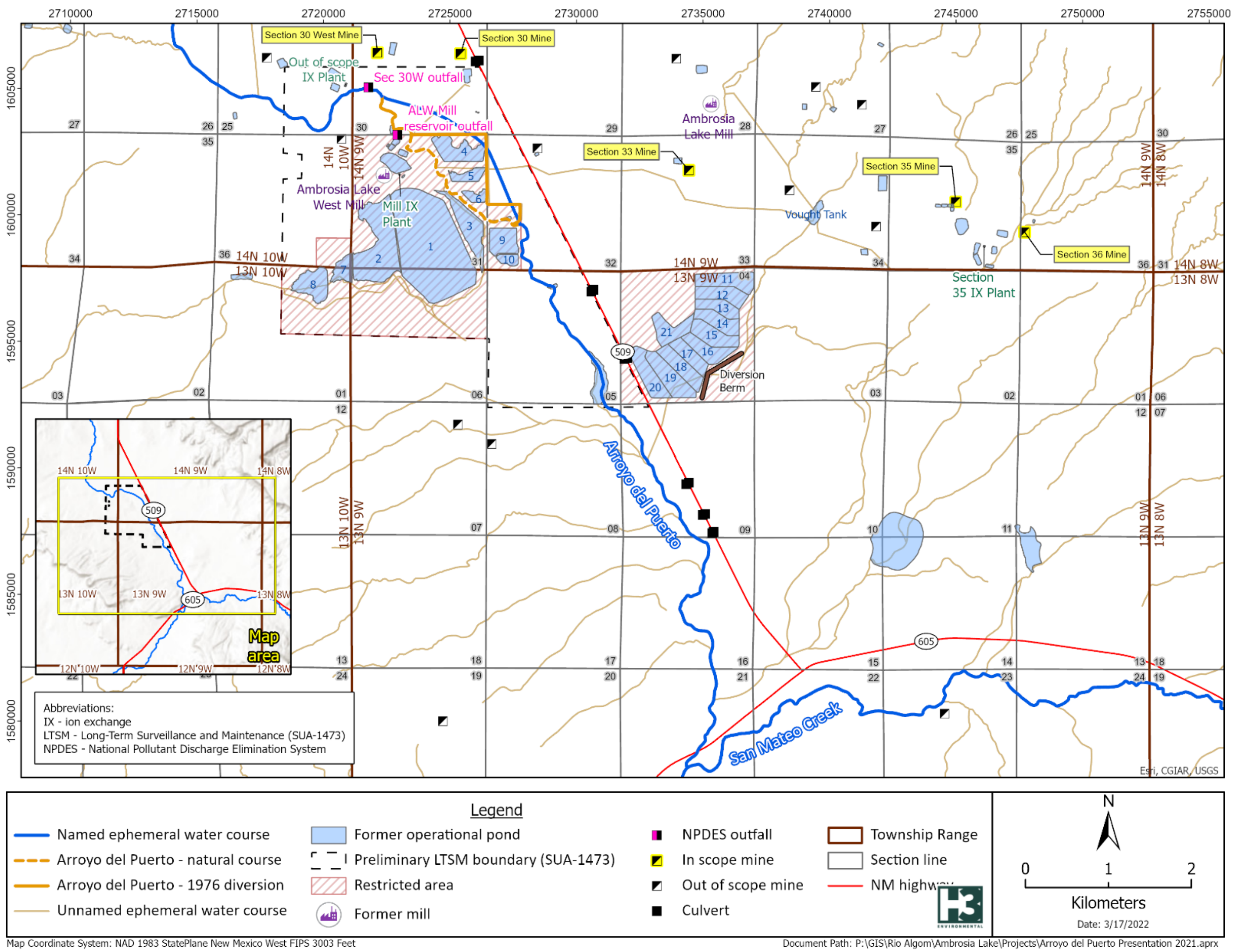

Figure 2-20 Ambrosia Lake Valley showing natural and re-routed channel of the Arroyo del Puerto.

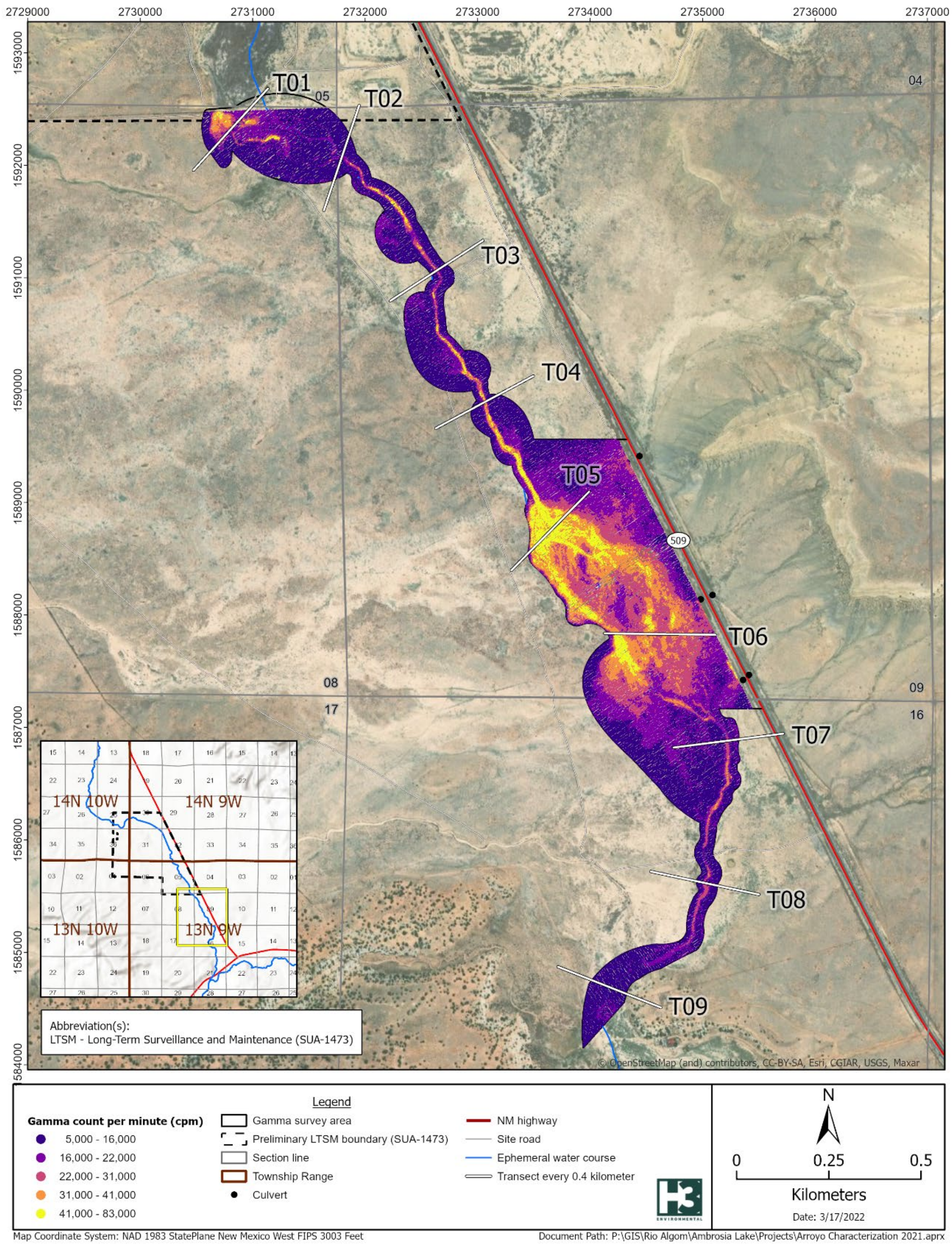

Figure 2-21 Gamma survey results in the Arroyo del Puerto south of the Ambrosia Lake West mill[6].

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[6] Data is in counts per minute (cpm) using a 5 by 5-centimeter sodium iodide detector. Sediment and water inputs to the south AdP are from the north (upgradient AdP), west (dry washes connected to upgradient out-of-scope uranium mines), and east (MDW ditches and other conveyances).

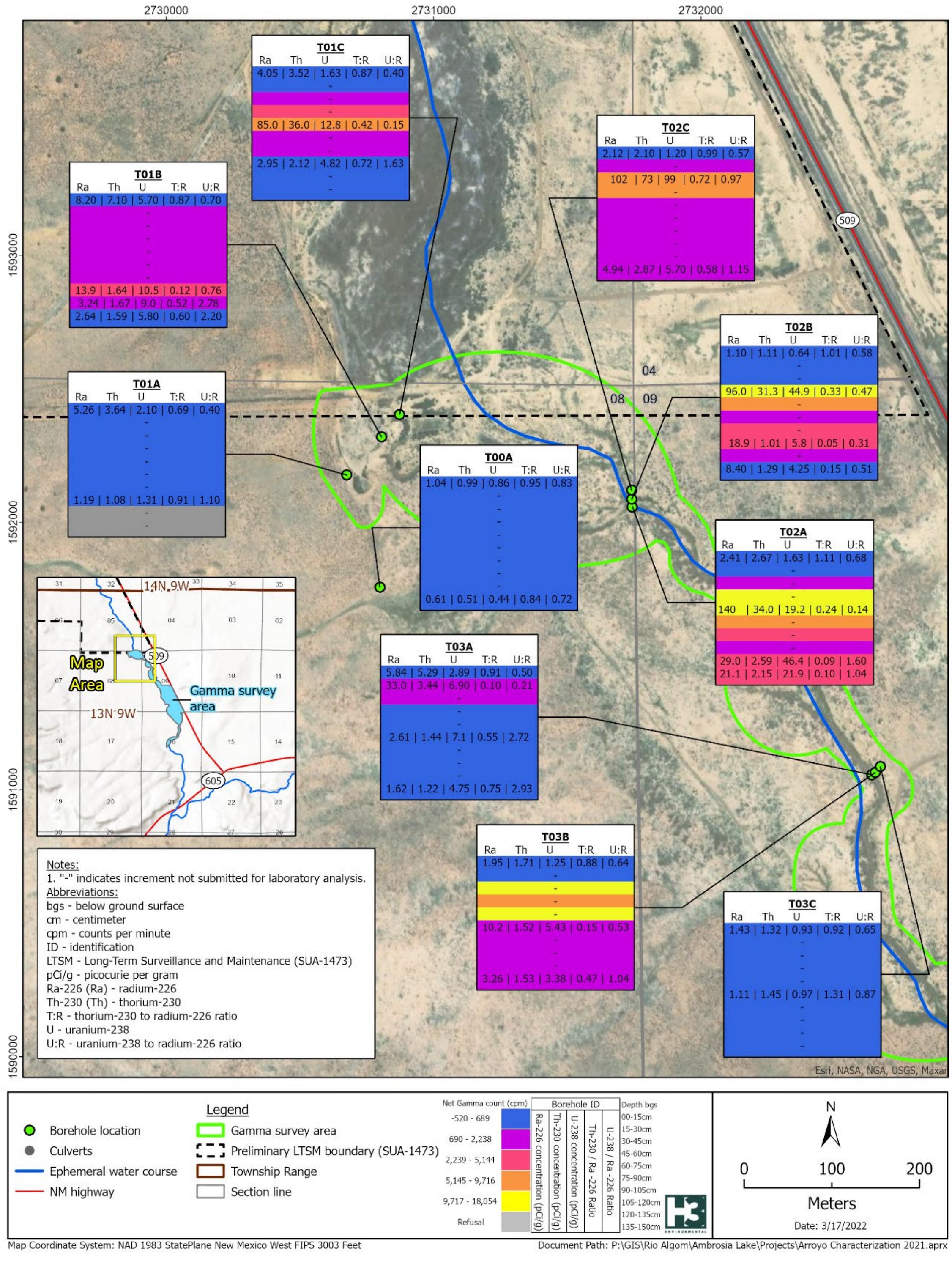

Figure 2-22 Sediment sample results from northern portion of the study area within the Arroyo del Puerto.[7]

[7] Sediment and water inputs to the south AdP are from the north (upgradient AdP), west (dry washes connected to upgradient out-of-scope uranium mines), and east (MDW ditches and other conveyances).

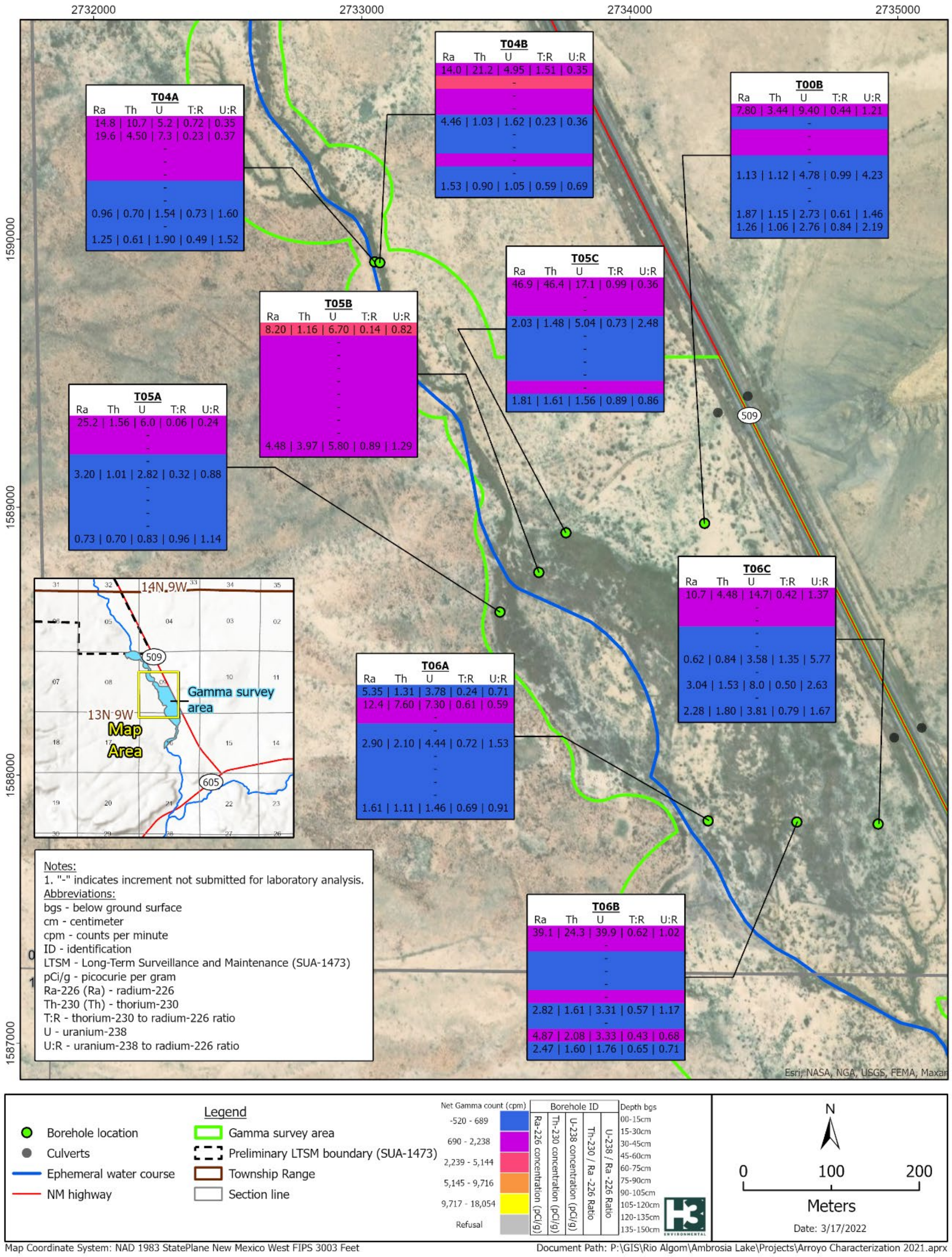

Figure 2-23 Sediment sample results from central portion of the study area within the Arroyo del Puerto[8].

[8] Sediment and water inputs to the south AdP are from the north (upgradient AdP), west (dry washes connected to upgradient out-of-scope uranium mines), and east (MDW ditches and other conveyances).

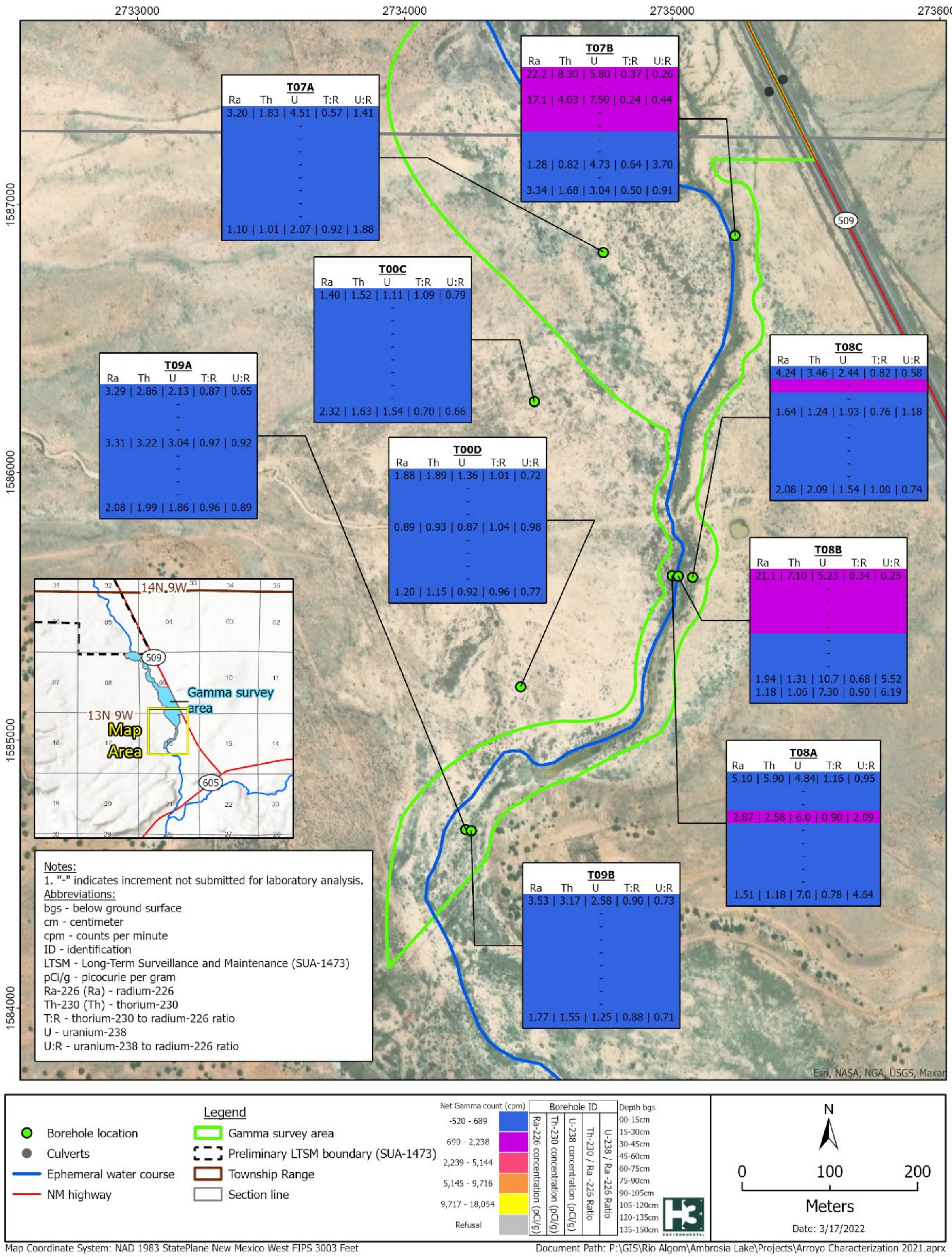

Figure 2-24 Sediment sample results from southern portion of the study area within the Arroyo del Puerto[9].

[9] Sediment and water inputs to the south AdP are from the north (upgradient AdP), west (dry washes connected to upgradient out-of-scope uranium mines), and east (MDW ditches and other conveyances).

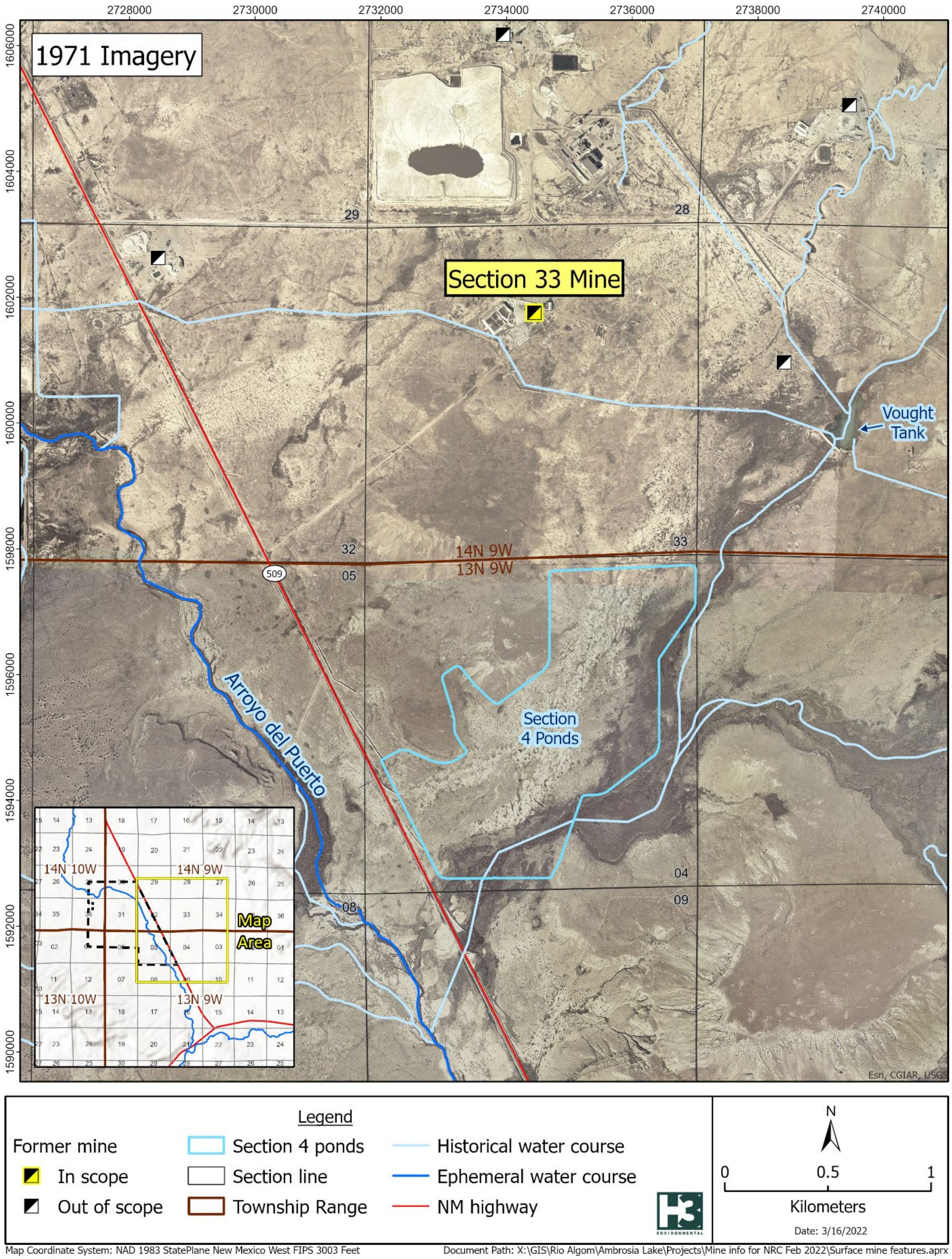

Figure 2-25 Section 4 area prior to construction of lined ponds 11-21.

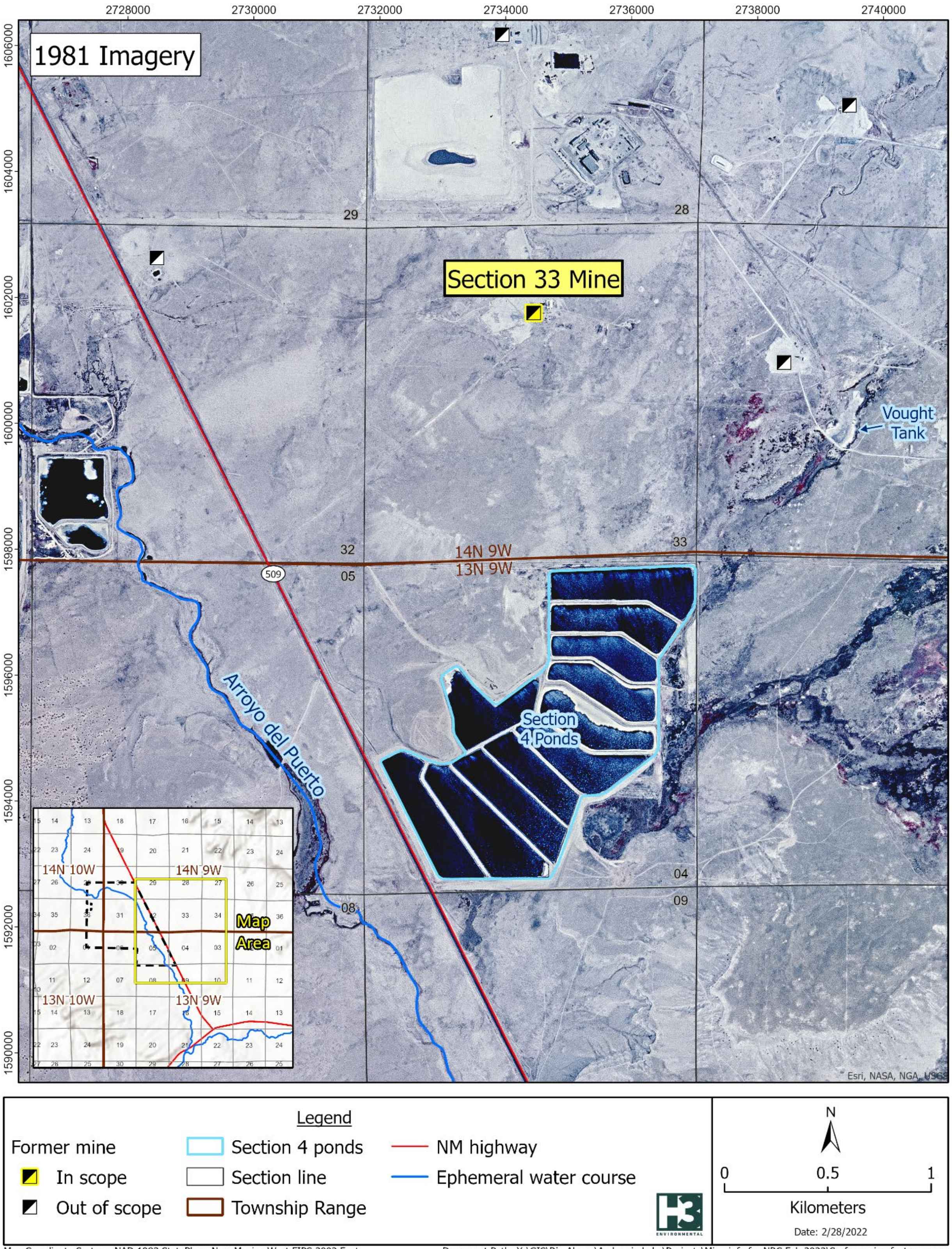

Figure 2-26 Section 4 area after construction of lined ponds 11-21 and diversion ditch and berm.

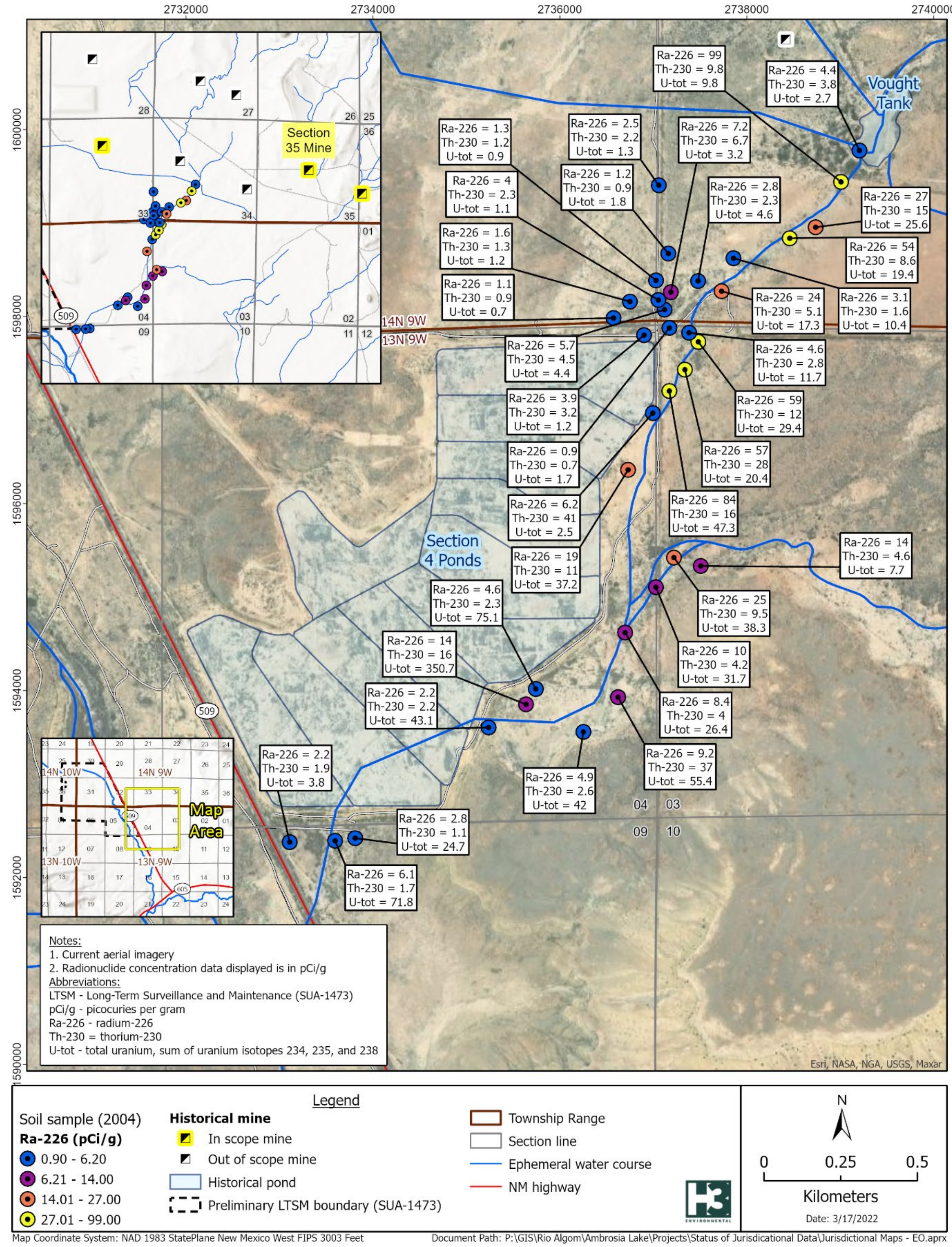

Figure 2-27 Results of soil sampling in drainages from northwest of section 4[10].

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[10] The Vought tank was cleaned by the DOE (DOE 1990).

3 Discussion and Future Work

A summary of historical mill and mill-like processes, as currently understood, at in-scope mines in the ALV is provided in Table 3-1. RAML looks forward to discussing next steps after NRC's review of this document.

Table 3-1 Summary of potential environmental impacts deriving from mill or mill-like processes at in-scope mines in the ALV.

Location	Media	Mill or Mill-like Process	Operational Years	Permitting Status	Report Section	Commingled Impacts?	Notes
Section 17 mine	Surface soil Subsurface soil	Heap leaching	1965-1972	No known permitting documentation	2.4	Yes	Magnitude of impact derived from mill or mill-like process is likely insignificant compared to and indistinguishable from surrounding uranium mine impact.
	Groundwater	Stope leaching with chemicals [1]	1982	SUA-616, SUA-1473, DP-362 [1]	2.2	Yes	Stope leaching with chemicals was tested at the section 17 mine; no record exists of production-scale recovery. The magnitude of the impact from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.
Section 22 mine	Surface soil Subsurface soil	Sandfilling	1958-1975	No known permitting documentation	2.3	Yes	Magnitude of impact derived from mill or mill-like process is likely insignificant compared to the surrounding uranium mine impact and *may be* distinguishable from surrounding uranium mine impact at discrete locations.
	Groundwater	Stope leaching with chemicals	1979, 1983, 1986	SUA-616, SUA-1473, DP-362	2.2	Yes	Stope leaching with chemicals may have been tested at the Section 22 mine prior to the years in this table. Production-scale recovery from stope leaching with chemicals occurred only in 1986. The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.
		Sandfill	1958-1975	No known permitting documentation	2.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely indistinguishable from the surrounding uranium mine impact.
Section 24 mine	Surface soil Subsurface soil	Heap leach	1966-1972	No known permitting documentation	2.4	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.
	Groundwater	Stope leaching with chemicals	1986, 1989-1991	SUA-616, SUA-1473, DP-362	2.2	Yes	Stope leaching with chemicals may have been tested at the Section 24 mine prior to the years listed in this table, which are years where production-scale recovery occurred via this process. The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.
Section 30 & 30W mines	Surface soil Subsurface soil	Heap leach	1968-1972	No known permitting documentation	2.4	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.
		Sandfill	1958-1985	No known permitting documentation	2.3	Yes	The magnitude of the impact derived from mill or mill-like process is likely similar to the surrounding uranium mine impact and *may be* distinguishable from the surrounding uranium mine impact at discrete locations.
	Groundwater	Sandfill	1958-1985	No known permitting documentation	2.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely indistinguishable from the surrounding uranium mine impact.
		Stope leaching with chemicals [1]	NA – did not occur	SUA-616, SUA-1473, DP-362 [1]	2.2	NA – did not occur	NA – did not occur
Section 33 mine	Surface soil Subsurface soil	Heap leach	1968-1972	None	2.4	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.
	Groundwater	Stope leaching with chemicals [1]	1981,1982	SUA-616, SUA-1473, DP-362	2.2	Yes	Stope leaching with chemicals was tested at the section 33 mine; no known record exists of production-scale recovery. The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact.

Location	Media	Mill or Mill-like Process	Operational Years	Permitting Status	Report Section	Commingled Impacts?	Notes
Section 35 mine	Surface soil Subsurface soil	Sandfill	1975-1985	DP-264	2.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to the pre-existing or third-party uranium mine impact and *may be* distinguishable from the pre-existing or third party uranium mine impact at certain locations.
	Groundwater	Sandfill	1975-1985	DP-264	2.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to the surrounding uranium mine impact, which includes pre-existing or third-party impacts, and indistinguishable from the surrounding uranium mine impact.
		Stope leaching with chemicals [1]	NA – did not occur	SUA-616, SUA-1473, DP-362 [1]	2.2	NA – did not occur	NA – did not occur
Section 35 IX	Surface	Ion exchange effluent	1976-1990	SUA-616, SUA-1473, DP-67	2.1	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to the pre-existing or third-party uranium mine impact and *may be* distinguishable from the pre-existing or third party uranium mine impact at certain locations. Historical permitting actions have treated the section 35 IX facility as both a licensed and non-licensed process.
	Groundwater	Ion exchange effluent	1976-1990	SUA-616, SUA-1473, DP-67	2.1	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to the surrounding uranium mine impact, which includes pre-existing or third-party impacts, and indistinguishable from that impact.
Section 36	Surface	Sandfill	1975-1984	DP-264	2.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to the pre-existing or third-party uranium mine impact and *may be* distinguishable from the pre-existing or third party uranium mine impact at certain locations.
	Groundwater	Sandfill	1975-1984	DP-264	2.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to the surrounding uranium mine impact, which includes pre-existing or third-party impacts, and indistinguishable from that impact.
Section 4	Surface soil Subsurface Soil (Northwest of berm & ditch)	Liquid effluent – ALW mill	1976-2004	SUA-616, SUA-1473, DP-71	2.5.2	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to the pre-existing or third-party uranium recovery (i.e., mining or milling) impact on section 4 and may be distinguishable from that impact. Note: because 3,500,000 cubic yards of soil have been excavated from the former lined section 4 ponds footprint as part of prior ALW mill reclamation activities, it may be very difficult to distinguish mine from mill or mill-like at this location.
		Water from section 3	1976-1985	SUA-616, SUA-1473, DP-67	2.5.2	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to the pre-existing or third-party uranium recovery (i.e., mining or milling) impact on section 4 and may be distinguishable from that impact. Note: because 3,500,000 cubic yards of soil have been excavated from the former lined section 4 ponds footprint as part of prior ALW mill reclamation activities, it may be very difficult to distinguish mine from mill or mill-like at this location.
	Surface soil Subsurface Soil (Southeast of berm & ditch)	Water from section 3	1976-1985	SUA-616, SUA-1473, DP-67	2.5.2	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to the pre-existing or third-party uranium recovery (i.e., mining or milling) impact on section 4 and may be distinguishable from that impact. Note: All 14 of RAML's alluvial wells associated with section 4 (DP-71) are effectively dry as of 2022 (Arcadis 2022) .
	Groundwater	Liquid effluent – ALW mill	1976-2004	SUA-616, SUA-1473, DP-71	2.5.2	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to the pre-existing or third-party uranium recovery (i.e., mining or milling) impact on section 4 and may be distinguishable from that impact. Note: All 14 of RAML's alluvial wells associated with section 4 (DP-71) are effectively dry as of 2022 (Arcadis 2022).

Location	Media	Mill or Mill-like Process	Operational Years	Permitting Status	Report Section	Commingled Impacts?	Notes
		Water from section 3	1976-1985	SUA-616, SUA-1473, DP-67	2.5.2	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to the pre-existing or third-party uranium recovery (i.e., mining or milling) impact on section 4 and may be distinguishable from that impact. Note: All 14 of RAML's alluvial wells associated with section 4 (DP-71) are effectively dry as of 2022 (Arcadis 2022).
Section 2 Downgradient Area	Surface soil Subsurface soil	Ion exchange effluent	1976-1990	SUA-616, SUA-1473, DP-67	2.5.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to or greater than the pre-existing or third-party uranium mine impact, which includes pre-existing or third-party impacts, and potentially distinguishable from that impact.
		Sandfill	1975-1976	DP-264	2.5.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely similar to or greater than the pre-existing or third-party uranium mine impact, which includes pre-existing or third-party impacts, and potentially distinguishable from that impact.
	Groundwater	Sandfill	1975-1976	DP-264	2.5.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium mine impact, which includes pre-existing or third-party impacts.
		Ion exchange effluent	1976-1990	SUA-616, SUA-1473, DP-67	2.5.3	Yes	The magnitude of the impact derived from this mill or mill-like process is likely significant compared to and indistinguishable from the surrounding uranium mine impact, which includes pre-existing or third-party impacts.
Arroyo del Puerto	Surface soil/sediment Subsurface soil/sediment Groundwater	Water from section 3	1976-1978	SUA-616, SUA-1473, DP-67	2.5.1	Yes	The magnitude of the impact derived from this mill or mill-like process is likely insignificant compared to and indistinguishable from the surrounding uranium recovery impact, which includes pre-existing or third-party impacts.
		Water from the ALW mill	1958-2006	SUA-616, SUA-1473, DP-169	2.5.1	Yes	The magnitude of the impact derived from this mill process is likely significant compared to and indistinguishable from the surrounding uranium recovery impact, which includes pre-existing or third-party impacts.

[1] In 1985, DP-362 permitted stope leaching with chemicals at this mine, however stope leaching with chemicals under DP-362 did not occur at this mine.
[2] This mine was permitted for stope leaching with chemicals under DP-362, however stop leaching with chemicals only occurred prior to the issuance of DP-362.
ALW – Ambrosia Lake West
DP – discharge plan
RAML – Rio Algom Mining LLC

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