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Alaskan North Slope Legacy Wells: Case Study

Authors: Jessica Starsman, Alaska Department of Environmental Conservation 610 University Avenue Fairbanks, AK 99709; Ashley Adamczak, Alaska Department of Environmental Conservation 610 University Avenue Fairbanks, AK 99709; Tom DeRuyter Alaska Department of Environmental Conservation 610 University Avenue Fairbanks, AK 99709

ABSTRACT 300624:

Various State of Alaska agencies, including the Alaska Department of Environmental Conservation (ADEC), are currently investigating 136 legacy wells within the National Petroleum Reserve-Alaska (NPR-A) and surrounding lands. These legacy wells were drilled between 1944 and 1981 by federal agencies, including the United States Navy and United States Geological Survey, to explore oil reserve potential and to develop drilling techniques for Alaska's arctic.

In 2004, 2010 and 2013 the Bureau of Land Management released preliminary studies describing potential environmental risks at each site. Many wells include historic reserve pits, flare pits, crude and diesel oil releases, and discarded solid waste. Tundra damage and potential residual contamination are of great concern. Due to their remote locations, information on the current status of waste is limited. Regulatory agencies are developing a cleanup plan that is appropriate for their remote, Arctic environment.

INTRODUCTION:

In 1944, the first legacy well was drilled in the National Petroleum Reserve - Alaska (NPR-A) by the United States Navy (USN), and by 1982 there were 136 legacy wells. These wells have numerous issues with the potential to impact human health, and they have already affected the environment. Solid waste and contamination are present at the wells, and improperly plugged and abandoned wells, piles of drilling mud, and wells leaking natural gas and other hydrocarbons remain. The Bureau of Land Management (BLM) manages these lands and has had an impact on the cleanup of the NPR-A. Early management practices by BLM was that they were not "legally obligated to take any action with regard to these wells" and that there were "no laws or regulations requiring BLM to plug and abandon wells located on federal land" (Rundell, 2002). By this view BLM had no need to clean up legacy well sites or regulatory standards to meet when it came to plugging and abandoning wells. However, over time, this practice has evolved into a collaborative approach to remediate the NPR-A legacy wells with input from Alaska State agencies.

This paper will describe past NPR-A drilling events, the extent of remaining problems (tundra damage, solid waste debris, contamination, introduced non-native species, improperly

plugged wells, and well cellars) as well as the lack of information associated with them, what has been done to cleanup the NPR-A, and current legislation. Information has been gathered through field assessments, historical well logs and interagency coordination.

DRILLING IN THE NPR-A:

The first reports of natural oil seeps on Alaska's North Slope came from an exploration expedition led through Hudson Bay Co. in 1839, they noted that the indigenous residents burned tundra soaked with oil from the natural seeps for heat (Bradner, 2008). However, written documentation of the seeps was made when Alfred Brooks and Ernest Leffingwell explored and mapped northern Alaska in the early 1900's for the United States Geological Survey (USGS) (Banet, 1991). Twenty years passed before American industry and government took greater interest in Alaska's North Slope. In 1923, President Warren G. Harding established the Naval Petroleum Reserve #4, commonly referred to as PET 4, by an executive order. This area totaled 22.8 million acres (Figure 1 and Figure 2) and would provide emergency oil supplies for the United States Navy (USN) (Banet, 1991; US BLM, 2013). The USN began drilling in 1944 to estimate the petroleum reserves. This operation was charged to USN Construction Battalion 1058 (CB 1058) (Collins, 1958; Collins, 1961).

CB 1058 arrived at Point Barrow, Alaska where they established camp and began drilling. The first wells were drilled near Barrow so crews could familiarize themselves with their equipment under arctic conditions (Collins, 1961). Once completed, crews were sent to Cape Simpson and Umiat where they drilled from 1944 to 1945 (Collins, 1958; Robinson, 1964). Starting in 1946, the USN developed a scope of work and hired Arctic Contractors, who drilled the remaining wells through 1953. In total, 91 wells were drilled between 1944 and 1953 (Collins, 1958; US BLM, 2013), and the Umiat, Fish Creek, and Simpson areas contained recoverable quantities of oil. In addition, six gas fields were discovered near Barrow, Gubik, Titaluk, Wolf Creek, Square Lake, and Meade (Schindler, 1983).

Drilling would not resume within the PET 4 until 1974, after Alaska became a state in 1959. Prudhoe Bay No. 1 was drilled in 1968 by Arco Alaska Inc. (Banet, 1991), and was estimated to contain 10 billion barrels of recoverable oil (Schindler, 1983). With this discovery the USN gained renewed interest in PET 4 and began to plan for additional drilling operations in Alaska's Arctic (Schindler, 1983). When the Organization of Petroleum Exporting Countries (OPEC)'s oil embargo of 1973 occurred, it became clear to the United States Government that exploration of PET 4 needed to happen sooner than anticipated (Schindler, 1983). By 1974, the USN was collecting seismic data and resumed drilling in the Arctic.

The USN continued drilling operations and cleanup until Public Law 94-258, also known as the National Petroleum Reserve Production Act of 1976, was passed (Schindler, 1983). The law transferred almost all of PET 4 to the Secretary of the Interior and re-designated it as the National Petroleum Reserve in Alaska (NPR-A). Paragraph 105B in PL-94-58 requires the Secretary of the Interior to "conduct a study, in consultation with representatives of the State of Alaska, to determine the best overall procedures to be used in the development, production, transportation, and distribution of petroleum resources in the reserve" (PL 94-258, 1976).

Paragraph 105C tasked the Secretary to "determine the values of, and best uses for, the lands contained in the reserve" (PL 94-258, 1976). To help meet the mandates in PL 94-258, the Secretary delegated the Bureau of Land Management (BLM) to manage surface soil and water in NPR-A and to protect its value. Additionally, the USGS was charged with managing the exploration program, enforcing related stipulations and continuing operations in the Barrow gas field (PL 94-258, 1976). Until 1982 information regarding the NPR-A was gathered; exploratory wells were drilled; and cleanup and revegetation of select abandoned wells occurred (Schindler, 1983).

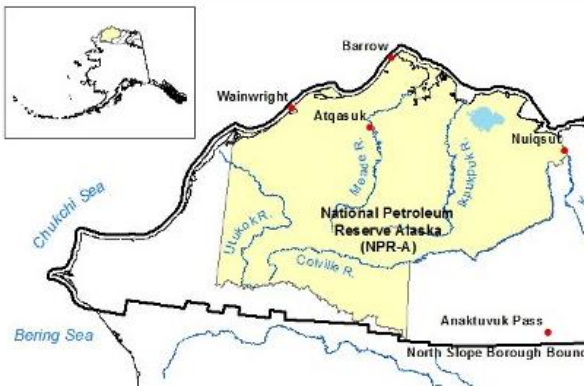

Figure 1. Map illustrating the boundaries of the NPR-A (ADCCEC, 2013)

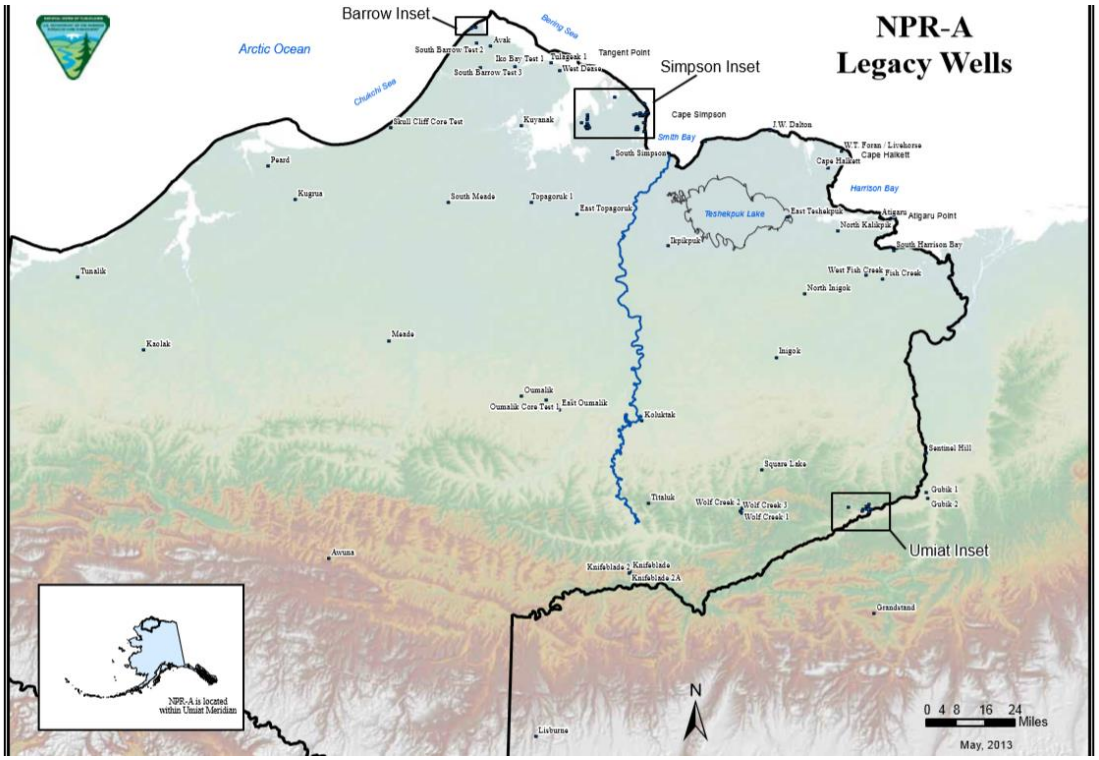

Figure 2: Map of legacy well locations (US BLM, 2013).

LEGACY WELL PROBLEMS:

A list of current problems, which are often interrelated, follows.

Tundra damage: Between 1944 and 1953 it was common practice to transport equipment via D-8 caterpillar tractor trains during winter and summer months. During summer months, it was difficult to maintain traction on the tundra and lead tractors often furrowed into the permafrost to enhance traction during transportation as well as at drill sites (Robinson, 1958). Permafrost was typically impacted between 12 and 18 inches below ground surface (Robinson, 1958), causing significant tundra scarring throughout NPR-A (Figure 3).

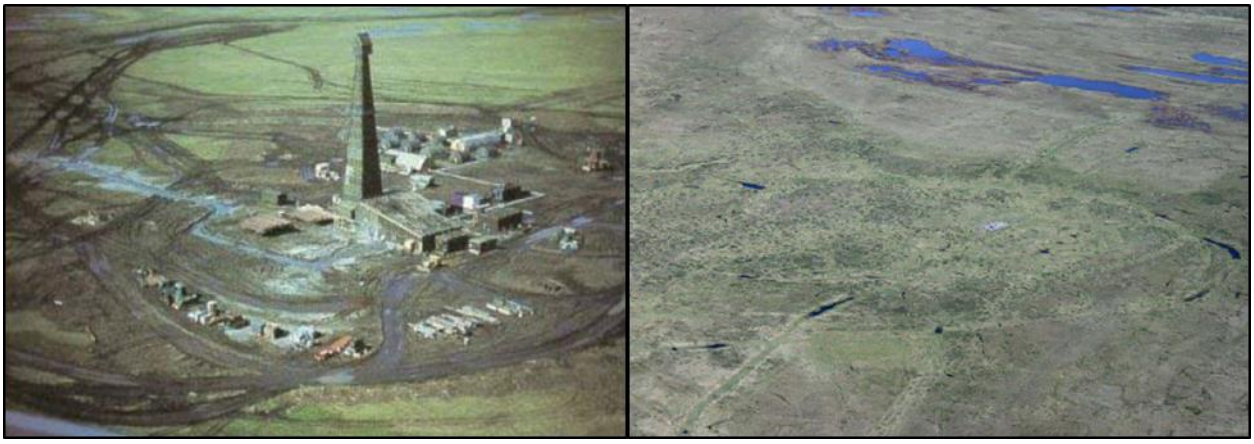

Figure 3: The image on the left shows drilling operations at Fish Creek #1 in the summer of 1947. The image on the right illustrates tundra scarification post drilling operations at Fish Creek #1 as photographed in July 2012 (US BLM, 2013).

Solid waste: Copious drilling material was left on NPR-A's tundra after drilling activities ended. Solid waste includes pilings, drilling equipment and buildings, drums, batteries, refrigerant tubing, Styrofoam from insulated pads and additional miscellaneous waste (Figure 4a) (US BLM, 2013). In addition, solid waste that was previously buried has been exposed over time, and waste exists within natural oil seeps (Brumbaugh and Porhola, 2004; US BLM, 2013). Simpson Core Test #26 exists in the middle of an active oil seep, during plugging operations that occurred in 2006 solid waste was removed however, not all could be retrieved (Figure 5) (US BLM, 2013).

Figure 4a) Awuna #1 Figure 4b) Skull Cliff Core Test #1

Figure 4a: Photograph from June 2011 was taken at Awuna #1. Styrofoam at this well site has spread more than 5 miles from the well (US BLM, 2013).
Figure 4b: Drums are a common solid waste problem at legacy well sites as shown in the photo. Skull Cliff Core Test #1 has numerous drums scattered across the tundra (US BLM, 2013)

Figure 5: Photo of Simpson Core Test #26 with solid waste present in the surrounding active seep (US BLM, 2013)

Drilling mud has historically been considered to be solid waste when properly disposed or located in regulated reserve pits by ADEC Solid Waste Program. Between 1944 and 1953 it was common to place drilling mud directly onto the tundra and piles of mud remain scattered across NPR-A (Robinson, 1964). After 1953, reserve pits were dug to deposit drilling mud (Schindler, 1983). However, piles of drilling mud remain on the tundra or gravel pads. There are 11 well sites with drilling mud on the tundra, and six well sites have drilling muds on pads (US BLM, 2013). At many of the drilling locations drilling muds are present on the tundra, as reported by BLM in their Legacy Well Summary Report. BLM has documented visibly stressed vegetation, as seen in Figure 6b, and at West Dease #1 arctic fox have been using drilling mud to make dens (Figure 6a).

Figure 6a) West Dease #1 Figure 6b) Umiat Well #11

Figure 6a: At West Dease #1, the image on the left, an arctic fox has made a den in drilling mud (July 2012) (US BLM, 2013).
Figure 6b: Black residue and rusty nails found in drilling mud at Umiat #11 (US BLM, 2013).

Contamination: Drilling mud typically contained components such as Aquagel, baroid, salt, Quebracho, tetrasodium pyrophosphate, seawater, crude oil, diesel fuel, lime and other additives (Collins, 1958; Collins, 1961; Robinson, 1964). Aroclor, a polychlorinated bisphenol (PCB), was identified in drilling mud at Umiat Well #9 (Collins, 1958; Waisner, 2011). Aroclor was used as a chemical tracer to determine if drilling fluid penetrated into core samples (Collins, 1958). Once work was completed and Umiat Well #9 was abandoned, crews leveled the area around the well head and replaced the soil with PCB contaminated drilling mud (Waisner, 2011). PCB contamination has been found at Umiat Wells #2 and #5 during recent US Army Corp of Engineer (USACE) plug and abandon activities, the source was found to be fluids that were used in Umiat Test Well #5 (Brumbaugh and Porohla, 2004). Drilling reports kept by Arctic Contractors between 1944 and 1953 only mentioned the use of PCBs at Umiat Test Well #9 and not at any other well sites (Collins, 1958). PCBs were also detected from an old tank at Umiat Well #8, but additional testing was not performed to determine if PCBs had been used within the well (Brumbaugh and Porohla, 2004).

Petroleum products are known to remain at legacy wells, such as Iko Bay #1 which BLM has the confirmed presence of diesel range products (AOGCC, 2013; US BLM, 2013). Wells where refrigerant tubing is on site still contain diesel fuel as reported by BLM. The diesel was cooled and circulated through tubing to prevent permafrost thawing. The aboveground portion of the refrigerant tubing has been removed but underground portions remain. Stressed tundra around the opening of these tubes has also been noted by BLM. At Fish Creek Well #1 a petroleum sheen is visible in the well cellar (Figure 7). Abundant petroleum products supported NPR-A drilling operations, but spills were not actively reported until the 1970's based on ADEC spill records. (US BLM, 2013)

Figure 7: Visible sheening from within the Fish Creek #1 well cellar (US BLM, 2013)

Due to a lack of records it is possible unknown contamination existing within the NPR-A. As an example, during cleanup operations at Inigok Test Well #1 reserve pit in 1979, dead vegetation was discovered outside the berm after increased spring runoff. Samples were subsequently collected, contaminants of concern were not listed but material was stated as having a high oxygen demand characteristic and to be only mildly toxic with a pH of 9. Additional testing in 1981 showed the pH drastically decreased to 3.3 and organic strength was noted to have decreased as well. To neutralize the material in the reserve pit, 5**,**000 lbs of solid Sodium Hydroxide (NaOH) was added through the ice. By 1982 the pH was in a range of 7.4–7.6; alkalinity was 120 mg/L, and conductivity was 7,600 μΩ/cm. This site has not been sampled since 1982, and the cause of the drastic pH readings remains unknown. (Schindler, 1983)

Introduction of non-native species: Cleanup and remediation began within the NPR-A after the National Environmental Protection Act (NEPA) was enacted in 1969. As a result it became common practice to revegetate wells upon completion of drilling operations to allow areas to blend with their environment (Schindler, 1983). However, during the 1980's, revegetation was performed with non-native species. This practice introduced the common dandelion (*Taraxacum officinale)* to Alaska's North Slope; *T. officinale* has been found at North Kalikpik #1 and Ikpikpuk #1 (US BLM, 2013).

Improper plugging and abandoning: Multiple methods have been used to plug and abandon wells within the NPR-A. Wells that were uncased did not require plugging and have collapsed blending into the background environment (Brumbaugh and Porohla, 2004; US BLM, 2013). Examples of improper P&A can be seen at Knifeblade #1, where the casing has been left open to the environment and at Skull Cliff Core Test #1, which was filled with 16 barrels of diesel and capped with a wooden plug (Collins, 1961). Improperly plugging wells frequently release hydrocarbons (AOGCC, 2013; US BLM, 2013).

In 1996, BLM identified natural gas leaking from Umiat Test #8 (Brumbaugh and Porohla, 2004). In 1999 the leak was reported to ADEC's Prevention and Emergency Response

Program (ADEC, 1999). It was stated that gas was leaking from different areas of the wellhead and had the capability to release crude oil, (DeRuyter, 1999; DeRuyter, 2000). ADEC PERP hired a term contractor, Fairweather Inc., to perform a site investigation and develop necessary plans to stop the release (DeRuyter, 2000). Leaking gas was determined to be the result of a loose fitting. The contractor tightened the fitting; however, a small leak from the top of the well head continued (Christenson, 1999; DeRuyter, 2000). By 2000, BLM repaired the remaining valve that was leaking gas, and in 2004 properly plugged and abandoned the well (Brumbaugh and Porohla, 2004). In 2001, Cape Simpson Core Test #31 was found to be releasing crude oil into a natural crude oil seep, which limited the need for cleanup activities (US EPA, 2001). The release was controlled and eventually the well was properly plugged and abandoned April 20, 2006 (US BLM, 2013). Another well that was recently plugged and abandoned was J.W. Dalton #1, which was under the threat of coastal erosion (Brumbaugh and Porohla, 2004; US BLM, 2013). Although proper Alaska Oil and Gas Conservation Commission (AOGCC) procedures were followed, the well is currently leaking hydrocarbon gas (AOGCC, 2013; US BLM 2013). Additional wells currently leaking hydrocarbon gas include Iko Bay #1 and Gubik #2 (AOGCC, 2013).

Reserve, flare and fuel pits: Reserve pits within NPR-A were closed and no longer accept drilling waste in accordance with an ADEC Solid Waste guidance document produced in 1995 (US BLM, 2013). Flare pits and fuel pits are located next to reserve pits and only separated by earthen berms. However, the berms separating the flare and fuel pits are degrading, and melt water can now freely flow between the pits as seen in Figure 8 (US BLM, 2013). Many of the pits have yet to be investigated for remaining contamination.

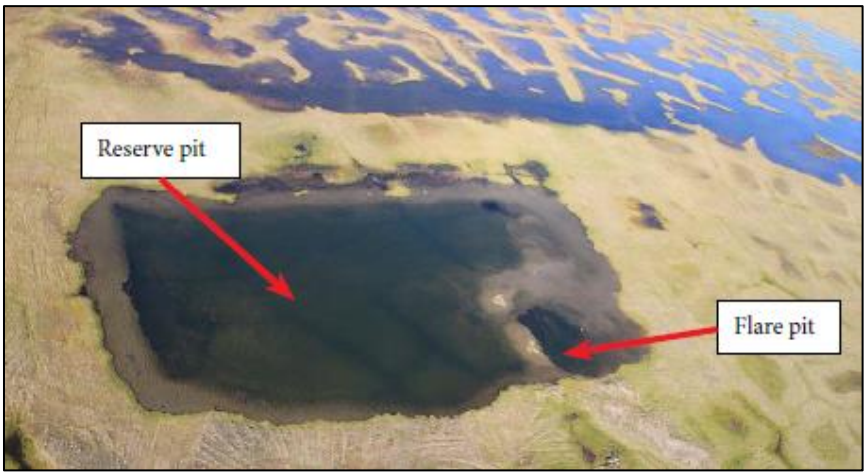

Figure 8: An aerial photo of South Simpson #1, showing the collapsed berm between the flare and reserve pits (US BLM, 2013).

Well cellars: Multiple well cellars are scattered throughout NPR-A, and all pose entrapment threats to both humans and animals (AOGCC, 2013). Some, such as the Fish Creek #1 (Figure 7), are contaminated while others contain solid waste and debris.

Summary: The 136 legacy wells have existed in NPR-A without significant management for many years. There is also a lack of analytical data, which could allow contamination such as PCBs, hydrocarbons and other potential contaminants to remain. Many of these sites are hazardous to the environment and human inhabitants, who rely heavily on the land. As time passes, many of these sites may be threatened by coastal erosion, creating the threat of a catastrophic petroleum release.

BLM CLEANUP AND PLUG AND ABONDONMENT REVIEW:

BLM has addressed NPR-A cleanup since the passing of NEPA and these activities were documented by Schindler (1983). Originally, BLM attempted to remove solid waste from the NPR-A. During the winter of 1976, a total of 2,280 drums and 2,000 lbs of solid waste were recovered from Skull Cliff #1. This was an expensive process and with the consent of ADECs Solid Waste Program, practices changed to burying debris onsite. Burying debris required a 2 ft. thick soil cap be installed as a cover. Additional cleanup continued through 1982 and included cutting pilings off at the surface, removing drilling pads, and filling reserve pits.

From 1988 through 1995 remediation was prioritized to an area containing 28 wells that were drilled between 1975 and 1980 (Brumbaugh and Porohla, 2004). ADEC's Solid Waste Program closed 27 of the 28 reserve pits associated with these wells through a 1995 Guidance Document. The only reserve pit not closed was East Teshekpuk #1 because solid waste was buried under the drill pad (Brumbaugh and Porohla, 2004). However, it was eventually closed in 2008 after solid waste and diesel contaminated soil were excavated (US BLM, 2013). If needed, the ADEC Solid Waste Program can require additional cleanup of the reserve pits.

When Umiat Test Well #8 was reported to be leaking natural gas to ADEC in 1999, the leak highlighted the need to properly plug and abandon wells. BLM determined that it was necessary to investigate all of the wells in NPR-A, and began mapping their locations (Brumbaugh and Porohla, 2004). Uncased core test wells proved to be difficult to find because they most likely collapsed, and original GPS coordinates were inaccurate. Three wells (Umiat Test Well #2, #5, and #9) were identified during BLMs investigation as needing to be immediately addressed due to erosion and contamination (Brumbaugh and Porohla, 2004; US BLM 2013). Funding for the cleanup and plugging and abandonment came from the USACE through Formerly Used Defense Sites (FUDS) (Brumbaugh and Porohla, 2004; Waisner, 2011). Additional wells that were plugged and abandoned are listed in Table 1 (Brumbaugh and Porohla, 2004).

Table 1: BLM P&A Operations

Year	Legacy Wells
2004	Square Lake #1, Umiat Test Well #3, #4, #10
2005	J.W. Dalton #1
2006	Simpson Core Tests #26, #27, #30, #30A, #31
2008	East Teshekpuk #1
2009	Atigaru #1
2010	Drew Point #1
2012	Umiat #6, #7

In the beginning of 2013, BLM developed a follow-up summary review of the NPR-A legacy wells and utilized a risk assessment to determine surface and subsurface risks. Risk criteria included protection of human health and safety, resource protection, solid waste characterization, and compliance with current federal regulations (US BLM, 2013). In addition to the summary report, a strategic plan was developed. Based on the risk assessment, it determined that 68 wells did not require additional action, 50 wells required further remediation, and 18 wells were currently being used by USGS for temperature data collection. After publication of these reports, the State of Alaska reviewed the documents and provided feedback to BLM:

- AOGCC commented that BLM will need to comply with Alaska State regulation for plugging and abandoning legacy wells as well as the Bureau of Safety and Environmental Enforcement's plug and abandon laws (AOGCC, 2013)
- BLM stated that surface remediation wouldn't be necessary if a historic site determination was made from State Historic Preservation Office (SHPO). SHPO testified to AOGCC that they "cannot and [do] not stop surface remediation" and so surface remediation would be required for all legacy wells (AOGCC, 2013).
- AOGCC determined that based on the available documentation, 38 wells did not require additional cleanup actions and 80 wells did. Additional cleanup is required at wells that were previously cleaned, and specific wells need to be re-plugged because they were not plugged properly the first time (AOGCC, 2013).
- Surface risk assessments performed by BLM did not take well cellars into consideration, these can pose a hazard to both humans and wildlife (AOGCC, 2013).
- Subsurface risk assessments did not consider cross flows and how this could influence the transfer of waste through these formations (AOGCC, 2013).
- Highest priorities should be given to wells with ongoing hydrocarbon releases and ongoing environmental damage (AOGCC, 2013).
- ADEC's Contaminated Sites Program (CSP) asked BLM to include a contingency for assessment of "known, likely, or unknown possible contaminant releases" at legacy well sites (Vreeman, 2013)
- ADEC's CSP determined from the provided information in the legacy well summary report that 15 well sites appear to have contamination and should be reviewed and added to the contaminated sites list (currently BLM has 13 legacy well sites on this list) (Vreeman, 2013)
- ADEC's CSP asked BLM to follow CERCLA regulations and guidelines (Vreeman, 2013)

RECENT LEGISLATION:

Properly plugging and abandoning legacy wells in NPR-A has been a monumental task, costing roughly $86 million since 2002. In 2012, BLM Director Bob Abbey spoke with Alaska Senator Lisa Murkowski and said it was an "unfunded mandate," and that BLM typically received $1 million per year for NPR-A cleanup (*National Petroleum Reserve: Hearing before the Committee on Energy and Natural Resources*, 2012). BLM only sought emergency funding if wells were determined to present immediate dangers (Kleeshulte, 2013). In 2006 Senator Ted Stevens successfully appropriated $52 million that would allow BLM to properly manage well

plugging activities (Kleeshulte, 2013). Senator Murkowski secured additional emergency funding through Interior and Environment Appropriations Bills in 2011 and 2012. On January 17, 2012 Primary Representative Millett introduced House Joint Resolution (HJR) No. 29 a resolution "urging BLM to properly plug legacy wells and reclaim legacy well sites as soon as possible to protect the Arctic environment" (H.J.Res. 29, 2012). Similarly, Alaska's HJR No. 6 was introduced on January 28, 2013 by Primary Representative Millet and requested the "Office of the Governor to increase nationwide awareness about legacy wells and well sites" (H.J.Res. 6, 2013). Both HJR 29 and 6 noted that if it were possible for the state to fine the federal government based on AOGCC violations, fines would amount $8 billion. Without considering statutes of limitation, these fines would exceed $40 billion. Most recently, the Responsible Helium Administration and Stewardship Act was passed September 27, 2013 and included an amendment to Section 349 of the Energy Policy Act of 2005 for Treasury funding (totaling $50 million) to be used for the remediation of National Petroleum Reserve Land (H.R. 527, 2013)

CONCLUSION:

When drilling began in 1944, there was little understanding of the Arctic or the overall impact of releasing waste into the environment. Regulatory policies began to reflect discoveries made during early Arctic exploration programs. Even with changes to regulatory policies, ongoing damage to the NPR-A continues to adversely affect the environment. Currently, three wells are known to actively be releasing hydrocarbon gas into the environment. Cellars, pilings, solid waste, and other debris could pose dangers to local humans and wildlife. With increased awareness, BLM and Congress have resumed efforts to address legacy wells. BLM has agreed to follow the AOGCC permitting process for plugging and abandoning wells and is working with AOGCC and other Alaska State Agencies to stay in compliance. The Federal government, for the first time in its history, has funded legacy well cleanup through legislation a non-appropriations bill (Kleeshulte, 2013). Although much remains unknown about legacy wells, these recent actions represent a step in the right direction that will decrease risk to human health and the environment, and protect the sensitive Arctic environment.

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