On-Site Inspections (OSI) will be an important verification component to deter violations and help verify compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). An important aspect of these inspections will be the measurement of radionuclide isotopes created in a underground test (UGT). Inspection teams dispatched to a suspected site will need tools to determine the nature of the event. An aspect in this process is an understanding of the radionuclides that are likely to be available for sampling and measurement. Which radionuclides will be at the surface in a contained test will be a function of chemistry.

This work investigates the radiological signatures that are likely to be available at the surface of a UGT. An overview of isotopes created, and their fate during transport is presented. The fate of radionuclides is dependent on the chemical reactivity of the elements. Decay chains that go through noble gas precursors are likely to transport further in the environment, however other elements and compounds have inert chemistry and may transport far enough such that they may be available for OSI teams to sample and subsequently measure. Based on this analysis, a prioritized list of these signatures is presented.

The Table to the left is a modified list from Miley et al. This table identifies various isotopes identified in an accidental release from the NTS and prioritizes them by the frequency of observation.

The limitations of this list is that not all isotopes were observed, and access to the NTS was uncomplicated, it is biased towards short lived isotopes.

The detection of most of these isotopes can be described by the isotope (or a precursor) having a chemical compound with a low boiling point. This suggests that isotopes that have a chemical nature with a low boiling point and are non-reactive will transport in the environment and be available for OSI detection.

There are several exceptions to this analysis. The Nb/Zr pair and the higher lanthanides don’t have volatile compounds in their decay chain. These should only be observed in a significant vent of a UGT along with many other volatile and non-volatile fission products.

Ground water transport of radionuclides is another important mechanism. Groundwater can be sampled and analyzed for short lived radionuclides. The mechanism for transport of various elements is complex and each specific site is unique. In an attempt to generalize isotopes that may be observed at a well, it was decided to only focus on activation products produced by neutron fluence interaction with groundwater. These elements will likely transport as they are already dissolved.

Over 70% of the total activation in this ground water is 56Mn, with the next closest isotope being 40Ca at 13%. These two elements are common to every ground water and will likely be present in groundwater that has interacted with neutrons from a UGT.

Other activation products of groundwater that would likely be observed include 60Co, 54Mn, 108mAg, 110mAg, and 64Cu. Other activation products likely to be observed include anion activation products (not reported in the SRM) including 34Cl, 85Br, 33P and 35S. These elements transport well in groundwater.