EPA Comments on the

Draft Workplan for 2015 Soil, Groundwater, Surface Water and Sediment Characterization,

Red Devil Mine, Alaska

General Comments:

1. While there are three down gradient wells associated with Monofill 2 only (MW-10) one has provided enough water for analysis. It is recommended at an additional well be installed in this area to monitor the potential for contaminants being released from the monofill. It is recommended that the depth of the screened interval be in the same range of MW-10 or shallower depending on local conditions. Also it was noted that MW-09 did not produce enough water to collect a sample. Is there some rehabbing of the well that could make that a viable monitoring well or does that just reflect the conditions of the aquifer at the screened interval and it will not be possible to collect a sample?

> **BLM Response:** As noted in the comment, during the RI groundwater sampling effort (August 2011), it was possible to collect groundwater samples from only one (MW10) of the three monitoring wells (MW09, MW10, and MW11) installed immediately downgradient of Monofill #2. At that time, MW11 was dry, and recharge to MW09 was too slow to allow development or collection of a sample. However, during the subsequent baseline groundwater monitoring, it was possible to develop and sample well MW09. Results of this sampling are summarized in the final RI report Appendix A - Final 2012 Baseline Monitoring Report. Sampling of well MW09 will be added to the planned spring and fall 2015 groundwater monitoring events.
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> If Monofill #2 is left in place with a cover as part of a site remedial action, post-construction groundwater monitoring would be performed to assess the effectiveness of the action. The existing monitoring wells (MW09 through MW11) would likely be destroyed as part of the excavation of adjacent tailings/waste rock associated with such a remedial action. New monitoring wells would therefore be installed downgradient of the monofill following the excavation. Such wells would be constructed with screened intervals at appropriate depth ranges to perform such monitoring (e.g., at depths similar to or shallower than in MW10).

2. In regards to the planned toxicity test, a test for toxicity and reproductivity will provide good information, though using the standard 10 day Chironomus and 28 day Hyalella sediment toxicity tests would probably provide the same information more quickly and at less cost. Bioaccumulation is also a concern at this site. A 28 day bioaccumulation test with the oligochaete Lumbriculus variegatus is recommended. This test is designed to measure contaminant uptake from sediments. This bioaccumulation test has several uses. One use applicable to Red Devil is it provides information that may not be easy to obtain from field collections of small invertebrate species in sediment. Sampling in the field sampling would not likely obtain a sufficient mass of benthic invertebrates to perform the chemical analysis of the benthic tissue with the detection limits needed to permit an evaluation of the following; risk, the extent of methylmercury concentrations in benthic invertebrates, and the potential for food web transfer of methylmercury into higher trophic level species. The laboratory bioaccumulation test with site collected sediment can avoid such a problem by adding a sufficient mass

of Lumbriculus to site sediment that one has enough tissue for chemical analysis for mercury and methymercury at the end of the test.

BLM Response: Please see BLM response to additional comments provided by the EPA on May 13, 2015 regarding evaluation of potential bioaccumulation of mercury for Kuskokwim River sediment (Use of 28 Day Hyalella Toxicity Test vs a 42 Day Test, Mercury Bioaccumulation Toxicity Test).

3. A corollary concern is the text for the DQOs for the upcoming work. Should another problem statement or key study question be added that specifically discusses bioaccumulation or can bioaccumulation be considered to be included as part of the potential toxicity of the Kuskokwim River sediments?

BLM Response: A separate problem statement/study question addressing bioaccumulation will be incorporated into the Data Quality Objectives discussion of the Work Plan.

4. The discussion on the Kuskokwim River sediments and toxicity tests should include more information such as the number of replicants needed for the study, including those for biological endpoints, pore water chemistry as well as an overview of how the sediment will be processed in the lab and distributed into the test chambers. Also the parameters that will be measured during the tests should be stated. It is recommended that AVS/SEM pH and pore water be included. See the attached section on bioassays, Pages B-10 to B-12 from another project, as an example.

BLM Response: USEPA (2000) specifies the number of replicates to be included in the *Hyalella azteca* sediment toxicity tests; how sediment should be processed in the lab and distributed to test chamber; and parameters to be measured in test chambers. This information will be summarized in the final Work Plan. Bioaccumulation of site-related contaminants from sediment will be evaluated directly by analyzing selected sediment samples for methylmercury. Please see response to General Comment #2 above.

<u>Specific Comments:</u>

1. P. 2-3, Fate and Transport, 3rd parg. The text states; "Leaching of inorganics from tailings/waste rock and other sources is the primary mechanism of contamination of groundwater and surface water." If leaching is the primary mechanism for surface water contamination it suggests that most Hg in surface water is in the dissolved form. If this finding is based on previous field work, then this should be clarified with a statement to that effect. For example,"….field sampling of surface waters showed that most Hg was in the dissolved form suggesting that leaching from tailings/waste rock was the primary source."

BLM Original (4/22/15) Response: Leaching of antimony, arsenic, and mercury from tailings/waste rock and other sources is evident in the groundwater results presented in the final RI report. Migration of such impacted groundwater into surface water along Red Devil Creek, notably within the Main Processing Area (where Red Devil Creek exhibits predominantly gaining conditions), is evident in the RI and baseline monitoring surface water results. Trends of concentrations in surface water are illustrated graphically in Figures 4-36 through 4-39 of the main body of the RI report and Figures 3-15 through 3-18 in RI report Appendix A – Final 2012 Baseline Monitoring Report.

CE Response (5/13/15) to BLM 4/22/15 Response: Figure 3-15 to 3-18 indicate that a high percentage of the Hg in the creek are bound to particles (appears to be up 90 to 95%). These results suggest that the Hg originates from sediment particle entrainment or bank erosion. It seems unlikely that particulate Hg is transported via a groundwater pathway, since particles are less mobile in groundwater than dissolved forms. Also, when comparing the spring and fall 2012 data in Figures 3-15 to 3-18 there is a large differences in the concentrations between these two periods…i.e. during the fall the Hg is around 100 ng/L whereas during the spring it appears to be over 500 ng/L. Such large temporal changes in concentration would not be expected from leaching of Hg from tailings and transport via groundwater, which would expect to result in more stable Hg concentration over time. Higher concentrations during higher discharge in the spring is consistent with increased erosion and sediment entrainment.

Therefore, both the high percent of Hg bound to particles and the large temporal variability of Hg linked to discharge suggests that much of the Hg originates from sediment entrainment and/or surface erosion.

BLM Response to CE 5/13/15 Response: Please see below.

BLM Original (4/22/15) Response (cont.): The conclusion that the surface water impacts were predominantly from influx of groundwater during the RI and baseline monitoring sampling events is supported by the general similarity of total and dissolved concentrations for antimony and arsenic in surface water, suggesting that loading to surface water is predominantly in the dissolved phase. Such loading from groundwater influx is supported by RI and baseline monitoring groundwater concentration data for wells in the vicinity of Red Devil Creek. As is noted in the final RI report, the ratios of total-to-dissolved concentrations for mercury in surface water are generally much higher (as high as 29) than for antimony, arsenic, and most other inorganic elements in most samples. This is attributed to formation and migration of mobile colloids in groundwater.

CE Response (5/13/15) to BLM 4/22/15 Response: How are colloids being defined here? A common definition is particles in the <0.4 um to 10 kilodalton range (Babiarz et al., 2001). Assuming that 0.45 um filters were used in Red Devil sampling, the colloidal phase would not have been distinguishable from the dissolved phase. Therefore, the formation of colloids cannot explain the high ratio or total-to-dissolved concentrations of Hg measured in the creek. While dissolved Hg in groundwater may become bound to solid material, this solid-phase bound Hg would likely not be very mobile.

BLM Response to CE 5/13/15 Response: Please see below.

BLM Original (4/22/15) Response (cont.): A detailed discussion of migration of mercury in groundwater and surface water in association with colloidal particles is discussed in final RI report Sections 5.4.4 and 5.6.2.2, respectively. The Work Plan will be revised to provide this information in more detail. As noted in Work Plan Section 2.3 – Non-Time-Critical Action, RI results also show that tailings/waste rock in the Main Processing Area also have been subject to active erosion along Red Devil Creek and into the Kuskokwim River. Such erosion and transportation as suspended load and bed load are discussed in Sections 5.5 and 5.6 of the final RI report. The Work Plan will be revised to more fully discuss these processes.

CE Response (5/13/15) to BLM 4/22/15 Response: There is concurrence that Hg can leach from the tailings into the groundwater. However, the root of the original comment was taking issue with indicating that leaching was the "primary" mechanism. By suggesting that one source if primary and another is secondary it indicates that there is sufficient information available to identify the relative proportions of Hg originating from groundwater compared to surface water input. At present, there does not seem to be sufficient information presented indicating that groundwater is the primary source of Hg to the creek; to the contrary the data seems to suggests otherwise…that groundwater may be a secondary source to the surface water given a) the large proportion of Hg bound to particles in the stream; and b) the large temporal variability in creek Hg concentrations associated with changes in hydrology.

BLM Response to CE 5/13/15 Response: As discussed during the May 28, 2015 comment resolution call, the statement referred to in the original EPA comment will be revised as follows: "Leaching of inorganics from tailings/waste rock and other sources is one of the primary mechanisms of contamination of groundwater and surface water. Erosion and entrainment of particulates also is an important mechanism. The 2014 NTCRA was completed to address this mechanism (see Section 2.3)."

2. P 2-4, Nature and Extent of Contamination, 3rd parg. The text states, "These same metals occur naturally at concentrations above risk-based and regulatory levels in native bedrock, soil, and sediment, and groundwater and surface water that flow through them." This is an important statement and a reference(s) should be provided to support it/or additional information should be provided; particularly with regard to surface water. Are there surface water concentrations that were measured upstream of the site or from proximate reference areas to support this? If so, such data/studies should be referenced here.

BLM Response: The subject sentence will be revised to state the following: "One or more of these same metals were detected above risk-based or regulatory levels in RI background soil, sediment, and groundwater samples."

RI surface water data do not clearly indicate impacts from native, naturally mineralized rock and soil that result in concentrations greater than risk-based or regulatory levels. However, as stated in Work Plan Section 2.1.3 – Surface Water: "Contaminant loading (e.g., antimony, arsenic, mercury, and methylmercury) along Red Devil Creek as it flows through the Main Processing Area are attributable primarily to groundwater migration into the stream along gaining reaches. Groundwater emerges to surface water as baseflow within the Main Processing Area as well as at a seep located adjacent to the creek in the Main Processing Area. Sources of inorganics in groundwater include leaching from mine wastes, as well as naturally mineralized bedrock and native soils. Other sources of surface water loading along the creek may include entrainment of contaminants within or adsorbed to particulates and dissolution/desorption of contaminants from bed and suspended sediment."

3. P. 2-5. Sect. 2.1.2, last parg. The text discusses methymercury. The text should state whether the methylmercury analysis was from filtered or unfiltered water samples.

BLM Response: The subject sentence will be revised as follows: "Groundwater samples were variously analyzed for total TAL metals, dissolved TAL metals, total low level mercury, dissolved low level mercury, methylmercury (unfiltered), …"

CE Response (5/13/15) to BLM 4/22/15 Response: OK

4. P. 2-6, Sect 2.1.2, 3rd parg. If possible, it would be informative to have the cross section in Figure 2-2 be located on the map on Figure 2-1.

BLM Response: Figure 2-1 will be revised to show the line of Cross Section B-B' presented in Figure 2-2.

5. P. 2-9. Sect. 2.1.3, 2nd set of bullets, 2nd bullet. The text states "Characterize the long-term (multiple year) variability in groundwater and surface water hydrology and chemistry; and . . ." This reviewer questions whether with only two sampling events of surface water collected in 2012, and only two additional events planned for 2015, there is a sufficiently robust dataset to make a determination of long-term variability. With such a small dataset, it seems difficult to distinguish between within-year and between-year variability. Perhaps the text should re-worded to just indicate that seasonal variability will be measured in two different years.

BLM Response: The BLM plans to perform baseline groundwater and surface water monitoring in the future, in addition to the two events performed in 2012 and the two events planned for 2015. The paragraph preceding the subject bullets will be revised to state: "To date, baseline monitoring of surface water and groundwater has been performed at the RDM in the spring and fall 2012. The purpose of the baseline monitoring is to augment the RI results and identify seasonal trends in groundwater and surface water flow and contaminant concentrations and loading. Specific objectives of the baseline monitoring are to:"

CE Response (5/13/15) to BLM 4/22/15 Response: OK

6. P 2-9, Fate and Transport, 1st parg. The text states; "Contaminant loading (e.g., antimony, arsenic, mercury, and methylmercury) along Red Devil Creek as it flows through the Main Processing Area are attributable primarily to groundwater migration into the stream along gaining reaches." Additional text should be provided to help explain this statement to that effect, provided there is sufficient data to back-up such statements. For example, "field sampling showed that most Hg was in the dissolved phase and did not change during high-flow events; therefore we believe that contaminant loading was primarily from groundwater."

BLM Original (4/22/15) Response: Please see response to Specific Comment #1.

CE Response (5/13/15) to BLM 4/22/15 Response: see response to specific comment #1

BLM Response to CE 5/13/15 Response: As discussed during the May 28, 2015 comment resolution call, the paragraph that includes the sentence referred to in the original comment will be revised as follows: "RI results indicate that transport of contaminants in surface water is occurring presently at the RDM. Contaminant loading (e.g., antimony, arsenic, mercury, and methylmercury) along Red Devil Creek as it flows through the Main Processing Area are attributable to groundwater migration into the stream along gaining reaches and erosion. Groundwater emerges to surface water as baseflow within the Main Processing Area as well as at a seep located adjacent to the creek in the Main Processing Area. Sources of inorganics in groundwater include leaching from mine wastes, as well as naturally mineralized bedrock and native soils. Surface water loading along the creek also is attributable to entrainment of contaminants within or adsorbed to particulates and dissolution/desorption of contaminants from bed and suspended sediment. The 2014 NTCRA was completed to address this mechanism (see Section 2.3)."

7. P 2-15, Sect. 2.3, 1st parg. The first sentence in the paragraph states "The RI results indicated that tailings/waste rock located in the Main Processing Area were subject to active erosion along Red Devil Creek and transport to the Kuskokwim River." However, earlier in this document it is stated that the primary source of contamination was from groundwater, which would be in the dissolved phase. The relative importance of erosion and groundwater sources needs to be better resolved in the text. Field data showing the relative proportions of mercury in the dissolved and particulate phases should be provided.

BLM Original (4/22/15) Response: Please see response to Specific Comment #1.

CE Response (5/13/15) to BLM 4/22/15 Response: see response to specific comment #1

BLM Response to CE 5/13/15 Response: Please see BLM response to Specific Comment #6 above.

8. P. 3-3 Sect. 3.1, Kuskokwim River Sediments. How well characterized is the potential for methylation of Hg associated with Kuskokwim river sediments? This seems like this is the biggest potential impact of the site on human and wildlife exposure and should be adequately understood and characterized. However, Hg methylation is not addressed in the DQOs, nor was it adequately mentioned in the "Existing Information" chapter. More information on Hg methylation should be included or there needs to be a very solid explanation presented in Chapter 2 indicating that methylmercury dynamics at the site are already sufficiently understood. Particular attention should be given to identifying if Hg transported off site can be methylated at downstream locations that may be more conducive to this process. Is such information is lacking the additional toxicity test for bioaccumulation may provide some pertinent information.

BLM Original (4/22/15) Response: Several approaches were taken during the RI to evaluate the potential for methylation of mercury in Kuskokwim River sediments, as discussed below.

Several types of data were collected that indicate that a large fraction of total mercury in site soil and sediment is sparingly soluble. For example, mercury SSE data indicate that only a small fraction of total mercury in site soil (see final RI report Section 5.3.5.1) and sediment derived in part from site soil (see final RI report Section 5.3.5.2) is water soluble (F1) or stomach acid soluble (F2) and that the proportion of these soluble fractions relative to the total mercury decreases with increasing total mercury concentration.

Similarly, SPLP (final RI report Section 5.3.4.1) data suggest that only a small fraction of the total mercury concentration in site soil samples is soluble under slightly acidic conditions. The soluble portion of the total mercury pool is the portion subject to methylation, and the soluble fraction in site-related wastes is limited. Kuskokwim River sediment samples were evaluated for methylation potential directly by analyzing methylmercury (see final RI report Section 5.3.6) in 26 bed sediment samples. Methylmercury was detected at concentrations ranging from 0.15 to 3.73 ng/g, and was detected above the background level of 0.49 ng/g in 14 of the 26 samples. The Work Plan will be revised to include this information.

CE Response (5/13/15) to BLM 4/22/15 Response: There is concurrence that a large fraction of the Hg is sparingly soluble. However, based on the SPLP and TCLP tests, even if a small fraction is soluble, the resulting concentrations can be quite elevated (>1 ug/L). Given that MeHg concentrations are typically only a small percentage of THg and are often 1 ng/L or less, there may be more than sufficient Hg capable of becoming available for methylation even though the percentage of the total solid phase Hg is relative low. A small fraction of a high Hg concentration could still provide amble Hg for methylation and subsequent bioaccumulation in biota to levels of concern.

The sediment MeHg values presented above showing values up to 3.73 ng/g are above national average values which are around 1.6 ng/g for rivers (Scudder, 2009) and the site-specific background value presented of 0.5 ng/g. Therefore, there appears to be some enrichment of MeHg at some of the sample sites.

BLM Response to CE 5/13/15 Response: Please see below.

BLM Original (4/22/15) Response (cont.): As indicated in BLM's response to General Comment #2, a bioaccumulation test using *Lumbriculus* will be performed. The *Lumbriculus* will be analyzed for key site-related contaminants, including methylmercury to provide a measure of the potential for mercury in Kuskokwim River sediment to be incorporated into the food chain as methylmercury.

CE Comment (5/13/15) on BLM 4/22/15 Response: MeHg production is often very spatially and temporally variable. The order of magnitude range of MeHg in sediment mentioned above illustrates this (0.15 to 3.7 ng/g). If the bioaccumulation tests are performed, it will be critical that they are representative of the range (or at least the high end) of MeHg concentrations at the site. Selection of sediment collection locations will be very important.

BLM Response to CE 5/13/15 Response: As agreed upon during the May 28, 2015 comment resolution call, analysis for methylmercury will be added for selected previously planned samples. As agreed upon during a call between Chris Eckley (EPA) and Mark Longtine (E&E) on June 1, 2015 to further discuss Kuskokwim River sediment investigative approach, analysis for methylmercury will be added to a total of fourteen (14) of the previously planned samples, extending from the area near the mine site to locations as far downriver as KR104 and KR105 as shown in Figure 2-4 of the draft Field Sampling Plan.

9. P. 3-6, Surface Water. The first sentence states "To address the lack of information on the quality of surface water at the site, including surface water impacted by flow of groundwater that is impacted by naturally mineralized bedrock and underground mine workings in the Surface Mined Area, the following

additional data will be needed:" There are methods to help identify/distinguish Hg between natural mineralized sources and mine waste, for example stable isotope Hg fractionation. While this technique has been in existence for about a decade, it is becoming commercially available for applications at sites like this where Hg from different sources needs to be identified. EPA can discuss this further with the group as necessary.

BLM Original (4/22/15) Response: Although the BLM is aware of the application of Hg isotope fractionation to potentially identify contributions from different mercury sources (e.g., calcines versus naturally mineralized rock/soil), it has not attempted to use this technique at the RDM due to anticipated difficulties presented by varying degrees mixing of the different Hg source types (calcines and naturally mineralized waste rock) throughout the Main Processing Area.

CE Response (5/13/15) to BLM 4/22/15 Response: End member mixing analysis (EMMA) may be a technique which could address the relative importance of different sources from mixed samples. The mixing of materials does not necessarily invalidate the use of stable isotopes to identify the percent contributions of different sources.

BLM Response to CE 5/13/15 Response: The final RI report provides a summary of the various natural and mine waste materials that may be sources of mercury at the RDM and the various media that either contain or may be impacted by one or more of the sources. The mercury isotopic makeup of the listed sources may be expected to vary from each other. Natural sources would generally be expected to vary in their isotopic composition from mine waste sources. However, some mine waste sources would be expected to have isotopic compositions similar to the natural sources from which they are derived. For example, waste rock and flotation tailings contain both Kuskokwim Group bedrock and hydrothermal mineral deposits. Furthermore, it is possible that any given source may itself exhibit some isotopic variability. For example, the cinnabar within a given structural level in the hydrothermal mineral deposits may be isotopically different from levels that are structurally higher or lower in the deposits. Surface water in Red Devil Creek may be impacted by all of the sources of mercury listed. As noted in the RI report, multiple factors and processes are expected to affect the fate and transport of mercury and other COCs at the RDM. Such factors and processes could themselves affect the mercury isotopic composition of the various sources and media. Considering the large number of sources that may impact surface water (and other media at the site), the potential isotopic variability between and within the sources and media, and the fate and transport processes that could affect isotopic composition of the sources and media, it is expected that an attempt to use mercury stable isotope analysis to distinguish between natural and mine waste-related impacts would require a very large effort that is beyond the scope of the present investigation.

10. P. 4-2, Sect. 4.2, 1st parg. The text notes that groundwater wells will be sampled immediately following their completion. It is recommended that all of the wells be drilled, well screens installed and wells completed prior to sampling any well. Sampling should then start at the well that was fully completed first to allow the aquifer some time to equilibrate prior to sampling.

BLM Response: The BLM agrees that the newly installed wells should not be sampled "immediately" following completion in order to allow the aquifer some time to equilibrate after completion and development. The text will be revised accordingly.

11. P. 4-3, Sect. 4.3, 1st parg. The text notes that the addition information gathered from 2015 sampling effort will be presented in the RI report supplement. Please provide clarification as to the purpose of this supplement. Is the additional data to be used for the final remedy that addresses groundwater, sediment in the Kuskokwim River, etc or is the 2015 data to inform the actions that are being developed in the current Feasibility Study?

BLM Response: The BLM plans to use additional information gathered from the 2015 supplemental RI effort to support development of final site-wide remedial decisions addressing groundwater and Kuskokwim River sediment. Soil data collected in the MPA from depth intervals below the tailings/waste rock will be used to refine our current estimate of depth/volume of material to be remediated through action being assessed under the current FS. A statement will be added to the Work Plan to indicate this. We don't anticipate that revising the total volume of material to be remediated will significantly impact evaluation of alternatives in the current FS.

12. P. 4-12, Sect 4.6, 3rd parg. It is recommended that more than two attempts be made before abandoning the sample location. It appears there are no back up locations anticipated so that after two attempts there will be no sample collected. While the QAPP for another site required ten attempts before abandoning the sample site, given the local conditions five attempts would be acceptable.

BLM Response: The 4th paragraph of Section 4.6 will be revised as follows:

"Based on past RI sampling efforts, it may not be possible to collect sufficient sediment from some proposed sample locations due to the swift current and/or the gravel/cobble nature of the bottom. It is expected that after the first or second deployment of the hand corer or van Veen sampler at a given location, the nature of the bottom conditions (i.e., gravelly/cobbly versus finer grained) will be apparent. In the event that the location is determined to be gravelly/cobbly, the sampling team will relocate, at the discretion of the E & E field team leader, to a secondary nearby location with potentially better bottom conditions for obtaining a sample. This new location will be selected based on similar location characteristics and using best professional judgment. The process of relocating to a backup location will be repeated up to three times, for a total of four sampling attempts per proposed sample location. In the event that a sediment sample cannot be obtained after such an effort, the station will be abandoned and the E & E project manager and BLM will be notified."

Field Sampling Plan

1. P. 2-5, Sect 2.2, General Objectives bullets. Recommend the addition of the bullet, Provide additional information on groundwater occurrence, depth and quality in the area of Monofill 2 and possible on-site repository.

BLM Response: The Work Plan will be revised to state that the planned groundwater sampling will provide additional information on the occurrence, depth, and quality of groundwater in the area of Monofill #2. See response to General Comment #2. In addition, the Work Plan will be revised to state that, although the planned wells in the Surface Mined Area are intended primarily to assess the potential influence of natural mineralization on groundwater upgradient of the Main Processing area, the resulting information may provide information useful for characterizing groundwater conditions downgradient of the possible on-site repository.

References

Babiarz, C.L., Hurley, J.P., Hoffmann, S.R., Andren, A.W., Shafer, M.M., Armstrong, D.E., 2001. Partitioning of total mercury and methylmercury to the colloidal phase in freshwaters. Environmental Science & Technology 35, 4773-4782.

Scudder, B.C., Chasar, L.C., Wentz, D.A., Bauch, N.J., Brigham, M.E., Moran, P.W., and Krabbenhoft, D.P, 2009. Mercury in fish, bed sediment, and water from streams across the United States, 1998–2005, U.S. Geological Survey Scientific Investigations Report USGS, p. 74.