Appendix 4.1-C

Technical Memorandum: Grants Reclamation Project Cessation of Corrective Action Program

TO: Brad Bingham

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RE: Grants Reclamation Project Cessation of Corrective Action Program

Introduction

The Grants Reclamation Project was originally a uranium mill that operated and produced yellowcake from 1958 until 1990. Uranium ore from mines in the San Mateo district, north of the Site, as well as from Homestake's Pitch property in Colorado fed the mill. At its peak, the Site reportedly processed 3,400 tons of ore per day. Tailings were disposed of in two unlined impoundments – the Large Tailings Pile (LTP) and Small Tailings Pile (STP). The LTP contains approximately 21 million tons of tailings and covers approximately 234 acres at a height of 90 feet. The STP contains approximately 1.2 million tons of tailings and covers approximately 40 acres at a height of 25 feet.

The primary source of groundwater impacts at the site is draindown from the LTP. This tailings porewater contains high concentrations of molybdenum, uranium and other constituents of concern. This impacted water moves from the bottom of the LTP into the partially saturated zone of the alluvial aquifer directly beneath the LTP. By the mid-1970s, seepage from the impoundments was found to be impacting off-site wells. Investigations confirmed that the alluvial aquifer underlying the Site was heavily impacted and bifurcated plumes reaching west and south of the Site were delineated.

Beginning in 1977, the Site has used a combination of extraction and injection wells to capture seepage and maintain a hydraulic barrier between the Site and the residential subdivisions located south of the Site. Initially, the primary means of treatment for contaminated water was through uranium removal in the mill circuit. Over time, in response to regulatory demands, evaporation ponds, a reverse osmosis treatment plant, and zeolite systems were added to the GRP to address groundwater impacts.

Source control began in 1995, when Site initiated a tailings dewatering program in the LTP to remove tailings pore water, thereby reducing the potential for further contamination. In 2000, this extraction effort was coupled with water injection in a pilot test. The full-scale implementation of the flushing program began in 2002. The flushing program involves the injection of unimpacted to slightly impacted water into the LTP and the subsequent extraction of tailings pore water using a network of extraction wells screened through the entire thickness of the LTP. A significant portion of the injected water seeps out through the bottom of the LTP into the partially saturated alluvial zone directly beneath it, which pushes the water with the high concentrations of uranium in this zone to collection wells to the south and west of the LTP, where it is removed. The remainder of the injected water is captured via the collection wells and toe drains within the LTP.

The flushing program ceased in the middle of 2015 when the average uranium concentration in the LTP had decreased from an original 40 mg/l to about 5 mg/l. Since then, the mounded water in the LTP has continued to dissipate. Seepage reported to the toe drains, along the perimeter of the LTP, has also decreased from a peak of 50 gpm to less than 5 gpm.

A reverse osmosis (RO) plant was installed in 1999 to increase the restoration capacity at the site. Prior to its implementation collection of the impacted groundwater was limited by the evaporation rate from the lined ponds where the water was discharged. The RO plant allowed for the treated water to be utilized in the hydraulic barrier placed downstream of the tailings pile, while reducing the total flow to the lined evaporation ponds by 75%. The RO plant was expanded in 2016 with the addition of a second clarifier, replacement of the sand filters with microfiltration skids, an additional low pressure RO skid, and a high pressure RO skid.

Land application was part of the Site remediation system that was approved by the New Mexico Environment Department (NMED). During the period of 2000 to 2012, approximately 9,551 acre-feet of water was used for irrigation. The GRP was ordered to discontinue the irrigation program in 2012 over concerns that uranium and other constituents could be accumulating in soils. Following discontinuation of the land application program, NMED withdrew regulatory support for the program. Since that time, the plume margins have been contained by the downgradient perimeter of injection wells and collection of impacted groundwater upgradient of the perimeter that is treated utilizing the zeolite treatment system.

Uranium has been the constituent at the site that has shown the highest concentrations above its applicable standard and the largest areal distribution. As such, this memo will focus its discussion upon uranium and not any of the other constituents. Recent evaluations of the GRP have indicated that restoration of groundwater to background conditions is an impracticable objective (HMC 2020). As such, a question of whether the groundwater corrective action that has been ongoing for over 40 years can be considered ALARA. ALARA is defined in Title 10, Section 20.1003 of the Code of Federal Regulations as articulated below:

ALARA *(acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.*

The following sections will discuss the various metrics that can be used to evaluate the groundwater corrective action program.

Observed Well Concentrations

The primary metric in which groundwater restoration is ultimately judged is the concentration at any given point. The objective of the groundwater corrective action plan has been to restore groundwater to background concentrations. The concentrations at wells used for both collection and monitoring have shown significant decreases since the inception of the corrective action program in 1977. However, in recent years, the reduction in those concentrations have largely stagnated. The overall concentration trends are best displayed by grouping wells by geographic region and Figure 1 presents the areas in which the wells are grouped. Figures 2 through 7 present time series graphs of uranium concentrations for various wells utilized for collection and/or monitoring over the period of corrective action.

The corrective action in both the C and K wells (Figures 2 & 3) have shown concentration decreases by over an order of magnitude, and in some cases two orders of magnitude. However, the progress in these wells has stagnated since the early 2000s. In spite of the progress that has been made in these areas, the groundwater concentrations remain above the background standard, and in most cases by at least an order of magnitude.

The D wells shown in Figure 4 show similar behavior to the C and K wells. Concentrations have decreased in this area by an order of magnitude in most cases, and two orders of magnitude in a handful of wells. A portion of this decrease in concentration, particularly in the western half of these wells is likely attributable to the collection for re-injection program that operated from 2000 through 2016 in which water collected in the L well area was re-injected into groundwater into a series of D wells at the toe of the large tailings pile (LTP).

The S wells which are located to the west and southwest of the LTP exhibit similar trends to the wells discussed previously (see Figure 5) with the caveat that a smaller percentage of the wells have observed an order of magnitude concentration decrease. The lower hydraulic permeability that exists to the west of the large tailings likely has a significant effect on the smaller number of wells seeing that level of decrease. The lower hydraulic permeability limits the number of pore volumes that have moved through this area. In addition, this area likely has more silts and clays that act as reservoirs of additional mass and thus act as secondary sources to the sands and gravels where the water flows. The concentration increases observed in the last few years in a handful of the wells is potentially due to the reduced treatment rates in 2019 and 2020 and the overall decrease in saturation over the last 5 years.

The B wells in Figure 6 are similar to the S wells discussed previously, where a handful of wells have been reduced by an order of magnitude, but the rest have seen decreases in concentrations that are less than an order of magnitude. Given the lack of concentration data prior to 1990, it is likely that the data presented doesn't fully encapsulate the decrease in concentrations observed in this general area, particularly considering the concentrations in the adjacent D wells directly upgradient from this area observed concentrations above 100 mg/L prior to 1990.

Figure 7 presents the T wells, which with the exception of T1 and T2 have the shortest period of record of any of the series of wells. As such, it's difficult to quantify how much concentrations underneath the pile have decreased since the start of corrective action. Given that concentrations were above 40 mg/L in well T2 at the edge of the LTP in the mid-1980s, and there are numerous wells with less than 5 mg/L underneath the pile today, it's plausible that over the course of corrective action at the site, portions of the footprint underneath the LTP have been reduced by an order of magnitude in concentration. In addition, the downgradient D and S wells both showed concentrations above 100 mg/L in the 1980s, and thus concentrations at these points underneath the LTP likely exceeded those observed values.

The relative differences in concentration decreases when looked at as a function of distance from the primary source of the LTP is consistent with the conceptual understanding of the site. The back diffusion of mass from the fine-grained silts and clays (immobile domain) into the sands and gravels (mobile domain) is the likely cause of stagnation in restoration progress (HMC 2022). Given that areas underneath the pile or directly adjacent to the pile have been in contact with higher concentration water for longer periods of time, it would be expected that the areas closer to the LTP would experience a larger effect on concentration from the back diffusion than the areas at a further distance from the LTP.

Across the entire series of wells, significant progress has been demonstrated by the decrease in concentrations in all areas. The greatest progress has been made in areas furthest away from the primary source of the LTP, but as noted earlier, groundwater standards have not been achieved at those locations, nor is there any indication from the observed data that it is an achievable objective.

Mass Balance Assessment

The significant difference in saturated thickness over the 4+ decades of corrective action on the site likely has influenced groundwater concentrations and thus there are limitations as to its use as a metric for progress that's being made. The total mass within the On-Site alluvial system above the site standard of 0.16 mg/L provides insight into restoration progress that eliminates the effect of variable saturated thickness can potentially have on concentrations observed. The mass that can be measured within the mobile domain of the aquifer has shown a similar stagnation over the last decade, similar to observed groundwater concentrations, in spite of continued corrective action as demonstrated in the Mass Balance Memo (HMC 2022). Figure 8 is taken directly from that memo and provides a summation of the history of groundwater corrective action at the site. The memo estimates that 87% of the mass that seeped out of the LTP has been collected as part of groundwater corrective action.

Figure 9 shows the same information as Figure 8, but for the timeframe of 2009 through 2020. In spite of over 160,000 pounds removed by corrective action during that period, the mass measured in the mobile domain has not significantly decreased over the last 10 years of corrective action. This stagnation in mass reduction cannot be adequately explained by the mass loading from the LTP seepage, as it has only contributed approximately 40,000 pounds of uranium during that time, approximately 25% of what has been removed through corrective action. The mass measured in the mobile domain of the alluvial aquifer has shown no substantial decrease over that timeframe in spite of the estimated mass being roughly half of the mass removed over a 10-year period. The change in the immobile domain mass over that period is largely a result of it being a calculated value from the other graphs shown. With no change in the mobile domain mass, over that 10-year period, honoring the method of calculation results in a decrease in mass unsupported by the conceptualization of the system.

This look at the mass remaining in the mobile domain provides an effective tool for demonstrating that the changes in concentrations observed are not merely a result of changing water volume within the aquifer (i.e. dilution). In addition, it shows good agreement with the lack of substantial progress towards restoration shown by the groundwater concentrations discussed previously.

Previous GCAP Analysis

The 2020 Groundwater Corrective Action Program (HMC 2020) evaluated an alternative in which an assumption was made that 50 years of additional pump and treat would clean up the mobile domain of the alluvial aquifer. While the assumption of restoration being achievable in a 50-year timespan is not supported by the historic progress of restoration nor the groundwater model developed to assess future actions, the results are informative as to the potential footprint of restricted access that would be needed to remain protective of human health following the cessation of corrective action. As part of that same alternatives analysis, a model run was also developed in which corrective action ceased at the start of the predictive model run.

Figure 10 shows the extent of uranium concentrations with no additional corrective action and natural attenuation after 200 years. The results of the groundwater restoration following 50 years of corrective action, removal of all mass in the mobile domain, and 150 years of natural attenuation are shown in Figure 11. As shown by the figures, even with overly optimistic assumptions in the restoration timeframe, the footprint in which groundwater exceeds the background standard for the site is approximately 60% of the footprint of the natural attenuation run, in which corrective action ceases at the start of the predictive model run.

This comparison shows that even if restoration of the mobile domain was an achievable goal within a reasonable timeframe, following the cessation of the corrective action, access to groundwater would still require restrictions due the rebound in groundwater concentrations derived from the LTP seepage and the back diffusion from the immobile domain.

Discussion

Amongst the metrics discussed above, there is no indication that restoration of groundwater is achievable at the GRP. The groundwater concentrations observed at the site have shown significant progress since the inception of the groundwater corrective action program but have shown diminishing returns over the last decade. The mass balance evaluation of the site shows that these concentrations decreases are not a function of dilution and overall support the interpretation that the lack of decrease in observed concentrations is indicative of diminishing returns on continued corrective action.

In addition, the alternatives assessment done in the 2020 GCAP show that even under a hypothetical best case scenario of groundwater restoration in a 50 year timeframe, the footprint of groundwater access restriction required for the protection of human health is still over half of the footprint needed for no further corrective action. With these two end points, it’s logical to assume that access restriction will remain the only mechanism to protect human health, and further corrective action will not significantly decrease the footprint in which those restrictions are needed.

Since the commissioning of Evaporation Pond 3 in 2010, the GRP evaporates 100 million gallons of water a year (HMC and HE 2022). This amounts to approximately 10% of the total combined water usage for the nearby municipalities of Grants and Milan (DOE 2020). For the theoretical alternative presented in the 2020 GCAP, the 50 years of continued pump and treat would result in a loss of 5 billion gallons of water to evaporation in order to reduce the footprint of necessary access restrictions by less than 40% beyond what's necessary with no further corrective action and loss of water to evaporation.

Conclusion

- The observed groundwater concentrations in the vicinity of the LTP have shown that while significant reduction in concentrations have been achieved historically, there's no indication continued corrective action will achieve background concentrations.
- The mass balance evaluation of the site show that the concentration decreases are not a result of dilution and that corrective action over the last decade have shown diminishing returns.
- The 2020 GCAP alternatives evaluation shows that even under overly optimistic assumptions with a significant waste of water resources, the footprint of access restrictions is not reduced by more than 40%.
- The present day conditions in groundwater can be considered ALARA given the three preceding bullets.

References

Homestake Mining Company of California (HMC), 2020, Grants Reclamation Project Groundwater Corrective Action Program, November 13, 2020, ML20358A52

HMC, 2022. Grants Reclamation Project Uranium Mass Balance Memo, Technical Memorandum, March 2, 2022

HMC and Hydro-Engineering, LLC (HE). 2022. Grants Reclamation Project, 2021 Annual Monitoring Report/Performance Review for Homestake's Grants Project Pursuant to NRC License SUA-1471 and Discharge Plan DP-200. Consulting Report for Homestake Mining Company of California.

U.S. DOE. 2020. Evaluating the Influence of High-Production Pumping Wells on Impacted Groundwater at the Bluewater, New Mexico, Disposal Site, August.

Figure 1. GRP Well Grouping Locations

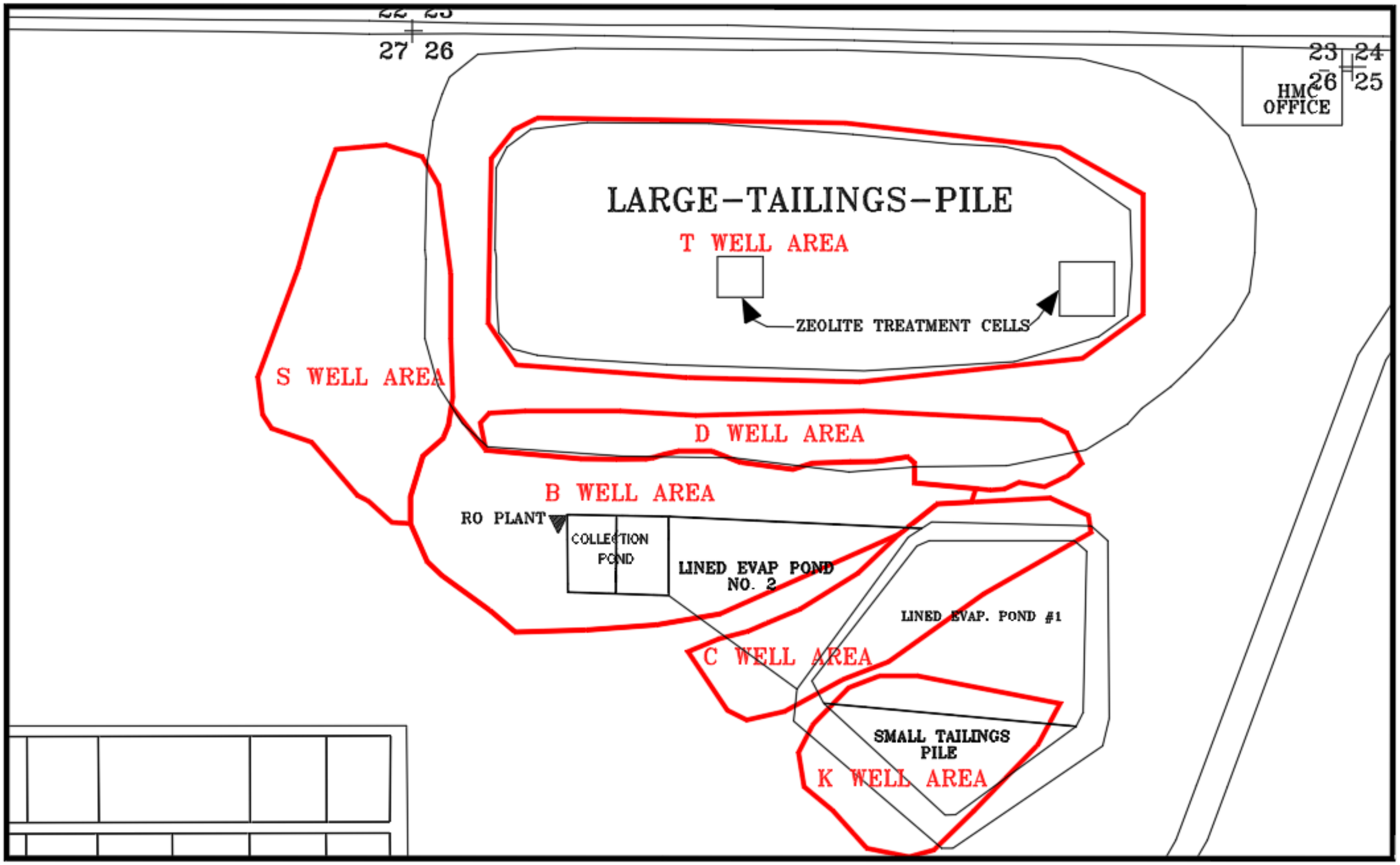


Figure 2. C Well Uranium Concentrations

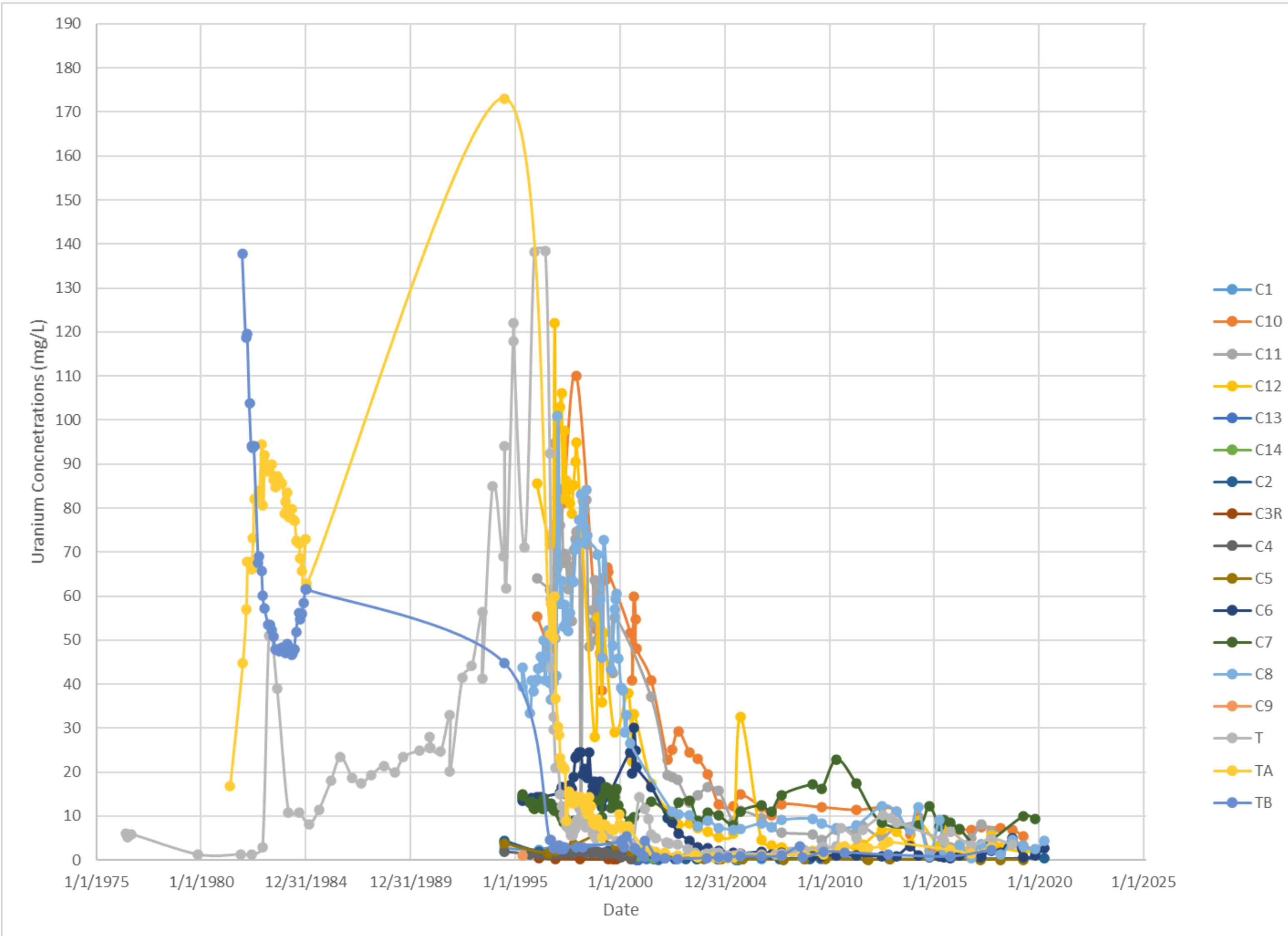


Figure 3. K Well Uranium Concentrations

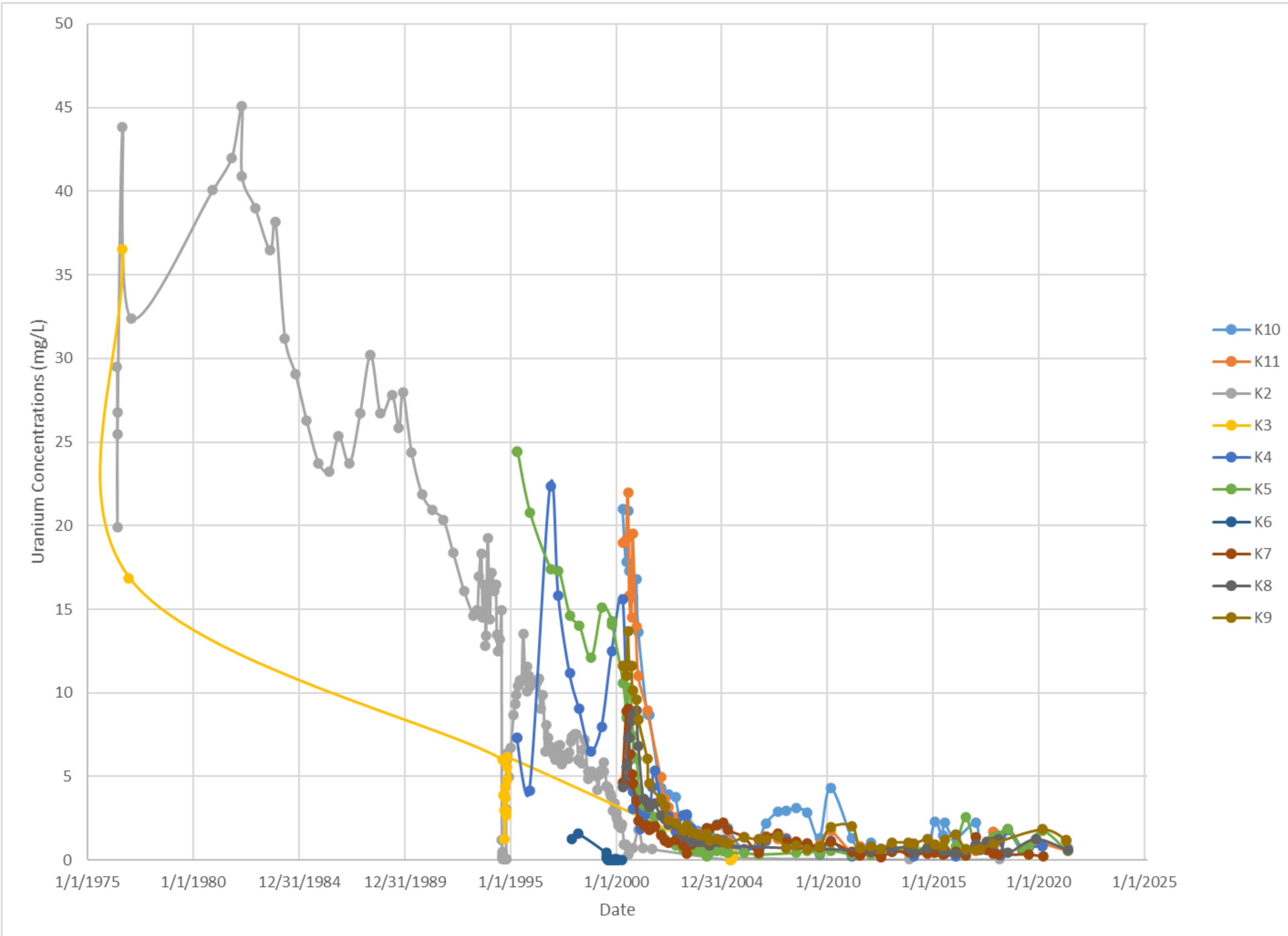


Figure 4. D Well Uranium Concentration

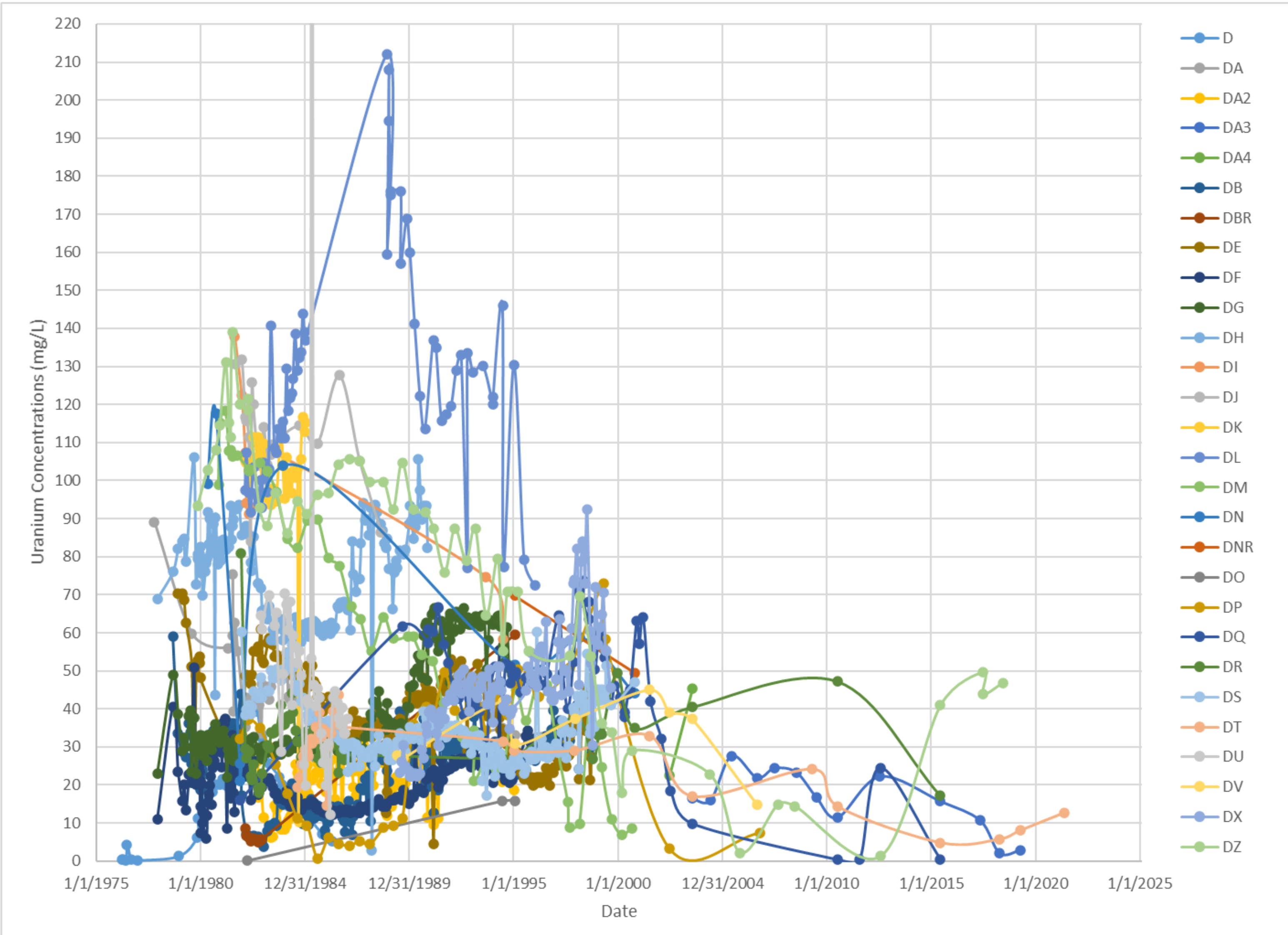


Figure 5. S Well Uranium Concentration

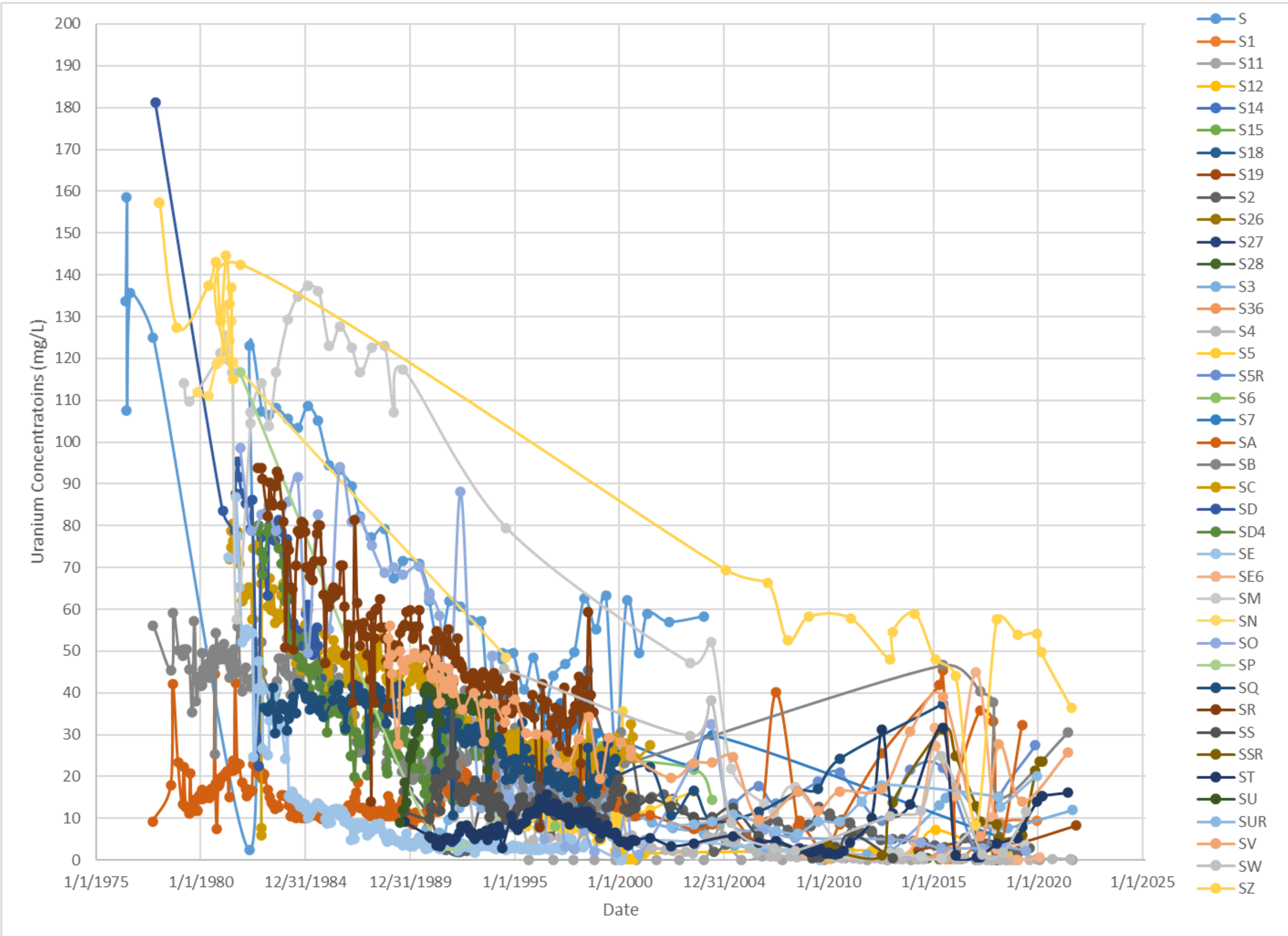


Figure 6. B Well Uranium Concentration

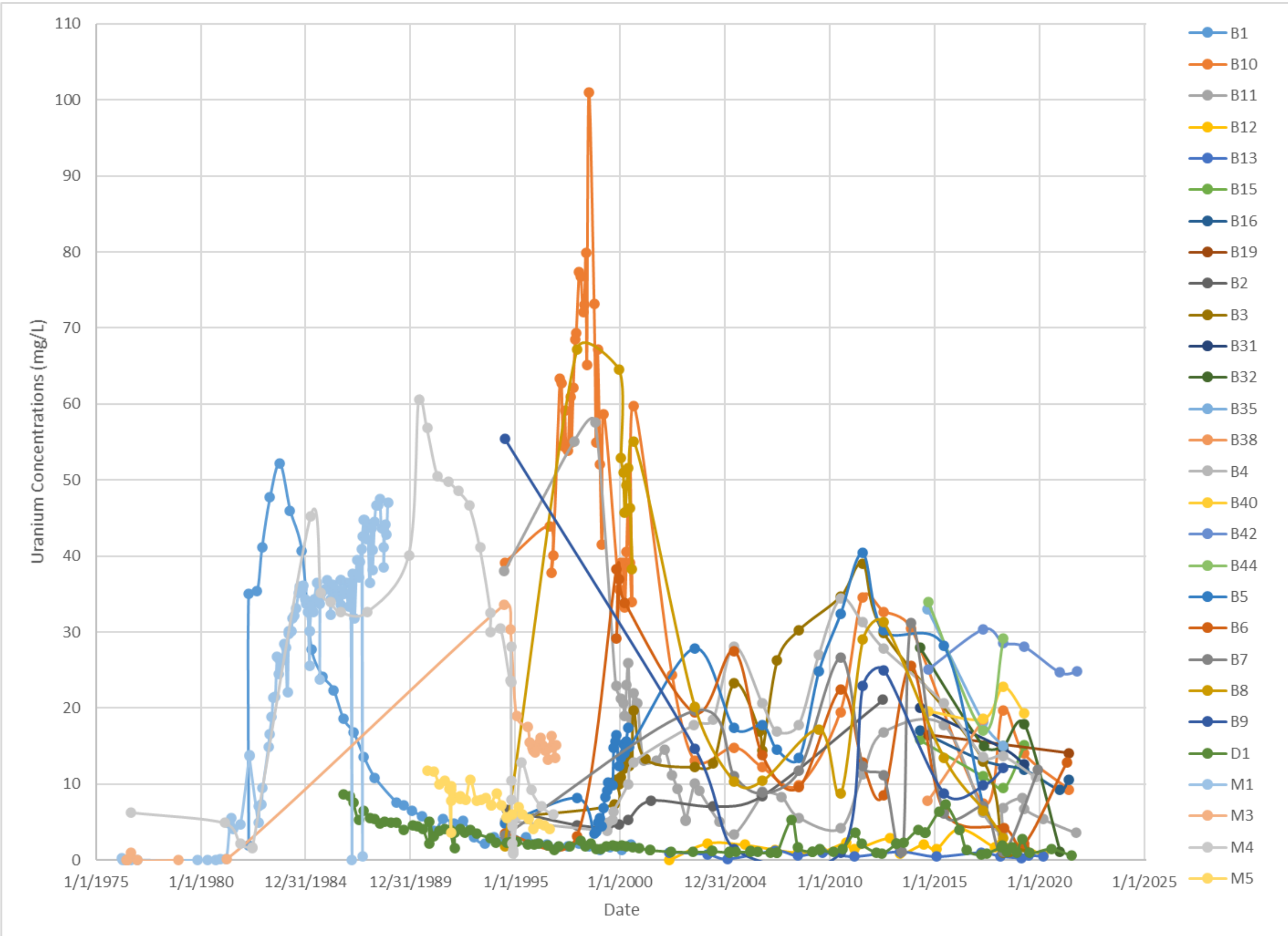


Figure 7. T Well Uranium Concentration

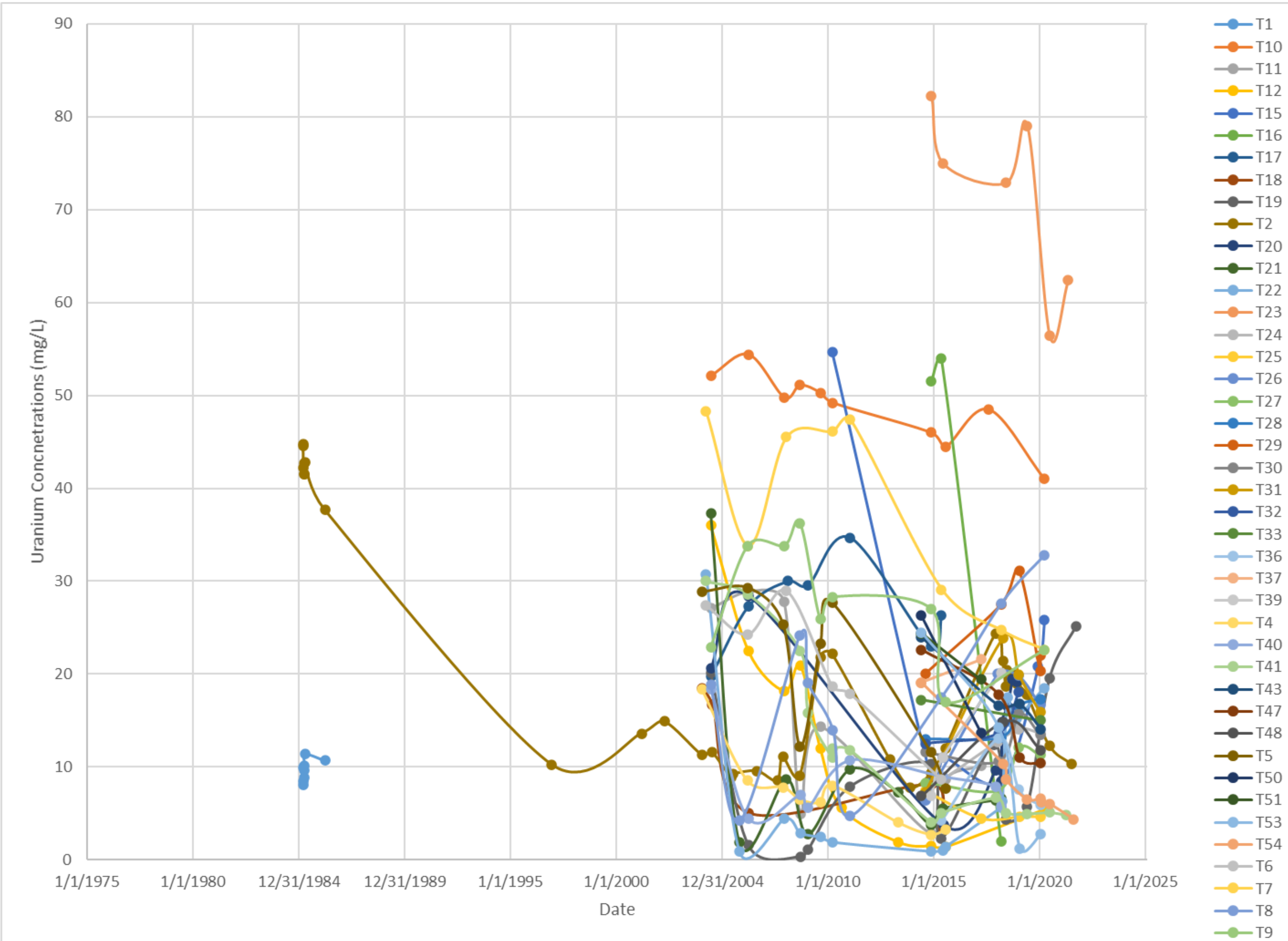
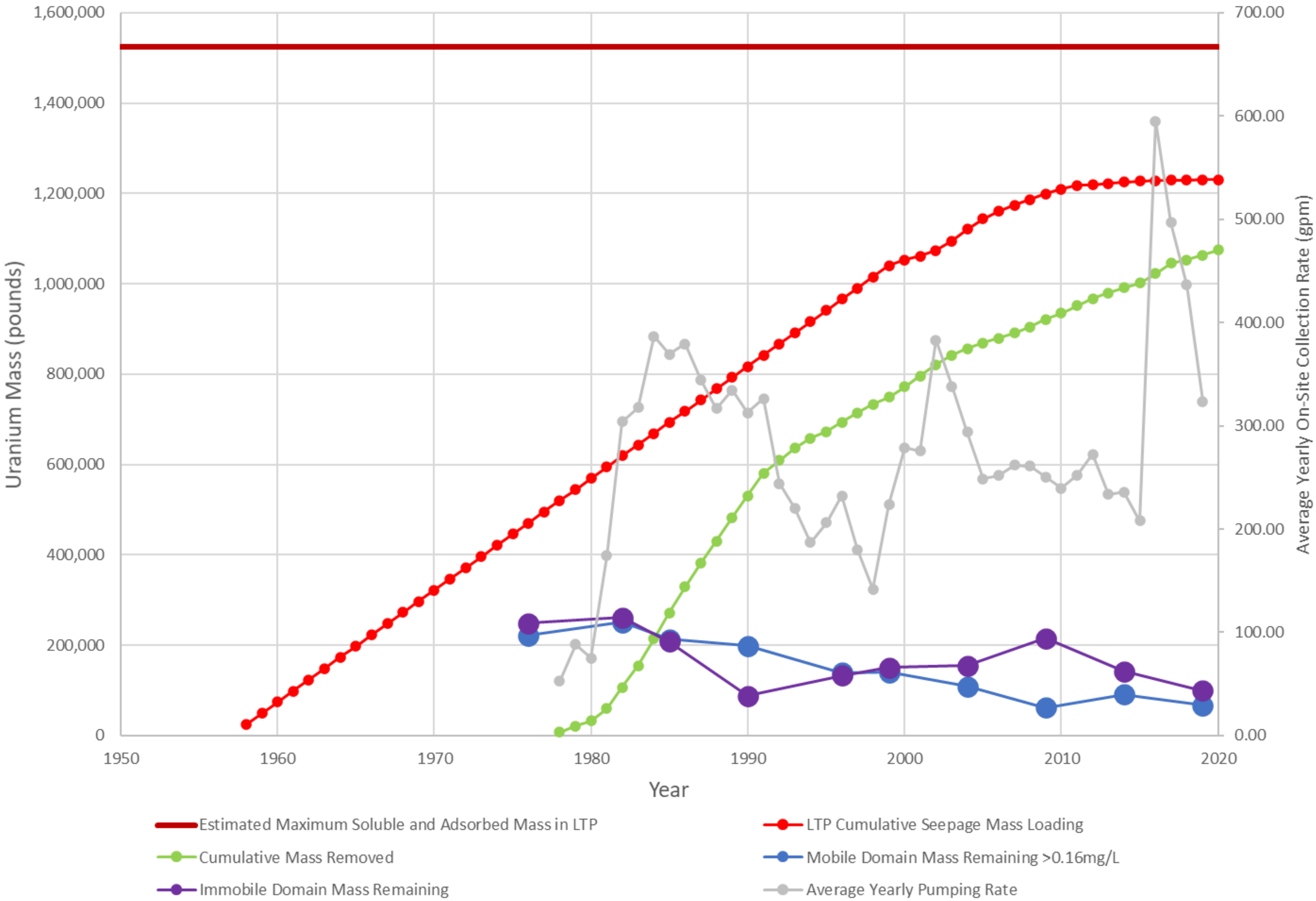


Figure 8. Uranium Mass Balance



HOMESTAKE
Doing it right... ...Right to the end.
Grants Reclamation Project

Figure 9. Uranium Mass balance from 2009 Forward

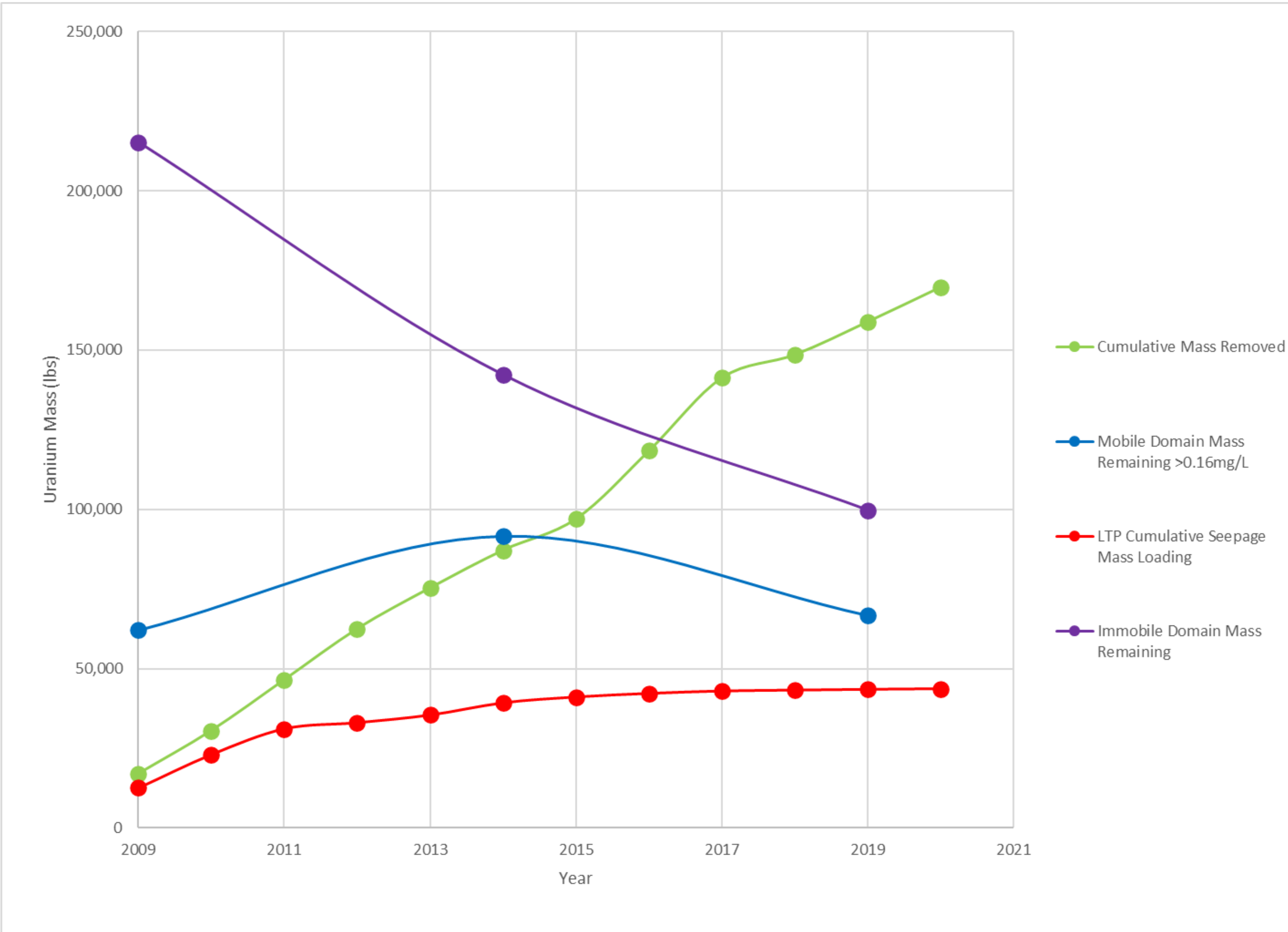


Figure 10. Uranium Concentrations After 200 Years following Cessation of Corrective Action

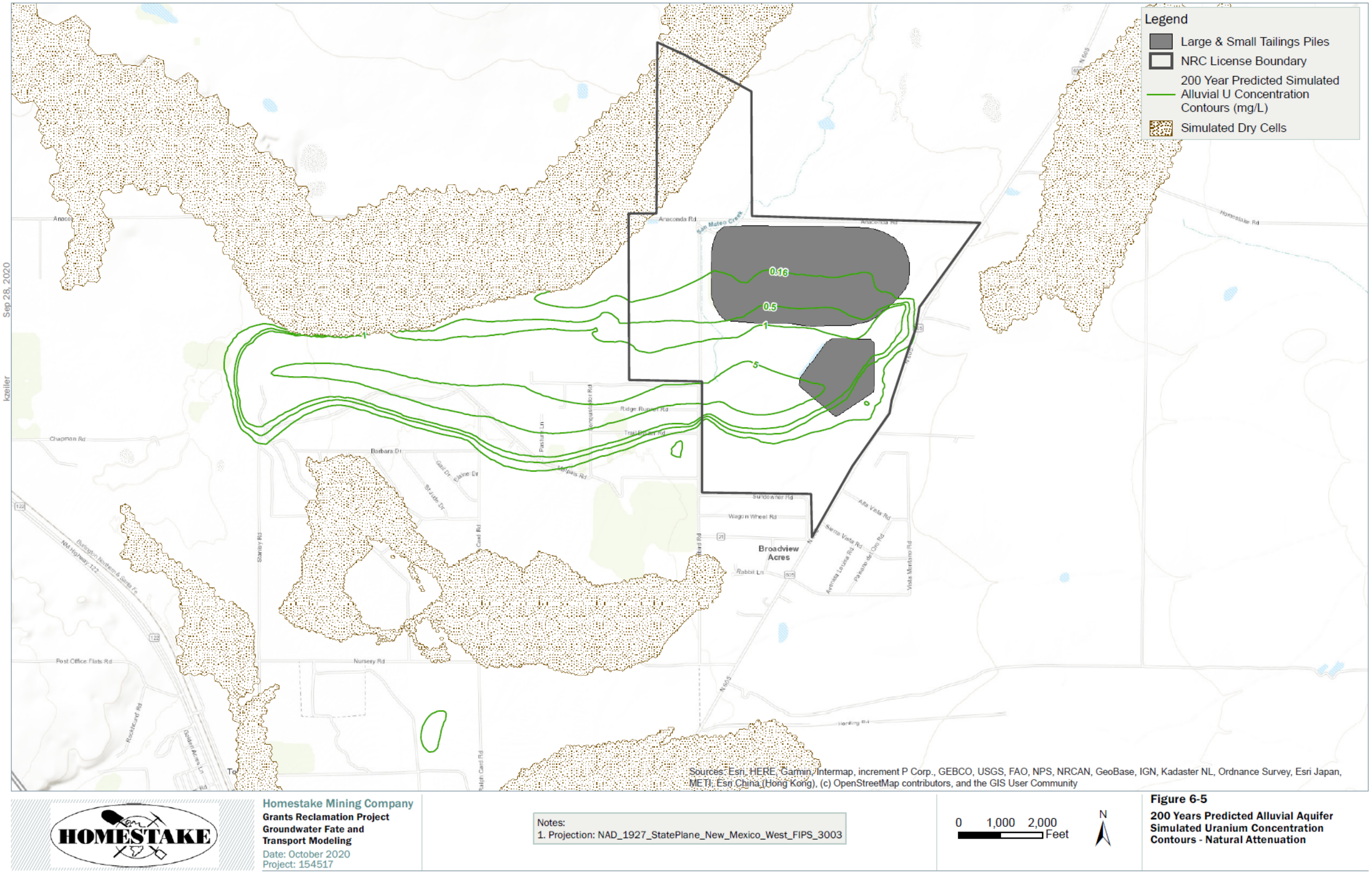


Figure 11. Uranium Concentrations After 200 Years Following Complete Clean-up of the Mobile Domain through 50 Years of Corrective Action