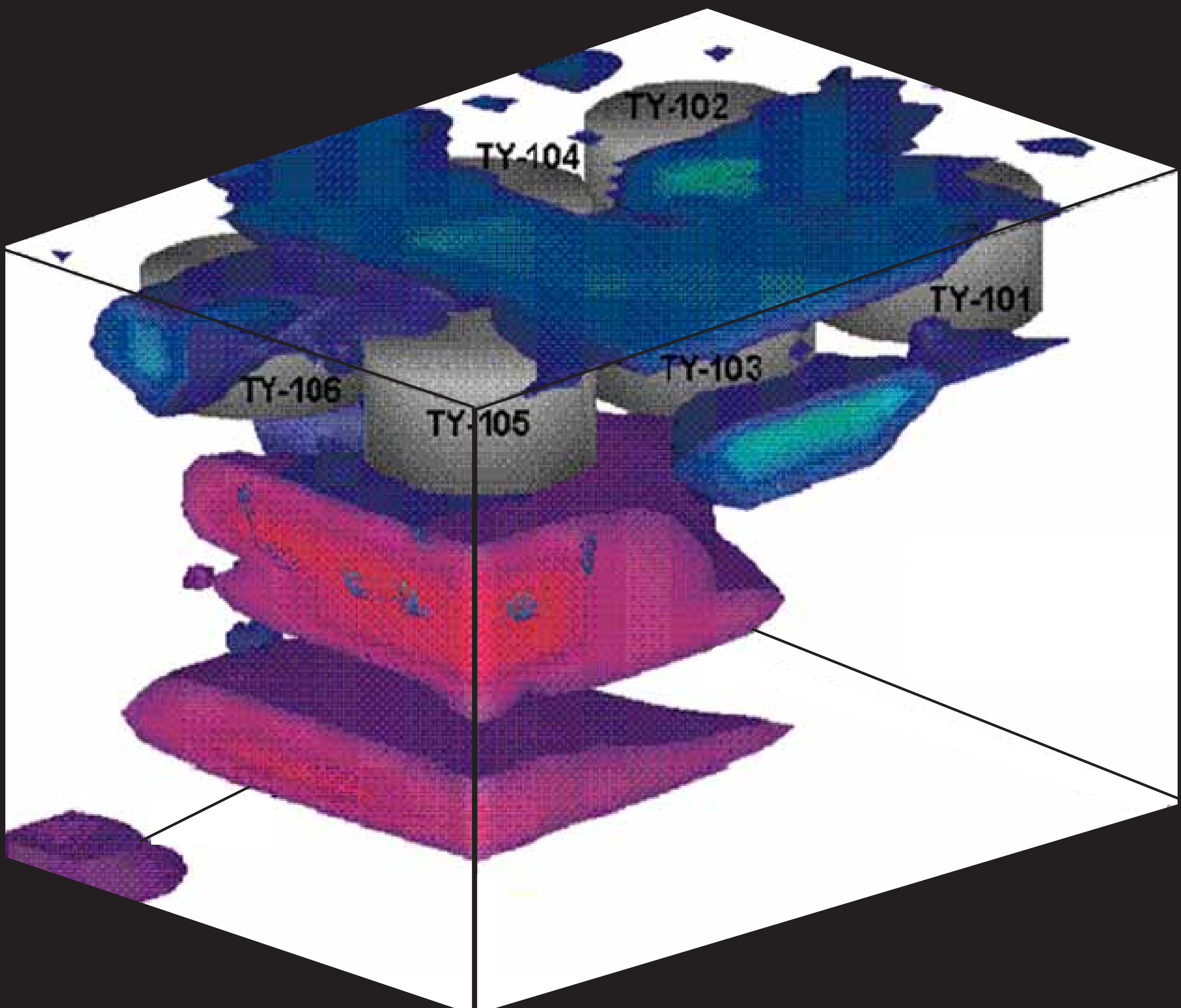
Recent Leaks From Hanford's High-Level Nuclear Waste Tanks:

USDOE's Failure to Monitor, Report or Characterize Tank Leaks



Prepared by John R. Brodeur, P.E., L.E.G
Energy Sciences & Engineering Kennewick, WA
for Heart of America Northwest
Publishing production by Priscilla Cole

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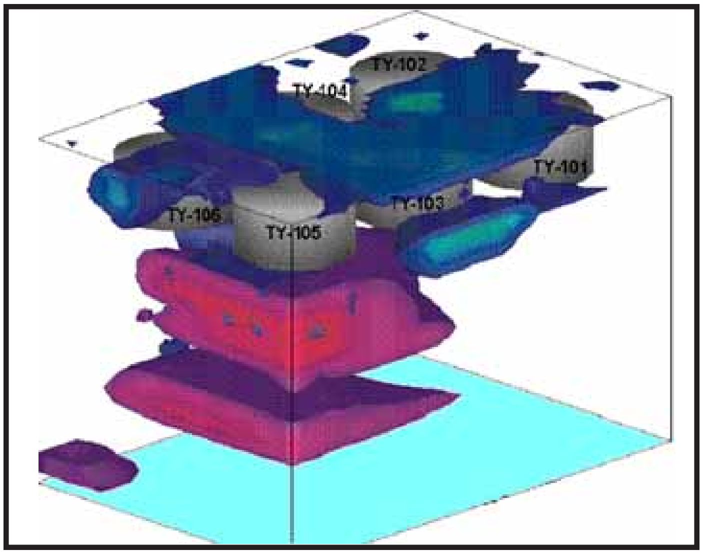

On the Cover:
Leaks from High-Level Nuclear Waste Tanks have reached Groundwater

Gamma radiation probes put down boreholes at Hanford's TY Tank Farm to study leaks. Blue plumes of radioactive Cesium 137 (^{137}Cs) and purple to red plumes of radioactive Cobalt 60 (^{60}Co) originated from TY Tank leaks and spills around the tanks. The depths of migration indicate that these plumes have reached groundwater. The figure illustrates behavioral trends of plumes where additional contamination will follow into groundwater. In 2002, a 50 fold increase in contamination was found between tanks TY-103 and TY-105, demonstrating the failure to report even recent tank leaks.

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Terms and Abbreviations

Closure: the legal term under hazardous waste laws for the condition which hazardous and mixed waste tanks (or a landfill) are required to meet to have their status ended as permitted hazardous waste units. Rules require emptying or removing wastes to the fullest extent practicable and ensuring that residual contamination does not pose risks above relevant standards (which may require caps, monitoring, etc… when all contamination can not be removed). See WAC 173-303-640(8) and RCW 70.105E.060(3).

DQO: Data Quality Objective – the formal process for determining what contamination will be investigated in the field, and the degree of reliability of the sampling. The DQO defining process is underway for characterization which will feed both closure permitting and the Tank Closure and Waste Management EIS (although the EIS schedule is on a fast track that will not allow much new data to be utilized).

GAO: Government Accountability Office – the investigative arm of Congress under the Comptroller General. GAO has issued numerous exceptionally well documented reports on USDOE ignoring or covering up contamination from tank leaks.

GJO: Grand Junction Office – the USDOE field office which was given responsibility in 1994 by then Secretary of Energy to implement the first borehole logging characterization of Hanford Tank Farms. GJO was given the responsibility to provide independence from DOE Hanford, where management had resisted the findings of the GAO and numerous whistleblowers to determine if tank leaks had reached groundwater and how far they had spread.

HWMA: Washington's Hazardous Waste Management Act (RCW Chapter 70.105).

RCRA: federal hazardous waste law (Resource Conservation and Recovery Act), including the Federal Facilities Compliance Act, which explicitly subjects USDOE's mixed wastes to state and federal hazardous waste law requirements and allows them to be enforced. 42 USC 6961.

SST: Single Shell Tank - RCRA and Washington hazardous waste law requires that all hazardous wastes, including mixed waste, be stored in double shell tanks with leak detection between the two shells, and the ability to contain leaks from the environment.

TCWMEIS: Tank Closure and Waste Management Environmental Impact Statement – replacing the prior effort to prepare a "Tank Closure EIS". Washington Ecology sued USDOE for failing to adequately consider cumulative impacts to groundwater in the Hanford Solid Waste EIS (Feb. 2004). In the January, 2006, settlement, USDOE agreed to expand the scope of the Tank Closure EIS to become the Tank Closure and Waste Management EIS and include an adequate analysis of the cumulative impacts to groundwater from all contamination sources in Hanford's Central Plateau (including the 200 East and 200 West Areas; and, the ERDF, proposed new IDF and US Ecology landfills). SEE Federal Register Feb. 2, 2006. USDOE's proposed decisions to leave waste in Single Shell Tanks and not to cleanup the leaks from tanks, as well as to use Hanford as a national radioactive and mixed waste landfill, are all to be based on consideration of the cumulative impacts disclosed in the TCWMEIS, due to be finalized in Feb. 2008.

High-Level Nuclear Mixed Waste Tank Leaks
How Much and How Far?

Findings of unreported leaks and recommendations for vadose zone characterization and contamination assessment data quality requirements for the T complex

Prepared by John Brodeur, L.G.E
for Heart of America Northwest

Executive Summary of Key Findings:

1. There are over 53 million gallons of waste in Hanford's High-Level Nuclear Waste Tanks and 30 million gallons remain in the Single Shell Tanks. US Department of Energy ("USDOE") admits that over one million gallons of waste has leaked from 67 confirmed or "suspect" leakers. Unfortunately, it is not known how much more than one million gallons has leaked. This report finds that USDOE's characterization program is designed in a manner as to avoid findings of additional tank leakage, to avoid characterization of the deeper contamination; and, that USDOE fails to implement real time leak detection monitoring.

   It is vitally important to know: what is in the soil; how far and how fast the contaminants spread; does this reality support or undermine the model for contamination spread used by USDOE; and, whether additional tanks are leakers or continuing to leak?

2. The Single Shell Tanks are all in violation of the most basic RCRA and Washington Hazardous Waste Management Act (HWMA) requirements for containment and monitoring. Federal hazardous waste law subjects USDOE's mixed wastes, including these tanks and the leaks from them, to federal and state hazardous waste law requirements and enforcement. State laws require retrieval of all wastes to the extent practicable – from both the tank system and cleanup of leaks from the soil. USDOE is actively considering proposals to avoid both of these – while failing to monitor or properly characterize releases. The failure to characterize releases makes it impossible to have credible analyses of USDOE's proposals to leave waste – either in tanks or the contamination already in the soil.

3. There has been a fifty fold increase, from 1996 to 2002, in contamination found in the one borehole tested between Tanks TY103 and TY-105.

- Retesting of the borehole between tanks TY-103 and TY-105 documented a rise in ^{137}Cs concentration right at the base of the tanks from an insignificant spec of about 1 pCi/g in 1996, to a continuous plume of about 50 pCi/g in 2002.

- The evidence supports the conclusion that one of the tanks has had a substantial release. Failure to report such a release, or a probable release, is a significant violation. Failure to consider the release and characterize it demonstrate the lack of credibility of USDOE's tank farm characterization program.

- Evidence includes the depth of the contamination, including the lack of near surface contamination, which makes it unlikely that the source is a pipe leak or borehole contamination.

4. There has been a fifty fold increase in contamination, from 1996 to 2002, between tanks TY-103 and TY-105; and, clear and convincing evidence that Tank TY-102 has leaked. USDOE has failed to report a release from TY-102, and failed to report any release from TY-103 and 105. Instead, USDOE and its contractor have declared the TY farm to be "Controlled, Clean and Stable".

5. USDOE has failed to designate tank TY-102 as a leaker and failed to act on the evidence. The most likely source of the vadose zone contamination at TY-102 is a leak from the tank with the second possibility of a leak from a subsurface pipeline. Either way, the tank should be listed as a leaker and treated as a leaker for purposes of waste retrieval, site characterization, monitoring and performance assessment. The Grand Junction Office report on the TY Farm (GJO, 1998) concluded:

- that the spectral gamma log "profile of the ^{137}Cs concentrations in borehole 52-02-11 (Fig 3) at depths between 42 and 53 ft is indicative of contamination from a subsurface source since there is no contamination above or below this interval."
- The contamination found "most likely resulted from leakage from tank TY-102".

  USDOE has ignored the evidence and its own internal evaluation which found it most probable that TY-102 had leaked.

6. During the tank leak designation process for TY-102, a representative from the Ecology regulator was present at one meeting. Ecology did not preside over the review process and apparently they did not approve the final determination for TY-102. Ecology has abdicated its regulatory responsibility. *The tank leak determination should be a regulatory process based on regulatory requirements, not a subjective decision by the owner and operator.*

7. DOE is determined not to understand the nature and extent of contamination in the vadose zone. This is not an unique opinion – the GAO reports show that USDOE was determined not to know. Little has changed over 26 years regarding USDOE attempting to avoid disclosure, or cover up, existence of tank leaks. In 1980, the DOE Inspector General found: "Hanford's existing waste management policies and practices have themselves sufficed to keep publicity about possible tank leaks to a minimum."

In 1989, the US GAO reported ("Understanding of Waste Migration at Hanford is Inadequate for Key Decisions"):

> "DOE does not collect sufficient data to adequately trace the migration of the leaks through the soils and studies predicting the eventual environmental impact of tank leaks do not provide convincing support for DOE's conclusion that the impact will be low or non-existent."

Little has changed since the GAO and Inspector General found that USDOE deliberately designed its High-Level Nuclear Waste tank leak detection and contamination characterization programs to avoid finding leaks and to support DOE's conclusion that the impacts of those leaks will be low. The evidence shows that this is dangerously wrong.

8. **USDOE's official characterization plan (RPP-7578) does not consider the deep ^{60}Co contamination at TY farm in estimating the leak volume**. It also does not consider the fact that ^{137}Cs has reached and may be accumulating on top of the Plio-pleistocene unit (borehole 52-06-05) and it misses the fact that the **data show both ^{137}Cs and ^{60}Co contamination has already reached groundwater (52-06-07).**

9. Having a high uncertainty on the tank leak volume is one thing, biasing it downward is another, using that conjecture to develop a site characterization plan is also a problem. *Bias should be towards a potential higher leak, when calculating potential cumulative impacts for an EIS and for risk assessment purposes for regulatory closure decisions.*

10. Under USDOE's TY tank farm characterization plan, USDOE will only pursue investigation of a potential leak from a tank if Cesium 237 is detected at concentrations of 10^5 to 10^6 picoCuries/Gm. This is a level so high that it was clearly chosen to avoid ever seeking to investigate leaks. Even the highest known leaks have not been at this contamination level. If a leak was at this concentration at 40 feet (the bottom of a tank) ten or twenty years ago, it would no longer be at this concentration since contamination has clearly moved and dispersed much more rapidly than USDOE's modeling predicted.

11. USDOE's characterization plans ignore both documented evidence of leaks and ignore the need to investigate deep contamination – which has spread much faster than USDOE predicted. USDOE and its contractor team are looking for 10^6 cesium at the base of the tanks in an effort to define the tank leak extent and volume. As noted earlier, such very high concentrations of Cs137 are not even associated with other confirmed leaks.

    This criteria is designed to NOT find leaks – echoing the GAO finding of 1989 that USDOE designed its monitoring program to not find leaks.

- For example, the penetrometer holes appear to be installed only to 40 ft (RPP-7578) and will miss the primary contamination regions

12. ***Boreholes should be installed to try to identify the source of some tank leaks or at least to confirm the tank leak status and documentation. This should be done at TY-102 as well as at TY-103, TY-105 and TY-106.***

13. Tanks are currently not monitored for leaks with external leak detection logging. *The vadose zone monitoring systems that were developed by the GJO for this purpose have not been used in several years due to a lack of support from health physics technicians*. This is also the reason that many of the in-tank monitoring instrumentation packages are also not working. That includes solid and interstitial liquid level measurements.

14. At the TY High-Level Nuclear Waste Single Shell Tank farm, **the data show that ^{60}Co and ^{137}Cs contamination has moved down deep and into groundwater**. The conclusions of the GJO report state:

    > "It is clear that ^{60}Co contamination has reached groundwater in this area of the TY Tank Farm, and it is likely that other more mobile contaminants such as ^{99}Tc have also reached groundwater"

15. In the assessment of the SX farm, it was determined that the occurrence of very high ^{137}Cs concentration plume as deep as 100 ft, which was the depth extent of the boreholes, indicated there was a great deal of contamination much deeper than previously acknowledged, and there was much we did not know about the extent of the contamination.

16. Single Shell Tank BX-102 has the third largest acknowledged leak at Hanford. Cesium 137 has definitively gone deep into the vadose zone. The implications of this leak are the same implications of the deep ^{137}Cs at the SX tank farm. That is, if the ^{137}Cs is deep, where are the more mobile contaminants like uranium? For the tank with the third largest tank leak at Hanford, there is no knowledge of distribution of contaminants through the highest concentration region of the plume. The fact that this was not identified in the DQO process is a testament to how broken the DQO process is at Hanford.

17. ***Before the C Tank Farm can be closed a significant amount of additional characterization work is required beyond what was done in the GJO reports to help solve the spatial data problem.*** The borehole depth and location limitations in the C Farm, severely limits the understanding of the nature and extent of contamination. These plumes need to be drilled out and traced down to find out how far the radionuclides have traveled and determine what contamination is present and evaluate the future risk to groundwater. Currently there are **increasing levels of nitrate, conductivity and ^{99}Tc concentration in the groundwater indicating a high probability that a good size plume of high mobility radionuclides is just now beginning to impact groundwater at C Farm**.

18. **Despite the lack of knowledge, failure to characterize releases and the lack of plans to properly characterize releases, in the Tank Closure and Waste Management EIS and in other decision documents, USDOE is proposing to to leave ten percent of the waste in the tanks and to avoid full characterization and cleanup of the waste that has leaked from the tanks. USDOE proposes to adopt plans for "landfill" closure of tank farms – which is a legal term referring to a plan where the tanks are declared closed without cleaning up the releases.**

19. A proper geostatistical structural analysis of the spectral gamma data completed as recommended in this report, will permit the quantitative assessment of the quality of the GJO empirical model and it will allow a determination of the quality of the spatial characterization of the various contamination plumes. It is a major step in the development of an understanding of the nature and extent of contamination. It is also a key item relative to the data quality objectives for the T complex work.

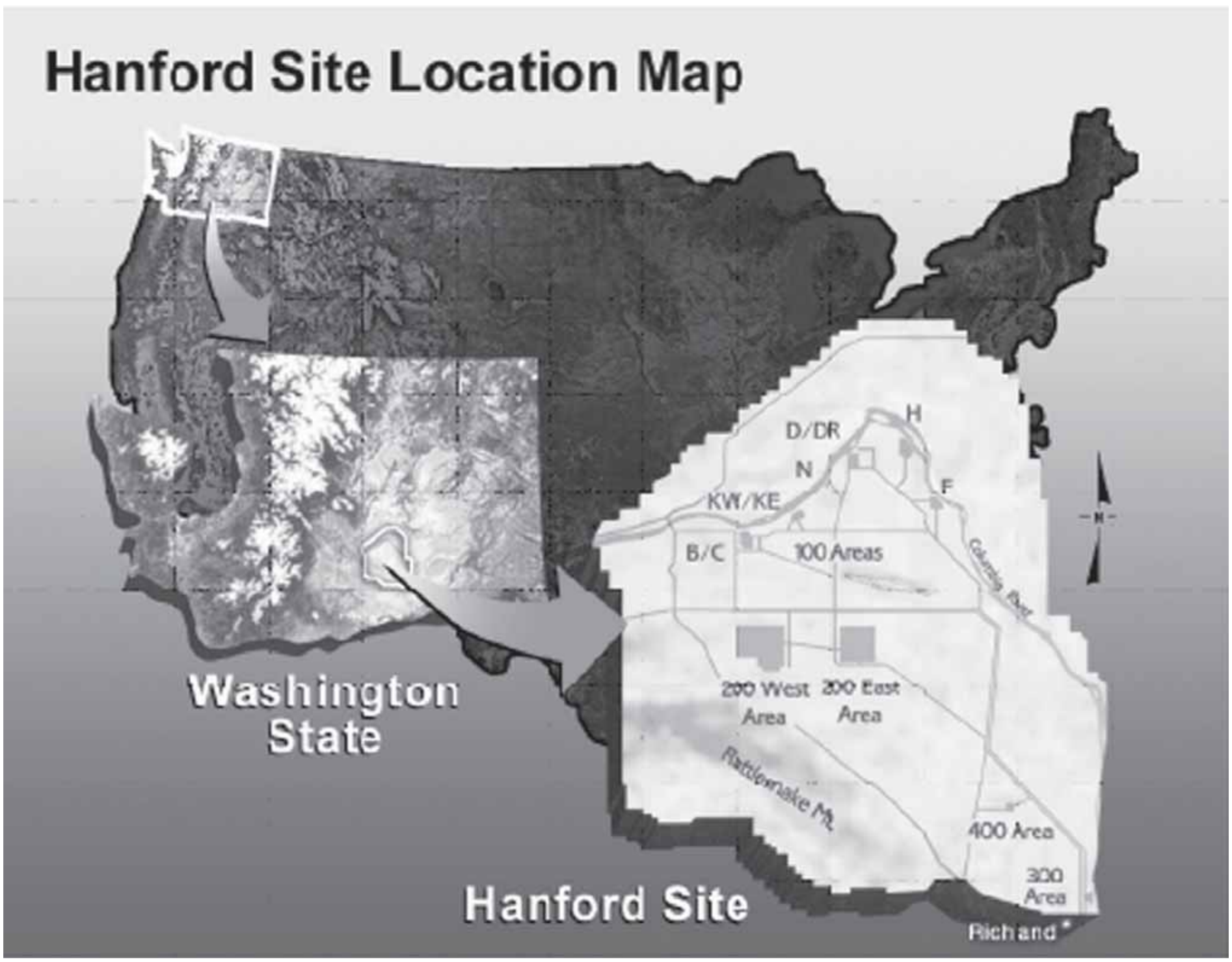
20. *The "spatial" characterization problem includes two primary data quality objectives:*
    a. *We need to determine where the contamination is; and,*
    b. *We need to determine how it is distributed in the vadose zone sediments*.

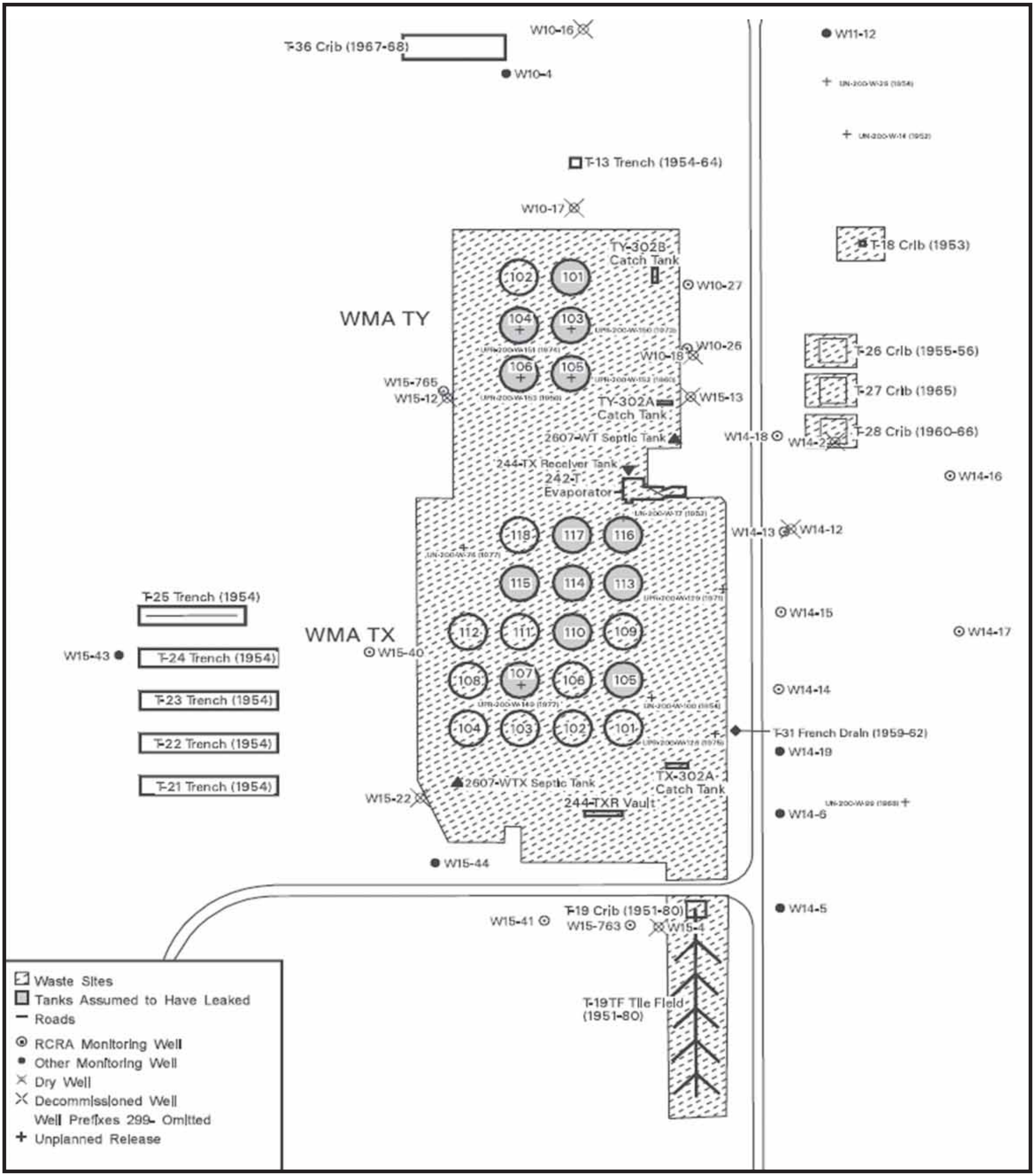
    Both involve determining the quantity or concentration of the contaminants in the sediment and developing an understanding of the correlation between the discrete spatial data points. The data required to do this can currently be obtained with either direct in-situ measurement methods such as borehole geophysics or it can be done with indirect methods such soil sampling.

21. *Estimates of curie content of leaks could be made using the empirical characterization data instead of basing those estimates on gross assumptions of the contamination distribution such as what the CH2M Hill vadose zone integration team has recently been done in Field and Jones (2005).* This recommendation is important for the Tank Closure and Waste Management EIS, where the cumulative impact analysis sought by Washington State and the stakeholders is highly dependent

upon estimating the contamination in soil by total Curies – as well as knowing where that contamination is. The use of leak estimates from inventory and tank level measurement, that have been shown to be manipulated to underestimate past leaks, will not get a credible estimate of the "load" of contaminants in soil; and, it can not show where the contamination went.

22. ***In order to properly complete the remediation or close a site under RCRA or CERCLA and also provide appropriate post closure monitoring of the contamination left behind, it is necessary to understand the nature and extent of the contamination in the vadose zone***. This must be done before attempting to determine what type of closure plans should be adopted. USDOE is seeking to avoid the characterization necessary to make decisions on closing mixed radioactive and hazardous waste tanks, including the investigation of whether specific tanks have leaked (and how much, what and how far the wastes have migrated.





Unshaded TY-102 indicates that USDOE does not consider this tank a leaker, despite evidence of new contamination spreading around and under the tank since 1996. This figure appeared on page A.87 in the Hanford Site Groundwater Monitoring For Fiscal Year 2002, prepared by USDOE.

High-Level Nuclear Mixed Waste Tank Leaks
How Much and How Far?

Findings of unreported leaks and
recommendations for vadose zone characterization and contamination assessment data quality requirements for the T complex
by John Brodeur, L.G.E. for Heart of America Northwest
March, 2006

<u>Background to this Report</u>[1]:
USDOE Admits One Million Gallons Have Leaked from 67 of Hanford's High-Level Nuclear Waste Tanks; will the upcoming "Tank Closure and Waste Management EIS" even address cleanup?:

The U.S. Department of Energy (USDOE) admits that over a million gallons have leaked from 67 of Hanford's "Single Shell Tanks" (SSTs) of High-Level Nuclear Waste. USDOE admits that the contamination is spreading through the soil (vadose zone) to groundwater and towards the Columbia River:

> "Sixty-seven of the single-shell tanks are known to have leaked an estimated one million gallons of waste to the surrounding soil."
>
> "The waste poses a serious safety concern to the public and to the environment."

"Report to Congress on the River Protection Project"; USDOE, 2001 (responding to requirement in FY 2001 National Defense Authorization Act) at ES-1.

> "The 149 single-shell tanks built until the mid-1960s had a design life of only 10 to 20 years. Waste leakage from those tanks to the soils beneath them was suspected as early as 1956 and was confirmed in 1959. By the late 1980s, 67 of these tanks were known or suspected leakers. DOE estimates that about 1 million gallons of waste had been released to the soils in the tank farms. ...
>
> "Approximately 150 square miles of groundwater at Hanford is contaminated with chemicals and radionuclide. Some of this contamination may be attributed to the 1 million gallons believed to have leaked from the storage tanks. ... Groundwater moving from beneath the Hanford tank farms will eventually discharge to the Columbia River. Estimated groundwater travel time for the fastest moving contaminant plumes from beneath the tanks farms to the river is 25 to 50 years."

"The Accelerated Retrieval, Treatment, and Disposal of Tank Waste and Closure of Tanks at the Hanford Site Environmental Impact Statement: A Guide to Understanding the Issues"; USDOE, Office of River Protection January, 2003, RPP-14193 at page 7.

Until November, 1997, USDOE continued to deny that leaks had reached groundwater, despite the gamma spectroscopy characterization program results showing that significant quantities of highly radioactive wastes had moved much deeper in the soil than USDOE had publicly admitted, and that the waste had reached groundwater. John Brodeur, author of this report, was responsible for that characterization effort –given responsibility for this program with fellow whistleblower Casey Ruud at the personal insistence of then Energy Secretary Hazel O'Leary.

In January, 2006, the U.S. Department of Energy (USDOE) announced that it would go through "scoping", for a second time, for its long-delayed Hanford High-Level Nuclear Waste Tank "Closure" Environmental Impact Statement. This notice resulted from a settlement with Washington State over the State's challenge to the adequacy of the related Hanford Solid Waste Environmental Impact Statement. In response to the State's challenge, the USDOE formally acknowledged that its groundwater analysis was inadequate and "not defendable"[2]; and, that it did not have an analysis of the *cumulative impacts* from current and future contamination in Hanford's Central Plateau soil and groundwater due to:

- waste that may remain in tanks;
- tank leaks;
- unlined burial grounds and liquid disposal units;
- and, USDOE's proposals to dispose of more waste in new landfills (including proposals to add more offsite waste than all the solid waste buried in the existing central plateau landfills; and, to dispose of the waste retrieved from the High-Level Nuclear Waste tanks).

Thus, on February 2, 2006, USDOE announced it would undergo a new "scoping" process for a new "**Hanford Tank Closure and Waste Management Environmental Impact Statement**."[3]

The proposed scope of this new EIS is breathtaking:

- How much waste to leave behind in Hanford's Single Shell Tanks of High-Level Nuclear Waste; and what are the impacts from leaving those wastes?
  - ☐ USDOE has 3 alternatives which it calls "reasonable", including:
    a) leaving ten percent of the 30 million gallons in the SSTs forever;
    b) retrieving 99% of the waste; and,
    c) retrieving 99.9% of the waste.

    pop quiz: which of the 3 choices above is the one which USDOE is required to try to reach under federal and state hazardous waste laws?
- What will be done, if anything, to characterize the releases / leaks from the tanks in order to project impacts and determine how much should be retrieved from both the tanks and the soil?
- How will retrieved waste be treated? USDOE addresses options that revolve around "vitrification" (solidifying as glass) of the highest activity (most radioactive) waste and a range of the lower activity wastes (LAW) – depending on how much is left behind or use of "alternative" or "supplemental" technologies.
  - ☐ How long it should take to treat these wastes under various options – which leave waste in tanks for varying amounts of time, and delay "closure" of tank farms (e.g., delay cleanup of contamination – if USDOE cleans up at all)?
- What are the impacts to groundwater and human health from burying in a Hanford landfill the vitrified or supplemental treated LAW (Low Activity Waste) tank wastes and the numerous highly contaminated 'secondary" wastes that come from treatment; and, disposing of the used "melters" and other equipment from the vitrification and supplemental treatment plants.
- What are the cumulative impacts to groundwater and human health from all the wastes buried, dumped, leaked in Hanford's Central Plateau in combination with the cumulative impacts from new disposal and future releases (e.g. from tanks and from new landfills, which will leak even if they have liners)?
- What are the impacts to groundwater and health from wastes in Hanford's massive Central Plateau Plutonium and Uranium processing facilities and the FFTF Reactor, under various alternatives for leaving those facilities in place or removing waste from them, or removing them entirely?

- What are the impacts from using Hanford as a national radioactive and mixed waste (mixed radioactive and hazardous chemical wastes) dump on top of the existing impacts from waste already in Hanford's soil and groundwater or to be disposed during cleanup?

What if significantly more waste has leaked from tanks, and there is contamination much deeper and in different areas than USDOE's models assume? If there are more wastes in the soil already and they have gone farther than USDOE claims, then a "cumulative impact" assessment – without new characterization and monitoring data – would lack any credibility. If more waste has leaked from tanks and it has spread farther, then it would be a tremendous error to base decisions on the data proposed to be used in the Tank Closure and Waste Management EIS, and proposed permitting processes. This report shows that decisions are about to be made with a deliberate ignorance about leaving waste in tanks, not cleaning up leaks or, adding more waste to soil in the belief that the cumulative impacts from current tank waste leaks are low.

The first and second bullets are the purview of this report, although the findings on characterization are relevant to the study of all impacts from contamination in Hanford's vadose zone (soil column). By examining past and current tank leak characterization efforts, this report gives vital direction for what characterization is necessary in order to consider the impacts from leaving waste in tanks or not cleaning up existing leaks. It also sheds important light on the need for monitoring and characterization during retrieval. This report began as an examination by John Brodeur, L.G.E., of the characterization of leaks and contamination from Single Shell High-Level Nuclear Waste Tanks to enable Heart of America Northwest and the public to effectively comment on the Tank Closure EIS, and proposed "closure" permits sought by USDOE for Single Shell Tanks. Secondly, the report is designed to serve the public need for independent information on the need for monitoring and characterization during "retrieval" of waste from the Single Shell Tanks.

Retrieval of waste to have the maximum amount of waste moved to newer Double Shell Tanks and for ultimate treatment involves adding large amounts of either water or waste from other tanks to "sluice" the hard saltcakes and residues from Single Shell Tanks. Characterization and monitoring are essential to know how much, and what, wastes are lost to the soil during "retrieval. This is essential not only to make sound decisions for retrieval – including whether to change retrieval methods if a leak is occurring – but, also to understand the cumulative impacts of the releases and make decisions about "corrective action" or cleanup.

Rather than wait for the Tank Closure EIS, USDOE sought to "close" individual tanks – and irreversibly leave waste forever in the tanks covered in a cement, as explained in a sworn affidavit by former Ecology Single Shell Tank unit manager, Richard Heggen:

> "Through 2004, USDOE continued to propose leaving significant portions of Hanford's High-Level Nuclear Mixed Wastes in tanks, to be covered in grout.
>
> "Covering tank waste in "grout" would be an irreversible action precluding future compliance with requirements to remove and treat all wastes to the degree practicable; and, preventing compliance with the tank closure requirements of WAC Chapter 173-303." [4]

Ecology informed USDOE that proceeding to attempt to "close" individual tanks without a permit, which would require an adequate EIS was not permissible. [5] Further, USDOE sought to proceed with retrieval without adequate leak detection – which meant that a leak would not be detected during retrieval. If traditional groundwater monitoring was used for leak detection (Single Shell Tanks lack the basic second shell with leak detection in the space between the two shells, which is required for all hazardous and mixed waste tanks), it might be years before the leak from a tank was detected - if at all, due to the inadequacy of the groundwater monitoring at the tank farms.

In May, 2004, Ecology wrote USDOE and insisted that the permit for retrieval include an external leak detection system ("extank-LDMM", meaning outside the tank monitoring): "DOE claims to have no plans to evaluate supplemental groundwater monitoring, and hasn't even considered this approach. To dismiss the possibility of supplemental groundwater monitoring without an effective ex-tank LDMM system is unacceptable, especially in light of the fact that these are declared leaking tanks."

USDOE has attempted to move forward with "closing" up to 124 of Hanford's Single Shell Tanks without either fully emptying them or characterizing and cleaning up the leaks. USDOE has sought to move ahead with a "landfill closure" of the tanks, which is a process under which characterization and cleanup of contamination from leaks does not have to occur.[6] Instead, USDOE proposes to simply cover the area of tanks with a cap – without knowing what is under the cap, how far it has spread and how fast and far it will spread.

Federal and state laws require characterization and removal of wastes and contamination (e.g., cleanup) to the extent "practicable" before a "landfill" closure plan may be used, in which some waste is left in place. WAC 173-303-840(b) and RCW 70.105E.060(6)(3). USDOE is actively contesting the applicability of these requirements. The scope of the Tank Closure and Waste Management EIS *does not include characterization and corrective action / cleanup* under the applicable regulations for each of the Single Shell Tank Farms.[7] As with USDOE's current budget and "baseline", USDOE proposes to use landfill closure, and make decisions to leave waste in tanks (up to ten percent) and in soil and groundwater without characterization and cleanup.

The Tri-Party Agreement has a milestone, or deadline, for completing "closure" of tank farm units. The specific requirements for "closure" under the state's hazardous waste law (HWMA[8]) are in rules at WAC 173-303-640(8). The rules require closure of interconnected tank system units, as opposed to piecemeal closure of individual tanks without consideration of the cumulative impacts of residues and releases – which the state's new Cleanup Priority Act echoes. RCW 70.105E.060(3). Characterization of residues, releases and potential future releases should occur pursuant to WAC Chapters 173-303 and 340.

Despite these requirements, USDOE is actively seeking to avoid Washington Ecology imposing conditions for characterizing the radionuclide releases from tanks under Ecology's permitting and cleanup authority.[9] This follows efforts to have the State relax or waive requirements for leak detection during retrieval. USDOE claims that Washington lacks any authority to require characterization of released radionuclide contamination and cleanup (corrective action) for radioactive contamination.[10]

Without characterization, it is impossible to assess the total cancer risk from future exposure to the wastes already in the soil and groundwater, or which will spread into the environment and groundwater. Thus, if USDOE succeeds in backing Washington State off of its RCRA/HWMA permit requirements for characterization of tank releases for the tank farms, there is no likelihood of meaningful assessment of the cumulative impacts and risks from USDOE's proposals to leave waste in tanks or to not cleanup contamination. Absent the assessment of cumulative impacts from characterization of all carcinogens that may remain in the tank systems, or which have leaked, the state is barred from issuing any closure permit and the environmental impact statement will not be adequate.

Washington's standard for what is an acceptable cancer risk from the contamination which will spread from the tanks (or from any hazardous waste release) is – at least – 50 times more protective than USDOE's own standard. If Washington does not use its cancer risk standard for corrective action, magnitudes more waste would be left in the tanks, soil and groundwater under USDOE's lax standards.[11]

Section 6(3) of Washington State's new Cleanup Priority Act (passed as Initiative 297, RCW 70.105E.060(3)) mirrors the existing requirements under Washington's hazardous waste law to require that all "practicable" efforts to retrieve residues and remove contamination from releases *prior* to allowing adoption of an alternative closure plan under "landfill" closure. Yet, USDOE's baseline and end state vision call for landfill closure of the tank farms without attempting to characterize and cleanup the million gallons of waste that has leaked from the tanks. And, the Tank Closure and Waste Management EIS proposed scope fails to include any alternative under which the tank farms are characterized and contamination cleaned up to the extent practicable. Instead, the EIS scope proposes landfill closure for tank farms – without characterization, leading to the question:

> *how can the proposed EIS adequately consider the risks to health, the Columbia River and groundwater if it is not preceded by meaningful characterization?*

The need for characterization – as shown in this report – is summed up by former Ecology unit manager Richard Heggen:

> "Unless Ecology considers the cumulative impacts from all residues and contamination in tank units, there is a grave danger that decisions to allow what may seem like a relatively small amount of waste in one tank to remain unretrieved, or contamination unremediated, would result in unacceptably high health and environmental impacts when similar amounts were left in 178 tanks and contamination allowed to remain spreading from numerous tank farm units."[12]

This report is designed to give the public the ability to provide comments on what characterization of leaks from High-Level Nuclear Waste Tanks is vital to include in the scope and draft of the upcoming Tank Closure and Waste Management EIS and proposed "closure" actions.

John Brodeur focused this report on the Single Shell Tanks in the T-complex Tank Farms (TX and TY tank farms) in order to provide a focused example of why, and what, characterization is necessary. By focusing on one tank farm, Mr. Broduer illustrates the potential for impacts from leaks to be gravely underestimated absent characterization, and how characterization should occur to meet the requirements for an adequate EIS (under both federal law, NEPA, and state law, SEPA) and for closure permitting decisions. [13]

The need for the public to have a guide to the question of what has leaked and what should be required for an adequate study of impacts from residues and leaks is vital in light of USDOE's efforts to declare tanks "closed" without knowing what was left in them, what had leaked from them, what may leak during retrieval, without emptying the tanks and without attempting to cleanup the leaks.

(Footnotes)

[1] Background Section prepared by Gerald Pollet, JD for Heart of America Northwest to provide lay readers with an overview of the problem addressed by this report and describing the report's purposes and proposed uses. It is not part of Mr. Brodeur's certified professional licensed engineering opinion, which is presented in the body of the report.

[2] Headquarters Review of the Hanford Solid Waste EIS, January, 2006; page iv.

[3] 71 FR 5655 February 2, 2006. "Notice of Intent to Prepare a Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site"

[4] Affidavit of Richard Heggen; US v. Manning; WA Dept of Ecology: Yes on I-297: Protect Washington; Heart of America Northwest, et al. ; February, 2006; U.S. District Court For Eastern WA; No.: CV-04-5128-AAM; ¶¶ CC, DD.

[5] September 13, 2004 Letter of Ecology (Jeff Lyons) to USDOE-ORP Roy Schepens.
[6] End State Vision (2004); and, Review of the EM Program. Also see affidavits of USDOE and TRIDEC in US. v. Manning.
[7] As proposed by USDOE in its February, 2006, Federal Register Notice and briefings to the Hanford Advisory Board; 71 FR 5655 February 2, 2006. "Notice of Intent to Prepare a Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site"
[8] RCW Chapter 70.105, which is the state counterpart to the federal hazardous waste law, RCRA.
[9] USDOE comments on RCRA Hanford Site-Wide Facility Permit, January, 2006.
[10] USDOE asserts that the state is preempted from regulating radionuclides (as radioactive source, byproduct and special nuclear material, under the Atomic Energy Act) even when released into the environment for purposes of cleanup standards and characterization. While RCRA, the federal hazardous waste law, preempts regulation of Atomic Energy Act radionuclides during storage, processing and even disposal – once they are released into the environment the preemption ends. Thus, the federal Superfund law, CERCLA, clearly subjects releases of radionuclides (and threatened releases) to cleanup, and allows for application of stricter state cleanup standards to apply to radionuclides.
[11] MTCA requires cleanup to a level such that the combined risk of all carcinogens to an exposed individual will not be such that more than one individual exposed to the residual contamination at the site will get cancer due to that exposure for every one hundred thousand persons exposed. WAC 173-340-700(5)(B). MTCA, along with CERCLA, considers radionuclides released into the environment to be hazardous substances which are carcinogens. USDOE has its own performance standard – not even an enforceable rule – allowing 100 mrem per year dose, which would be expected to cause 20 fatal cancers for every 10,000 adults exposed. DOE Order 435.1.
[12] Heggen Affidavit ¶II, January, 2006.
[13] As discussed in the Introduction (which follows), John Brodeur has written the report in the first person describing his professional opinion. Footnotes explaining legal requirements for tank closure, data requirements for risk assessment (including from Chapters 173-303 and 173-340 WAC),and any implications for human health risk assessment have been provided by Gerald Pollet, JD, who has extensive background in both the legal requirements for hazardous waste tank closure and characterization, and for human health risk assessment under Washington's Model Toxics Control Act (RCW Chapter 70.105D and WAC Chapter 173-340), under which human health risk assessment is required to be conducted for closure and corrective action for RCRA units, including mixed waste tanks, in Washington State.

Acknowledgements

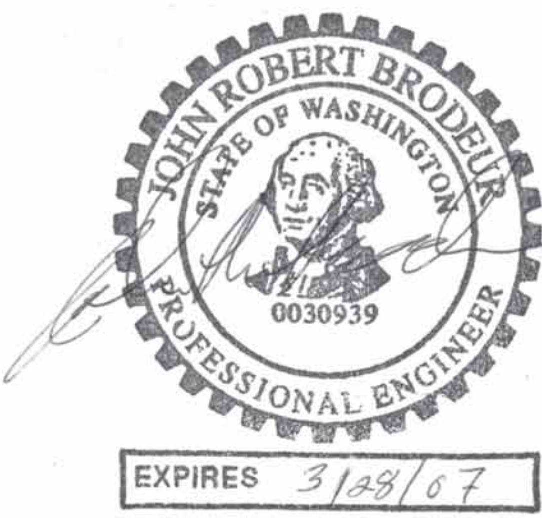
The author wishes to acknowledge the assistance received from Floyd Hodges, Ph.D. who provided a technical review of this document. Floyd is a hydrogeologist, recently retired from Pacific Northwest National Laboratory and as a past consultant to the Washington Department of Ecology, Nuclear Waste Program. His insight and understanding of more recent work at Hanford has allowed better integration of the past characterization work into comments directed toward the current environmental studies at Hanford.

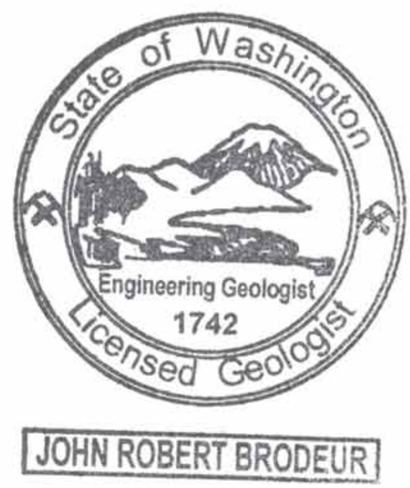
I also wish to acknowledge assistance received from Mr. Casey Ruud in helping me to accurately recall and explain details of past events related to the baseline characterization of the tank farms. Casey was burdened with the responsibility of implementing that characterization program and making it the unprecedented success that it was, all while working in a truly hostile environment. In the end, Casey was rewarded by DOE with being removed from his job. He now lives in the Washington's North Cascades.

Vadose zone characterization and contamination assessment data quality requirements for closure of the single shell tanks and cribs at the T complex

This report was prepared by:

John R. Brodeur, P.E., L.E.G
Energy Sciences & Engineering
Kennewick, WA





Prepared for:
Heart of America, Northwest
1314 NE 56th St. #100
Seattle, WA 98105

Executive Summary

This report is intended to provide input to three studies and projects that are beginning, or are planned, at Hanford:
1) a cumulative impacts assessment for all wastes on Hanford's Central Plateau that is being conducted as part of the preparation of a new Tank Closure and Waste Management Environmental Impact Statement (EIS);
2) a site characterization effort being planned for remediation of the groundwater beneath the 200 Areas under the CERCLA program; and,
3) the ultimate closure, including permitting, of Hanford's High-Level Nuclear Waste Tank Farms, which is a RCRA program under the state's Hazardous Waste Management Act.

The CERCLA program addresses the groundwater as separate Operable Units for different portions of the 200 Areas. For this report, I look at the T complex groundwater operable unit which is undergoing a Data Quality Objectives (DQO) process, which is the process used to identify site characterization data requirements.

These studies are integrated under the Tri-Party Agreement and will use the same site characterization data and likely the same site conceptual models. This report is intended to provide input to the EIS and the DQO process for the T-complex by reviewing some of the data and information available from the TY tank farm.

In this report I explain some of the basic data needed to characterize the nature and extent of contamination plumes in the vadose zone soil. This is explained and referred to as the "vadose zone problem". This is largely a spatial data problem, or a problem of a lack of spatial data. In simple terms, we do not have enough boreholes to understand how the contamination plumes are distributed in, and through, the vadose zone soil. We need to quantify the horizontal and depth extent of the contamination plumes. This spatial data problem also involves a lack of understanding of the contaminant migration pathways along with a poor understanding of past and current impacts to groundwater. Those impacts to groundwater remain unrecognized at several of the tank farms and are not addressed in many key Hanford site documents.

We need to know where the contamination is, how fast it has migrated and where it is likely to go in the future. The intent is to predict future risk or impacts via a performance assessment and ultimately determine what the future impacts to groundwater will be.

This report presents a preferred approach to obtaining some of the data needed to solve the spatial data problem. The recommended approach is to employ a borehole installation technique that uses a pile driver to drive a large diameter steel borehole casing (5" typical) down, deep into the subsurface and all the way to groundwater if necessary. This borehole installation could then be logged with a variety of borehole geophysical logging tools to obtain a direct measurement of in-situ soil and contamination properties. This method was demonstrated at the SX tank farm where it was used to confirm the accuracy of the empirical contamination model developed under the Grand Junction Office (GJO) baseline characterization project.

Marrying the pile driven borehole installation to qualified borehole geophysical measurements creates a low-cost site characterization method and an economical way to provide enough spatial coverage that there is at least some hope of solving the spatial data problem. This characterization method could be used to answer many questions about the distribution of contamination in all of the plumes at the tank farms and crib sites. Other characterization and monitoring methods, such as electrical resistivity monitoring and characterization, would be compatible and desirable additions.

I also explain some of the geostatistical methods that must be employed to confidently perform the site characterization, solve the spatial data problem and demonstrate that we understand how the contamination is distributed. Geostatistics offers the only way to characterize and describe the spatial character of the contamination plumes and it provides the only way to quantify the uncertainty associated with the spatial characterization. Essentially, geostatistics lets us quantify how well we know what we know or how much we don't know what we don't know. It provides a way to quantify the quality of the plume spatial characterization and determine if we have enough boreholes and enough data on the plumes.

I also review documentation on the most recent characterization effort at the TY tank farm in this report (RPP-7578). The intent of the review is to identify areas where the recent characterization effort failed to address key data needs so that these may be captured in the next round of site characterization. This review of the recent site characterization reveals that this problem of a lack of data on the spatial distribution of contamination has not been addressed or even recognized. The TY farm characterization provides an example of what it is that we don't know about the vadose zone contamination and what we must find out in a comprehensive the site characterization.

My review demonstrates the characterization effort for the TY Tank Farm (and others as well):

- ignores actual data that deep contamination has already reached and impacted groundwater;
- is misdirected in its focus;
- does not investigate deep enough into the vadose zone soil;
- uses the wrong instrumentation; and,
- lacks an essential monitoring component.

In sum, the characterization effort goes after the wrong thing for the wrong reasons, with the wrong instrumentation and, completely ignores the need for monitoring data. The characterization effort also ignores the deep contamination at the TY farm that has already impacted groundwater.

One of the conclusions of this report is that the biggest obstacle to performing an effective DQO process for the T-complex will be in overcoming the institutional bias, bad science and an apparent determined cover-up of data and information by the DOE and Hanford contractors. This statement is supported by numerous examples – including findings from prior US Government Accountability Office reports - that create a well documented historical pattern that cannot be ignored or denied. This pattern of obfuscation was established long ago as was documented by the DOE inspector general as early as 1980 and that mode of operation continues today at Hanford.

This report presents data showing that tank TY-102 has leaked, creating a contamination plume at the base of the tank. In spite of this, the tank remains designated as a sound tank. I provide a bit of the history of the tank leak designation process and show how the DOE and Hanford site contractors have performed and continue to support biased assessments of the tank leak data, how they invent implausible scenarios such as flooding, and use a tortuous logic to exaggerate the uncertainty of the data in an effort to <u>not</u> designate the tank as a leaker.

The leak designation process is highly biased. As a result, Hanford site personnel should not be the ones in charge of designating tanks as leakers or sound. That effort should at least be overseen and approved by the RCRA regulator. However, at this point it does not appear that the State (Ecology) is willing to accept this responsibility.

Tank TY-102 clearly leaked at some point in the past and it should be treated as a leaker for characterization purposes and for purposes of assessing environmental impacts. The fact that this tank is not listed as a leaker is a testament to the unbridled institutional bias so prevalent at Hanford.

During the review of the TY farm data, I also found clear evidence of a continuing leak from either tank TY-103 or TY-105. This evidence is from gamma-ray monitoring data from borehole 52-03-06, located between these two tanks. ^{137}Cs contamination levels in the soil measured in 2002, show a 50 fold increase from the baseline data obtained in 1996. That increase occurred right at the base of the tank which is precisely where it would be expected from a tank leak. This contamination is either from a new or a continuing tank leak or it is the result of the mobilization of previously leaked contamination. In either case this should have been recognized and treated as a new leak and it should have been investigated under the most recent characterization (RPP-7578).

Perhaps the most troubling aspect of this continuing tank leak is that the monitoring data showing additional leakage has been completely ignored by DOE and the CH2M Hill vadose zone integration team. It is not reported in the annual environmental reports and it does not appear to have been reported to the RCRA regulating agency (Ecology).

This report also provides data showing that some contaminants from the tank leaks have reached groundwater at the TY farm. This too was ignored by DOE and the CH2M Hill vadose zone integration team in the facility investigation report (FIR) and in the recent characterization effort (RPP-7578). The data showing contamination of the groundwater was dismissed by CH2M Hill as being some sort of instrumentation noise and it appears that CH2M Hill has accused the Grand Junction Office of synthesizing the data. Again, we find evidence of a determined cover-up of this data and information.

The implications of this groundwater contamination for the coming DQO for the T-complex and for the EIS are significant. Evidence of new shallow contamination increases at the base of tanks shows an urgent need for action –

before the contamination migrates. The evidence of groundwater contamination at TY Farm demonstrates that contaminants from the high-level nuclear waste tank leaks moves faster and farther than predicted by any of the contaminant transport models that are used by DOE to predict environmental impacts.

Another good example of the determined cover-up of data and information that is briefly discussed in this report is related to the uranium intrusion into the groundwater from the BX-102 tank leak. Some details of this cover- up are provided in this report but more information is provided by others.

After presenting multiple examples of a determined cover up of tank leaks, showing how and where biased assessments were used, and showing how data on groundwater and vadose zone contamination were ignored, I come to the conclusion that this type of action by the DOE and Hanford contractors will be the greatest obstacle to preparing a competent DQO for the comprehensive characterization of the tank farms. This will undoubtedly have great repercussions for the characterization of the vadose zone contamination at both the tank farms and crib sites.

It is clear that a considerable amount of site characterization data are required in order to produce the truly comprehensive characterization that is needed to assess future impacts and perform an environmental impacts assessment. Simply put, the first step to assessing the environmental impacts is to find out what current site conditions are. This will require several years to complete. Therefore, I recommend that the EIS should be delayed until the comprehensive site characterization is completed for all of the tank farms and for all of the crib sites.

Without a reliable and comprehensive site characterization, an assessment of the cumulative impacts of the new Integrated Disposal Facility landfill along with the tank farms, unlined burial grounds and the crib waste sites will not be possible. The DOE is not likely to agree with this or to support such a delay. As a result, I predict the new EIS will ultimately end up being challenged in the courts just as the latest EIS was.

Much of the characterization data that is needed for the comprehensive site characterization and specifically the data needed to solve the spatial data problem, could have been provided by the Grand Junction Office characterization program in the 7 years since the DOE and the CH2M Hill vadose zone integration team, integrated the GJO out of any involvement in the vadose zone characterization work at Hanford. The most recent characterization effort at the TY Farm by the CH2M Hill vadose zone integration team demonstrates that much of the last 7 years has been spent chasing windmills, rather than investigating reality.

Introduction

This document, provides an explanation of some basic site characterization requirements and data needs for assessing the groundwater contamination sources in the vadose zone soil at Hanford. The vadose zone is the region of unsaturated soil between the surface and the groundwater table. Contamination that leaked from the single shell tanks (SST) at Hanford migrated into and through the soil to differing depths, creating plumes of radionuclide contamination in the soil. In some cases those plumes are limited in extent and the radionuclides that were released are strongly adsorbed onto the soil particles. In other cases, the contaminants have migrated considerable distance and have already reached groundwater, and the radionuclides are still highly mobile in the soil. These plumes present significant future risk of adding additional contaminants to the groundwater.

Recommendations for characterization of the vadose zone contamination plumes are first presented and discussed in generic terms explaining what type of data are needed, why they are needed and how to obtain the data. Then, some of the data from the TY tank farm are reviewed and discussed and data needs specific to that facilities are identified.

The recommendations provided in this report are intended to support current cleanup processes at the tank farms. First, the Tank Closure and Waste Management EIS is being re-scoped to include a legally defensible cumulative impact analysis for all sources of contamination in Hanford's Central Plateau, under the terms of the legal settlement between Washington State and USDOE (SEE Federal Register announcement of notice for scoping of the EIS, February 2, 2006).

The second is for the groundwater beneath the 200 Areas that is remediated under a CERCLA cleanup process. That process is now developing data quality objectives for the site characterization at the T complex in the 200 West Area. Hence, an emphasis is made in this report to provide recommendations for that DQO process.

The funding provided to Heart of America Northwest by the Monitoring and Technical Assessment fund was initially intended to perform a review of DOE's tank farms Environmental Impact Study. Since that study was not completed by the DOE so this report is instead intended to support the coming comprehensive EIS.

Funding for this review only permitted an assessment of specific data needs for TY farm. However, the TY farm provides an example of the type of data needed and the level of characterization required for decision making at all of the Hanford tank farms. The intent of the TY farm review is to provide an example of what it is that we know about the groundwater contamination sources and what it is that we do not know and, therefore, what needs to be determined in the next attempt at site characterization.

The approach to site characterization recommended in this report and the method of answering some of the questions about the contamination distribution is a blueprint that is applicable at other tank farms and crib sites at Hanford. It is the process, not the facility specific recommendations that are important.

This is not a typical technical document that provides information and recommendations for the latest site characterization effort at Hanford. That approach has been tried before. Instead, I try to provide appropriate historical information on some of the subjects along with information and discussion of why or where past attempts at characterization have failed because specific data needs were not addressed.

The recommendations for characterization presented in this report are entirely my opinion although most of the ideas and data assessments are not. They come from others I have worked with both on the Hanford site and with non-governmental organizations.
Much of what is presented in this report is repeated from documents prepared under the Grand Junction Office (GJO) vadose zone project which I was involved with through most of the 1990's.

This report is written mainly in the first person singular as I consider this document an opportunity provided by the non-governmental organizations to explain a few things about vadose zone characterization that many have recommended over the last 20 years. The idea is to get these recommendations out on the table for inclusion in the T complex DQO process and in the tank farms EIS.

Please keep in mind that my intended audience for this report is not the DOE or DOE contractors. This report is written for those involved in oversight of the EIS for the tank farms and in oversight of the cleanup of the T complex groundwater operable unit under the CERCLA process. It is intended to give the reader enough information about the vadose zone contamination issues that they can provide qualified input to the DQO process.

In this report I concentrate on what is needed to assess the nature and extent of contamination beneath the waste sites and tank farms without regard for regulatory requirements. I look at what is required for the characterization from a data quality perspective and focus primarily on solving the spatial data problem.

I don't address data quality aspects of understanding some of the complex geochemistry, conceptual model development or predictive modeling problems. That is not to say that these other problems are less important than solving the spatial data problem.

What I present in this report is an approach to site characterization at Hanford that was developed in the mid-1980's. This approach involves using low-cost drilling and borehole geophysical logging methods to solve the spatial data problem and determine where the contaminants are and how they are distributed in the subsurface. Once that understanding is developed, characterization can be completed to target specific data needs such as geochemistry problems or assessing some of the more mobile radionuclides that are not easily assayed with borehole geophysical logging methods.

After presenting and explaining this approach to site characterization, I review some of work at the TY farm and discuss data quality objectives associated with the T complex groundwater operable unit that is now undergoing a DQO process.

The reader is likely to find that this report is difficult to follow and much too long. That is the result of all the diversion that is required to explain details of all the interrelated topics. Yet, additional time and resources will be required to produce a better report with a more comprehensive coverage of the issues. To really understand the context of the general and specific recommendations, you the reader are burdened with reading the entire report.

The Vadose Zone Problem

In terms of contamination mass, radioactivity or volume measures, the contamination in the vadose zone at Hanford represents the largest quantity of uncontrolled contamination that has been released into the environment. The vadose zone contamination also represents the largest source of potential future groundwater contamination. With that in mind, one might think that, next to groundwater monitoring, vadose zone characterization would receive a lot of attention. After all, some portion of what's in the soil today is likely to be in the groundwater and Columbia River in the future — which requires knowing what is in the soil (how much the tanks have leaked and what they leaked) and how fast the contamination is migrating.

Historically, USDOE has not been interested in knowing what has leaked from tanks and where it has spread; at least not according to the United States Government Accountability Office (formerly General Accounting Office) (GAO 1989, 1991, 1992, 1998). Those GAO reports are now up to 17 years old and one would wonder if the concerns identified in the reports are still valid.

The 1989 GAO report stated:

> "DOE does not collect sufficient data to adequately trace the migration of the leaks through the soils and studies predicting the eventual environmental impact of tank leaks do not provide convincing support for DOE's conclusion that the impact will be low or non-existent."

The 1998 GAO report is titled: "Understanding of Waste Migration at Hanford is Inadequate for Key Decisions" and the report provides appropriate details to justify the title. Apparently, over the nine year period, little was done to trace the contamination and define the extent of the vadose zone contamination. The 1998 report identified specific issues or uncertainties relating to the vadose zone contamination at the tank farms (GAO, 1998).

Despite the repeated findings of the GAO, and other independent reviews, a quick review of the most recent characterization work indicates that very few of those questions or concerns have been addressed.

Two years ago, the DOE called in a technical review panel to review the closure process for the C Tank Farm. At the public participation meeting with that panel, I noticed the opening slide of the CH2M Hill (CH2M Hill Hanford Group is the prime contractor at Hanford to operate the High-Level Waste Tank farms and retrieve wastes for the USDOE-Office of River Protection (ORP)) vadose zone team presentation showed a solid surface model of a vadose zone plume that was derived from gross gamma log data from some other tank farm.

The reason they didn't provide a visualization of the C farm contamination became apparent later in the presentation; the vadose zone team had not yet started the characterization of the contamination plumes. Yet, they were talking about "closing" the tanks. "Closure" is a legal term for not having any further cleanup work to do for a hazardous waste tank system. Federal and State laws require closing with an understanding of the impacts from all residues and releases (see WAC 173-303-640(8)).

The best data and representation of the subsurface contamination available at the time was from the baseline characterization of the C Farm prepared by the Grand Junction Office (GJO 1998). Apparently, the CH2M Hill vadose zone integration team chose not to provide the panel a copy of the GJO report on the C Farm vadose zone contamination and they chose not to use the contamination visualizations to describe the spatial data characteristics for their briefing to this expert panel.

The problem with this was that, while some of us are pondering over the limitations of the GJO, C farm data in terms of our understanding of the extent and distribution of the contamination, the CH2M Hill vadose zone integration team does not find it necessary to present and discuss any spatial data to a technical review panel that DOE has tasked with reviewing the closure process. Either the vadose zone integration team did not consider the spatial information provided in the GJO work to be important for closure or there was a conscious intent to withhold key information from the panel.

DOE and CH2M Hill vadose zone integration team were set to move ahead with closure of the C Tank Farm with little real understanding of the nature and extent of contamination. The review panel appears to have understood this as reflected in their findings (Kosson, et al. 2004). It appears that DOE's technical review panel agreed with the GAO assessments.

Before the C Tank Farm can be closed a significant amount of additional characterization work is required beyond what was done in the GJO reports to help solve the spatial data problem.

The problem that I refer to as the "spatial data problem" is twofold problem of a lack of data on the contamination distribution in the soil and an absence of a statistical analysis of the spatial correlation between data points. The borehole depth and location limitations in the C Farm, severely limits the understanding of the nature and extent of contamination and is the cause of the first part of the spatial data problem. These plumes need to be drilled out and traced downward to find out how far the radionuclides have traveled, to determine what contamination is present and to evaluate the future risk to groundwater.

The second part of the spatial data problem is due to a lack of a statistical spatial analysis that is normally performed under a geostatistical analysis. That type of analysis has not been completed for any contamination plumes at Hanford and is discussed below in the section on geostatistics.

Currently there are increasing levels of nitrate, conductivity and ^{99}Tc concentration in the groundwater at C Farm indicating a high probability that a good size plume of high mobility radionuclides is just now beginning to impact groundwater. Yet, we don't know where the bulk of that contamination is, what the concentration levels are, and what the risk is to groundwater.

The vadose zone problem is a lack of knowledge of the contamination distribution beneath the tanks and crib sites at Hanford. We don't know where the various contamination plumes can be found, we don't know subsurface soil concentrations and we don't know how the contaminants are distributed in the soil. Ultimately what is needed for a performance assessment for the EIS and for tank closure is an empirical soil inventory estimate.

This rather large data gap is caused by a lack of spatial characterization data on the plumes. This data gap prevents the proper modeling and assessment of current and future risk and it prevents us from closing the sites. That is, unless one ascribes to a closure process similar to that used in the 100 BC Areas.

We need to determine where the contamination is; and we need to determine how the contamination is distributed in the vadose zone sediments before we can close a site.
Both of these data needs involve determining the quantity or concentration of the contaminants in the sediment and developing an understanding of the correlation between the discrete spatial data points. The data required to do this can currently be obtained with either direct in-situ measurement methods such as borehole geophysics or it can be done with indirect methods such soil sampling.

To some degree, it does not matter what radionuclide profiles are assessed in determining the spatial distribution characteristics of the contamination. If we know the characteristics of the contaminant pathway to groundwater and we know where to find the different radionuclides along that pathway, and then, if we are able to confirm that knowledge through site characterization data, this knowledge would be a good foundation for a conceptual model and for a performance assessment. Without that information, the conceptual model is simply conjecture.

You will find later that the T complex has numerous specific areas where there is no understanding of the nature and extent of contamination at both the tank farms and the crib sites. The data quality objectives for the T complex must address this rather large data gap in the contaminant migration pathway.

The Regulatory Conundrum

In the past, DOE and its contractors have dismissed or resisted recommendations similar to those in this report related to characterization of the vadose zone radionuclide contamination and potential future groundwater contamination. These recommendations are likely to be ignored or dismissed by the DOE and contractors during the DQO process for the T complex because of the current regulatory stance that the DOE is self regulating when it comes to radionuclides as a result of the Atomic Energy Act of 1954. Neither the State (Ecology) or the EPA appear willing to challenge that stance.

In 1989 I requested a regulatory assessment of the vadose zone characterization and monitoring issue as a part of establishing the basis for development of the spectral gamma logging system. We were being told that the logging systems were not required because vadose zone characterization and monitoring is not a regulatory requirement for operational environmental monitoring or for the site wide environmental monitoring programs. The consequence of this was that the greatest quantity of contamination released into the environment at Hanford was not being monitored with the environmental monitoring programs at that time.

The analysis was completed in 1989 by subcontractor SAIC and reported (Borneman, 1990). The assessment explained that in order for a facility to be effectively remediated under either a CERCLA or RCRA process, a comprehensive assessment of the vadose zone contamination is required. The basic conclusion of the study is summarized by the following:

> "Only occasionally did specific mention of unsaturated-zone monitoring occur in the above regulations. However, it must be noted that regulations require the compliance with performance standards and only generally outline specific ways in which those standards are met. The regulations then compel unsaturated zone monitoring via one of three ways. One, they directly cite and require such monitoring. Two, they imply environmental monitoring and tracking of contaminant pathways in which the standard can only be met in part by unsaturated zone monitoring. Three, they require performance by deferring the standard to coexisting regulations (primarily RCRA)."

The study also went on to explain that post closure monitoring is required for any contamination left in place.

> "In order to properly complete the remediation or close a site under RCRA or CERCLA and also provide appropriate post closure monitoring of the contamination left behind, it is necessary to understand the nature and extent of the contamination in the vadose zone."

Shortly after that assessment was released, I requested modification of the environmental monitoring programs to include measurement and monitoring of the vadose zone contamination. Management realized what I had done with the regulatory assessment and subsequently prepared a letter with a new, short and sweet regulatory assessment (Handy, 1990) that impeached everything in the comprehensive assessment that was just completed by the consultant.

When it comes to imposing specific data quality requirements for the characterization of radionuclides in the vadose zone, my perspective tells me that the DOE and regulators do not see the forest through the trees. Under the current regulatory environment, there are no enforceable expectations or milestones for vadose zone characterization and monitoring, despite RCRA and CERCLA regulatory requirements to assess tank leaks or determine the nature and extent of contamination at the crib sites.

This is one of the primary reasons why in 2006, there still is no operating external tank leak detection capability or a vadose zone characterization and monitoring program for the T complex facilities. This also applies to other sites including many of the 100 Area sites that are supposed to have met interim clean-up criteria and be under a post-closure monitoring program.

The regulatory stance of a strict interpretation of regulatory authority over radionuclides is also one of the reasons why there still is minimal knowledge of the nature and extent of contamination at the US Ecology low level burial grounds (Brodeur, 2003 and 2006). In this case the US Ecology site may violate some of the basic NRC requirements for site suitability and monitoring such as 10 CFR 61.50 (a) (2) and 10 CFR 61.53 (a) & (d), by not having determined the nature and extent of contamination prior to licensing. There is also no monitoring capability that can provide early warning of releases from the site, violating 10 CFR 61.53 c & d.

For the US Ecology Site, adherence to the specific requirements quoted above is described with a tortuous logic of site boundary and exposure points so that the site is allowed to cause contamination of the groundwater before a problem is detected and certainly before any mitigative action can be taken. The WA State Department of Health (DOH) appears unwilling to impose regulatory restrictions upon themselves by allowing the State's burial ground for the Northwest Compact waste to operate while overlooking these apparent violations of NRC regulations. The irony of this is that nobody is asking the DOH to regulate radionuclides but simply to require a determination of the nature and extent of contamination and to monitor that contamination so that groundwater will be protected. Yet, state and federal laws do require cleanup of radionuclide contamination along with all other carcinogens, recognizing them as "hazardous substances" when released to the environment.

DOE is self regulating when it comes to radionuclides – *if properly stored and not released to the environment*. Yet, USDOE continues to claim exemption from RCRA regulation for released radionuclides as well. This bears heavily on the DQO process as it is typically implemented at Hanford. Most DQO meetings are densely populated with those who have little knowledge or understanding of site characterization or the quality requirements appropriate for site characterization. As a result, the primary focus or objective of the DQO ends up becoming one of simply identifying the appropriate regulations and then determining how to satisfy the specific regulations or how to employ a twisted logic as did Handy (1990), to justify not satisfying specific regulations. This type of process is not a DQO but simply a highly manipulated assessment of regulatory compliance.

It is stated in the documentation for the 100 Area DQO process that the 100 Areas site characterization work is conducted for the purpose of remedy selection. In other words it was what some believed was the minimum data needed for remedy selection. In this case the DQO process determined precisely what was needed to satisfy the regulatory process to justify a preconceived remedy selection. Instead of the DQO focusing on what data are needed to characterize the sites to a certain level of assurance and permit consideration of all remedies as well as the long-term monitoring aspect, the DQO focused on justifying the absolute minimum amount of data that would be required to justify implementation of their preconceived interim remedial action.

For the 100 Areas that meant removal of the top 15 ft of soil and not looking at the deeper, high risk contamination. The DQO ended up justifying a characterization that did not assess the contamination that is most likely to impact groundwater in the future and a site remediation was performed that does not assure the long-term stability of the contamination or the protection of the groundwater.

The DQO process might work fine if there were regulations requiring a certain level of knowledge of the radionuclide distribution, but this is not the case. DOE appears to be the ultimate arbiter when it comes to determining the level of knowledge of the radionuclide contamination distribution and justifying a cleanup action. This will ultimately prejudice and jeopardize any DQO process for the 200 Area groundwater operable units.

For those less familiar with the 100 Area cleanup, our review of the 100-BC Area cleanup is described in Brodeur and deBruler, (2005). For the entire BC Area, the knowledge base for the region of deep contamination beneath the cribs, that being the contamination between the bottom of the excavation (15 ft) and the groundwater, includes data from one test pit at the 116-BC-1 trench. That single data point was used to verify the performance of the "clean-up" and justify an institutional myth that the groundwater beneath the BC Area is protected. They have little data and a very poor knowledge of what was left behind after the "clean-up" of many of the 100 Area facilities. Because of the proximity of the Columbia River to the 100 Areas, this could be a bit of a problem.

A misdirected DQO process, inadequate oversight by the EPA and a political desire to demonstrate quick progress at Hanford, all appear to have contributed to the failure of the 100 BC Area "clean-up" to address the contamination in the vadose zone that presents the highest risk of future groundwater contamination.

These same mistakes must not be made in dealing with the 200 Area groundwater operable units. In the T complex DQO process, anyone proposing to do a comprehensive vadose zone characterization is likely to encounter significant resistance because of the current regulatory stance on regulation of radionuclides or at least a lot of questions about how much data is enough.

Without real characterization at scores of soil sites, it will be impossible to do a credible cumulative impact and human health risk assessment for the Tank Closure and Waste Management EIS.

Basic Approach to Site Characterization

The basic approach to site characterization promoted in this report is an approach that originated from the "Scintillation Logging Plan" for assessing the inactive crib sites in the 200 Areas (Last, et al., 1984). The idea is to use borehole geophysics to assess the spatial distribution of the contamination and monitor that contamination over time.

This may seem somewhat strange to those who know of my intense criticism of that early monitoring effort. I will say that the basic approach to monitoring is a good one but the implementation of the Scintillation Logging Plan was preposterous. That program was plagued with all around bad borehole geophysical logging and it was full of unsupported conclusions about groundwater contamination or the lack of groundwater contamination (more on this later).

The first step toward implementing the basic approach to site characterization at Hanford that is recommended in this report, was to fix the logging instrumentation problems and develop a qualified borehole geophysics capability. That was largely completed by the mid-1990's with the start of the vadose zone characterization effort under the GJO vadose zone project. The GJO project did not have a full suite of logging tools available for the characterization effort at the tank farms, but it had the critical one (spectral gamma logging) and other logging tools were being developed for implementation. Most importantly, the GJO project had a quality assured program with a comprehensive understanding of the limitations and error associated with the measurements as well as an understanding of the limitations of the characterization method.

The next step was to extract as much information as possible from several thousand existing boreholes on the Hanford site, assess the data and see what it tells. This was largely completed for the tank farms in a series of baseline logging reports for each tank farm (see GJO references).

The geophysical logging assessment of existing boreholes has not been completed for the cribs in the 200 Areas, and it was not done for the 100 or 300 Areas. These facilities have received spotty coverage at best in terms of boreholes logged and minimal assessments of the spatial characteristics of the contamination plumes.

The next major step in the proposed characterization scheme was to marry the borehole geophysics capability to an inexpensive and simple drilling method to drill out some of the plumes. This is required to allow more detailed characterization of the distribution of the plumes with the specific intent of answering some of the spatial question. The borehole logging would produce the actual data obtained from the subsurface and the low-cost drilling method would provide the required access to the subsurface plumes at critical locations.

This low-cost characterization method should be utilized to assess where the contamination is, where it has gone and where it will likely go in the future. This will effectively solve the spatial characterization problem and allow us to address other problems that require more expensive drilling and sampling methods. Drilling boreholes for detailed site characterization studies could come once we know where to drill.

Knowing where to drill will permit an economically viable means of performing the detailed, comprehensive site characterization where soil sampling is required to answer some of the hard questions. Solving the spatial problem first allows us to figure out where the contamination is or where it is likely to be and it lets us determine where to place more expensive boreholes required to complete the characterization.

To solve the spatial problem, it is necessary to first find the contamination plumes and then trace them out to determine the contaminant pathway as well as the distribution and extent. This must be approached by tracing the contamination from the groundwater back and up to the vadose zone sources and by tracing from the vadose zone sources down and out to discover where it enters or will enter the groundwater. The task at hand is similar to the task of chasing uranium roll front deposits. You simply need to follow the low-level contamination until you find the mother lode. That is what vadose zone characterization at Hanford is all about.
The combination of cheap drilling and borehole logging will allow this.

In the 300 Area, the interim groundwater cleanup strategy of allowing the uranium in the groundwater to dilute, is not working. This is because there are mobile sources of uranium contamination in the vadose zone that continue to contribute to the groundwater. There is little understanding of the contamination source plume distribution and even where the major plumes are located. As a result, the groundwater uranium contamination is not decreasing with time as predicted by the models used for the cleanup “interim records of decision.”.

When dust suppression water was added to the open excavations in the 300 Area, an almost immediate increase occurred in groundwater uranium. This is precisely the same thing that happened during site remediation work in several of the 100 Areas where the increases were attributed to a rise in the river level. (referred to as “bank storage” – the river level rising in spring increased the height of the groundwater, effectively washing contamination out from the deeper soil layers, rather than mobilizing it with water added from above.)

Understanding the spatial aspects of the contamination plumes will allow development of a groundwater remediation strategy that uses a qualified, empirically derived source term. This can be accomplished without drilling numerous expensive boreholes, each costing hundreds of thousands of dollars.

For the 300 Area, passive gamma logging to determine the concentration of various uranium isotopes is not as easy as assaying other hard gamma emitters but it is still not difficult with a fully qualified logging program. Drilling holes down to the relatively shallow groundwater depths in the 300 Area (approx. 50 ft) is also a very easy thing to accomplish in an economical manner.

I am not proposing that we drill out one hundred percent of the plumes in the 200 Areas. Then again, I am also not talking about the detailed characterization level that is proposed under the current 200 Area waste site groupings. Right now I would estimate that a detailed spatial characterization will be needed for over 50% of the contamination plumes.

That number could come down significantly if enough is learned during site characterization to justify not characterizing specific plumes. The problem comes in when determining when enough data is enough and when it is justified to not characterize a plume, and who is doing the justifying.

In the early 1990’s, DOE made an attempt to address some of the criticisms leveled by the early GAO reports. So, a decision was made to perform a reassessment of the T-106 tank leak. I was initially involved in what was to be a series of meetings to prepare the new characterization plan for T-106. That effort started with a plan to drill up to 10 new boreholes. In subsequent meetings, the 10 boreholes was pared down to 5 holes, then to 3 and 2 and finally 1 new borehole. That new borehole was intended to re-assess the nature and now only the “vertical” extent of contamination at T-106. The characterization effort was completed and reported in Freeman-Pollard, 1994. That one borehole cost several hundred thousand dollars to complete including drilling, sampling, performing laboratory analyses and putting it all together in a report.

With that kind of fiscal performance, I have little doubt as to why there has been little vadose zone characterization and monitoring at Hanford.

Application of Borehole Geophysical Methods

In the mid-1980’s a small group of us started looking at the vadose zone monitoring work at Hanford and it was enlightening to find that there were a few thousands of boreholes on the Hanford site. Most of the boreholes were drilled with cable tool drilling methods to permit soil sampling. Considering that it required about $50,000 to install a borehole at that time, we quickly turned our attention to determining how best to apply borehole geophysical methods to extract as much information as possible from the existing steel cased boreholes.

The borehole geophysical methods employed at Hanford in the 1980’s focused primarily on using gross gamma logging to assess whether or not the contamination had reached groundwater. Examples of these assessments are found in the three volume Scintillation Logging Plan mentioned earlier (Fecht, et al. 1977).

Unfortunately the gross gamma logging work had a few quality issues related to calibration, instrumentation, data acquisition, and data interpretation. This meant the data from these logs was not reliable. Also, there was usually only one monitoring borehole for each crib plume so spatial coverage was usually only on dimensional (downward).

On top of that, the contamination assessments were blatantly biased toward not identifying problems. If the gross gamma activity profile clearly showed that contamination had traveled all the way down to groundwater and there was no way to avoid it, the assessment stated that the contamination "may have reached groundwater" (underscore added) (Fecht, et al. 1977). All the while, the lack of any data, the limitations of the gross gamma logging method, and the limitations related to borehole locations or spatial density did not deter anyone from concluding that "the contamination at this site has not reached groundwater". Basically, the absence of data to the contrary from the monitoring program was enough to justify a conclusion of no groundwater impact, such that no data was good data. This was, somehow, the foundation of that program.

If there was a way to dismiss an activity profile as being borehole contamination or due to some other cause, the opportunity appears to have been taken with little justification. The borehole contamination theory has been extensively abused at Hanford for many years. It was the basis of the initial challenge to the GJO work at the SX Tank Farm.

In the mid 1980's the tank farms had a better gross gamma logging program in terms of instrumentation and operations but they too had problems relating to the data acquisition and calibration. The instrumentation system developed to satisfy requirements for leak detection were not effective for plume characterization and monitoring.

One of the problems with the tank farms program related to the fact that nobody really sat down and analyzed the data. Instead, the gross gamma log profiles were simply used to visually compare with a baseline log and determine if there had been an increase that could be an indication of a tank leak. This was a leak detection system where nobody really interpreted the log data and put it all together with an attempt to assess the nature and extent of the contamination or to determine if the groundwater is/was being impacted. As a result, the contamination of the groundwater at several of the tank farms, including the SX Tank Farm, went unrecognized. This takes us back to consider the quality of the environmental monitoring programs of the 1980's and even the early 1990's.

Incidentally, there was a reason why we went into the SX tank farm first under the GJO baseline characterization program. That reason was because Secretary O'Leary gave us specific instructions to go out and find her worst contamination problem at the tank farms. An initial assessment of the tank farms gross gamma log data told us the SX farm had the most extensive and deepest contamination.

I bring up this painful history of past monitoring programs to support my argument, that the vadose zone issue has had a long history of biased assessments, at both the cribs and the tank farms. With that kind of a history, the reliance at Hanford on borehole geophysics as a vadose zone contamination characterization and monitoring method was minimal.

One can imagine what would have happened if our initial assessments of deep contamination at the SX farm had been based on previous gross gamma log data. Clearly, for an unbiased assessment, there needed to be improvements in the data acquisition systems.

In the late 1980's, a group of us developed the instrumentation, calibration methods, and implementation techniques for the first down-hole gamma ray assay logging system that we called the Radionuclide Logging System (RLS). We chose the spectral gamma logging tool as the first geophysical logging tool to deploy because of the significant utility and applications at Hanford for characterization and monitoring in the steel cased boreholes. Spectral gamma logging was clearly the most useful tool for the vadose zone problem.

There had been some downhole spectral gamma ray assessments at Hanford in the past (Routson, et al. 1979) but this work suffered from bad calibration methods, inadequate spatial resolution and other problems that made the method less than effective as a routine or production logging method. A system was needed for logging several thousand existing boreholes. The RLS was the first production spectral gamma logging system at Hanford with the appropriate quality components to allow direct in-situ assay of subsurface contamination.

The RLS was used in a limited way in the early 1990's to assess the contamination at some of the cribs. This work involved logging only one borehole per crib at about 50 crib sites (see Brodeur et. al, 1993). These data and the assessments of the contamination were used as one of the primary data sources on the crib sites to help establish the waste site groupings and develop the site-wide remediation strategy under CERCLA (see DOE, 1996 and DOE 1997). Limitations of this work related to the fact that only one borehole per crib was logged and we were not able to perform any spatial analysis or correlation to begin addressing the spatial data problem.

The RLS was also used to assess the contamination around waste tanks C-105 and C-106 (Brodeur, et al., 1993). This application focused on determining if there was any evidence of a tank leak in preparation for a sluicing operation. This project demonstrated the utility of using the logging assay data to do a spatial analysis and develop a 3-dimensional empirical model of contamination around the tanks. This allowed anyone to see and understand exactly how the contamination was distributed around the tanks, allowing application of the characterization method for purposes other than just leak detection. In this case we were able to do a rudimentary spatial correlation of the log profiles and develop representative visualizations and try to distinguish the specific sources of contamination.

The most significant utility of passive gamma logging at Hanford comes about when multiple boreholes are logged and the data are put together and analyzed to produce a spatial assessment of the contamination as demonstrated by that first effort at the C farm. This low-cost assessment of the spatial distribution of subsurface contamination was the primary goal in developing the characterization method.

Unfortunately, beyond doing the special projects mentioned above, the RLS was not applied at Hanford to solving the spatial characterization problem.

Next to spectral gamma logging, the most important cased hole logging method is neutron-neutron moisture logging. It simply makes sense for plume monitoring and leak detection purposes to monitor the primary contaminant migration driving force (water). The neutron moisture logging method has been developed into an operational method and has been employed at some projects at Hanford. It has not been used extensively at the tank farms.

Other borehole geophysical logging methods which are applicable to the cased boreholes at Hanford include a suite of cased hole density logging tools. When interpreted together, these tools can yield significant formation and borehole properties data. A good summary of steel-cased-borehole density logging is provided in Crowder (et al., 1989).

Other active neutron source logging methods such as n-gamma and fission neutron logging also have applications at Hanford and some active neutron methods have been tested for various purposes but have yet to be properly applied at Hanford.

On the other hand, the current attempt to use active neutron methods to locate iron in steel caissons buried out in the 618-10 and 618-11 burial grounds is a good example of a complete waste of time and money. Apparently, the decision process to test this method did not involve obtaining sound advice from a qualified physicist.

Tank Farms Vadose Zone Application

In 1994, we were given an opportunity to implement spectral gamma logging at the tank farms. This opportunity came from the Secretary of Energy Hazel O'Leary as the result of the work of Tom Carpenter with the Government Accountability Project. Tom's effort and the support of other public interest groups, such as Heart of America Northwest, encouraged the Secretary to appoint Casey Ruud to a position with DOE at the Hanford tank farms which, according to her, was the biggest environmental problem within the DOE complex.

Casey was given the responsibility of launching the baseline characterization program at the tank farms. This was to be the first systematic assessment of the subsurface contamination around the tanks. Considering the scope of the contamination problem at the tank farms, it is surprising that it was not until 1994 that such an effort was undertaken and it is enlightening to know that it took the direction of the Secretary to make it happen at Hanford. The resistance to this program and to Casey's appointment with DOE is legendary.

The tank farms vadose zone project was set up under the DOE Grand Junction Office (GJO) to provide a level of independence that was required to produce unbiased assessments of the vadose zone contamination. The GJO had extensive experience setting up qualified geophysical logging programs and they had the best intellectual resources for the passive spectral gamma-ray assay technique.

This logging program was set up and operational in about 6 months with a qualified operation that included procedures, calibrations, data analysis methods, quality control and an error analysis (see GJO references). All of this was required to produce reliable data and accurate assessments of the contamination.

All of the boreholes in the SX farm were logged, reports were prepared for each tank (called Tank Summary Data Reports) and the data were put together in a Tank Farm Report (GJO, 1994).

During preparation of the SX Farm Report, groundwater monitoring data for the SX farm were reviewed that showed there was a “small” plume of ^{99}Tc in the groundwater on the southeast side of the farm. The plume was defined by one groundwater well that was sampled infrequently - so the size and spatial extent of the plume were unknown. Previous assessments of that groundwater contamination attributed it to other nearby cribs or to the U pond located west of the SX farm. Again, it seems that a tortuous logic was employed to explain this insignificant groundwater contamination away as being due to some other source.

In the assessment of the SX farm, we determined that the occurrence of very high ^{137}Cs concentration plume as deep as 100 ft, which was the depth extent of the boreholes, indicated there was a great deal of contamination much deeper than previously recognized, and we realized there was much we did not know about the extent of the contamination.

A non-conformance report was prepared with the concern that if a low mobility radionuclide such as ^{137}Cs could migrate at very high concentrations to depths greater than 100 ft, the high mobility radionuclides such as ^{99}Tc are likely to have reached groundwater.

At the time, DOE proffered and supported the borehole contamination theory as an explanation of the cause of the deep vadose zone contamination. We had dismissed that possibility because the high concentration regions originated down deep and there was no pattern of high contamination levels above that could act as a source. Besides that, there was very good horizontal cross-borehole correlation of the high concentration regions indicating the contamination was rather widely spread in various stratigraphic horizons.

We figured that if it looks like a duck and quacks like a duck, it must be a duck. But, we also stated that “The exact origin of the ^{99}Tc in the groundwater at the SX Tank Farm remains to be conclusively resolved under the RCRA groundwater assessment plan.”

Later groundwater data including a chromium detection in one well led us to conclude that:

“Now that chromium has been detected and a zone of high ^{137}Cs concentration has been detected near tanks SX-109 and SX-112, the SX Tank Farm is considered a source of groundwater contamination.”

In an effort to resolve this issue, DOE called together an expert panel to review our results. The panel decided that the best way to confirm the deep ^{137}Cs contamination was to drill some new boreholes.

For the new borehole drilling effort, we requested that they be installed as pile driven casings. That request was part of our underlying plan to utilize this drilling method to extend our spatial assessment of the contamination plumes. This initial drilling effort would be used to demonstrate the proposed drilling method.

The first borehole (41-12-01) was a disaster. It showed almost no deep contamination and it produced a significant amount of contamination carry-down during drilling.

We knew the borehole had been relocated prior to drilling to avoid a subsurface pipeline. But, it was many months later that we found the new borehole location was located precisely where our empirical contamination model showed there was no deep contamination. This borehole confirmed our model but we did not know it at the time.

We also found out later that for the first borehole, instead of using a downward pointing cone bit on the end of the casing string, a conventional “cone” bit was used for some portions of the borehole. This was the type of bit that is concave upward and uses the bottom circular rim of the cone to break up rock material when cable tool drilling. The concave hollow pocket of the bit retained contaminated sediment from a contamination zone above and caused excessive contamination carry-down during drilling.

A second borehole (41-09-39) was drilled in an appropriate location using the desired downward pointing cone bit. It encountered high levels of ^{137}Cs contamination down to 130 ft and there was no significant contamination carry-down during drilling. Although we didn't know it at the time, both boreholes confirmed our empirical contamination model. But, the second borehole demonstrated the viability of the borehole installation method.

Later drilling work at SX farm found some of the highest concentrations of ^{99}Tc in the groundwater that had ever been found on the Hanford Site. Those levels of ^{99}Tc in the groundwater were not exceeded until just recently when higher levels were found adjacent to tank T-101.

This historical fiasco at the SX farm is discussed because it demonstrates the utility of a spatial assessment of the subsurface contamination as well as the viability of our basic characterization concept of marrying the logging technology to an inexpensive drilling method to answer the spatial distribution questions. I use the word 'inexpensive' loosely here because our group had no responsibility for drilling those first boreholes and, with so much at stake, there were way too many people latched onto the project with charge codes for it to have been considered to be inexpensive.

The GJO baseline characterization project completed the logging of all of the existing boreholes at the tank farms and assessed the vadose zone contamination distribution at each farm. The set of reports that were created and the empirical subsurface contamination models that were developed continue to be the most accurate assessments of the spatial distribution of contamination that have completed at Hanford so far.

The GJO characterization program was the most successful program that many of us had ever experienced at Hanford and is a testament to the work of Tom Carpenter, Casey Ruud and the GJO staff. Unfortunately, one month after DOE Secretary Hazel O'Leary left, Casey Ruud was sent packing from DOE tank farms because as site manager John Wagoner put it, "we need someone with a stronger technical background" to manage the vadose zone program.

To many of us, (but strictly speaking for myself) Casey was clearly the most effective DOE program manager we had ever encountered. If one were skeptical of DOE's intent, one might think that the demise of the project had something to do with our assessments and our surprising conclusions about potential impacts to groundwater at several of the farms.

After Casey was dismissed, the GJO project was integrated out of the characterization work, marginalized and turned into a logging services contractor. No action was taken to extend the GJO project beyond an initial limited scope of the baseline characterization work at the tank farms.

The fact that the GJO characterization effort was never fully developed and employed to assess the nature and extent of contamination at the tank farms and crib sites is a testament to the DOE's desire not to know the extent of the vadose zone contamination. It also is one of the major obstacles to producing an effective clean-up effort in the 200 Areas and, in particular, at the T complex. The fact that at this stage of the cleanup surprises continue to come up, like the high ^{99}Tc concentration in the groundwater on the NE corner of T Farm, causes me to ask what else do we not know about the vadose zone contamination.

So, you the reader must ask, are we ready to do an assessment of environmental impacts with our current level of knowledge of the vadose zone contamination?

The GJO baseline characterization at the tank farms, was limited by the location and most significantly by the depth of the boreholes in the farms. Most of the boreholes were only drilled to 100 ft because at the time they were drilled, it was common knowledge that once contamination leaked from the tanks, it did not go anywhere (this despite the GAO's explicit findings to the contrary in 1989). Our assessments found there are many areas where the depth extent of even the low mobility radionuclides such as ^{137}Cs is unknown. Other plumes, such as the BX-102 plume and the big C-105, C-106 plume, extend beyond the borehole coverage area.

Relative to the C-105, C-106 plume, we don't know at this point, where to find the ^{99}Tc and other mobile contaminants that are just now beginning to impact groundwater. That is because the contamination pathway has not been traced from the source downward or from the groundwater up.

Not knowing current conditions of the nature and extent of contamination makes it difficult to predict potential future impacts. It will also continue to result in unpleasant surprises such as new groundwater plume discoveries.

The core concept that I wish to convey in this report to use for discussion in the data quality process for the T complex and for the coming EIS, is that it is imperative to get a handle on the distribution of the vadose zone contamination. The spatial analysis and assessment problem remains to be solved.

Drilling Methods

The recommendations in this report for solving the spatial problem depend upon having a low-cost drilling method.

As stated in the previous section, the preferred drilling method is that which we used to confirm the accuracy of the empirical model of the deep contamination at the SX Farm. That is, to use a pile driver and a cone point and simply pound the casing down into the formation. This creates a self-sealing borehole with a large diameter casing that supports the use of a variety of logging tools including the spectral gamma tool. These borehole installations can also be used for continued monitoring during closure and for post-closure monitoring which I discuss later in this report.

Boreholes installed as large diameter pile driven boreholes can be used to reach groundwater depths in the 200 East and 200 West areas. They can be used to sample groundwater although they may not comply with all requirements of a RCRA groundwater monitoring well. Depth limitations of the drilling method do not limit the ability to characterize the depth extent of the vadose zone contamination.

Other casing driving schemes are possible such as the use of a hammer drill or even a cable tool rig. But, the high impact pile driver method works well and does not have a significant adverse impact on adjacent tank structures.

A production drilling system should, at a minimum, include instrumentation of the production rate in distance/blow as well as the energy/blow.

During the borehole installations at the SX Farm in 1996 the vibration of the dome on adjacent waste tank (SX-112) was monitored with a suite of accelerometers. The amplitude and mode of vibration indicated minimal potential impact to the tank structure from drilling. However, the modal response of the tank dome indicated that that particular tank dome was fractured and was not behaving as a monolithic structure. A report on these measurements was never prepared because funding for that project was terminated shortly after it was determined that the data suggest there may be structural integrity issues with the SX-112 tank dome.

Determining what drilling method to use is the easy part. The hard part, especially at Hanford, is to get the cost of drilling and installing the boreholes down to a reasonable level. The first requirement would be to turn this effort into a project with the specific goal of getting the cost per borehole down to a level where a drilling crew can work continuously at a production level to make the drilling economical. Since I am not a project manager I cannot provide any qualified recommendations as to how to accomplish this. I do know some project managers who could accomplish this.

I used to believe that a competent drilling crew could install a borehole to 100 ft in one work day and do it for about $10,000. That estimate is based on past drilling experience in the coal fields of Wyoming and the uranium prospects in New Mexico where drilling is difficult and generally the only means of producing data.

In November of 2005 I discovered that my estimate of drilling cost is apparently off. I attended an EPA sponsored meeting to provide solicited public input for the DQO on the 200 East Area groundwater operable unit. When I began to discuss the need for vadose zone characterization data and I mentioned $10,000 per borehole installation, I was informed by the CH2M Hill's vadose zone integration team leader, Mr. Frank Anderson, that I was "looney".

Besides severely hurting my sensitive feelings with his name calling, Mr. Anderson effectively shut down any consideration of my recommended approach to site characterization. And, he demonstrated how the DOE deals with qualified input from stakeholder groups or anyone with ideas that do not conform with the preferred Hanford institutional approach. Now consider what is likely to happen in the T-complex DQO meeting.

In spite of this, I believe that if a project were created with the singular intent of delivering a low-cost borehole and an effective project manager was given the required authority by DOE, the cost per borehole could reach as low as $10,000 with a production rate of 100 ft per work day. I have no doubt that this could have been accomplished had the task been given to Casey Ruud even with his weak technical background.

Understand that requirements for the use of supplied air in the tank farms will seriously damage the efficiency of a drilling operation. Obviously a drilling project would have to start on the outside of the tank farm fence line.

A Short Lecture on Geostatistics

Geostatistics could be extremely valuable in any vadose zone characterization effort. For the approach recommended in this report, it is critical. Geostatistics is required to demonstrate that we know and understand the spatial characteristics of the contamination plumes.

From a simple standpoint, geostatistics will let you understand whether or not you are justified in connecting the dots between boreholes. With a better understanding, geostatistics may allow you to calculate reliable quantities. A very powerful application would be in determining how many boreholes are needed to properly characterize a plume with a specific error statistic. This sort of gets at the heart of data quality issues when discussing the spatial data problem. Even better, geostatistics can tell us where we don't know and where we need to find out.

The geostatistics was one of the weaknesses of the GJO models. Then again, not really. We did brag about the fact that our program EVS, used a geostatistical correlation to determine data averages in developing the plume images. In truth, it was only a little better than a classical statistical data averaging method such as what was used for the first assessment in C farm (see Brodeur, et. al 1993).

The GJO models were largely created by doing an assessment of the spatial correlations by laying out the logs and making sure the models correlated and made sense. In short, it was done by qualified people who specialize in that specific task with that type of data and know how to do spatial correlations. We had discussions and debates and made decisions about whether or not we could correlate the data between the boreholes or if we could attribute the contamination to something like borehole contamination. This was done in a determined manner to be objective about it.

The limitations of the EVS visualizations are that the geostatistical structural model was developed from the total data set and we had not had the opportunity to do an intensive geostatistical structural analysis.

Instead what happened was that others who apparently did not understand geostatistics, commissioned a geostatistical analysis of our data. This was done after Casey was fired and the CH2M Hill vadose zone integration team was limiting the involvement of the GJO project at Hanford.

This misuse of the baseline characterization data occurred without so much as a discussion with those of us who might know something about the data that we generated. As a result, the vadose zone integration team got a geostatistical study that was fixated on obtaining an answer in terms of "kriging" the results and getting a total curie content. (Goodman, 2000).

So, what is wrong with that?

The real utility of geostatistics is in the structural analysis of the data. In a proper geostatistical structural analysis you need to group the data, evaluate the anisotropy, assess directional changes, determine the ranges of the data for the data sets and model the data variance with a variogram. This all needs to be done on individual contamination plumes.

The data point averaging calculation or weighting process is called kriging. The kriging operation determines the contaminant concentrations at points between boreholes by minimizing the error. The basis of the kriging operation is the variogram, an example of which is shown in Figure 1. The variogram shows the magnitude of the difference between points (the variance), as you increase the distance between data points.

The point on the variogram curve where you reach the sill value on the Y axis is called the sill point. At the sill point, the variance is the same as the classical statistical variance of the entire data population. The X axis value of the sill point is called the range.
The range of the data shown on the variogram, is the distance below which you can demonstrate that the data are spatially correlated.

In a proper structural analysis of the data, one produces variograms for groups of data, different plumes and different directions and orientations, in an attempt to discover and determine where and when the variance is minimized, showing a strong spatial correlation. Once that is done, geostatistics offers methods to quantify the error of the data used to describe the contamination plumes.

A comprehensive geostatistical structural analysis was not included in the Goodman (2000) study. Instead, it appears the study focused on providing an estimate of quantity to come up with leak volume estimates and little effort was spent on exploring the data with a structural analysis.

The integration project expert panel understood there were problems with the Goodman study (IPEP,2000) and they pointed out some problems with the variogram statistics. But, they did not quite connect the deficiencies of the Goodman report to the minimal structural analysis and explain the value and importance of performing a geostatistical structural analysis.

A geostatistical structural analysis of the spectral gamma data can provide the best description of the spatial character of the contamination plumes. It can provide quantitative proof of the range of influence of the boreholes and help to quantify the characterization borehole spacing required for specific plumes and specific radionuclides using specified error statistics. This is particularly true with the spectral gamma baseline characterization data because the smallest data interval in the vertical direction is 0.5 ft. This high spatial data density provides excellent data resolution and aids in the development of accurate variograms.

Structural analysis of different plumes and differing groups of plume data will define the plumes to the point that accurate calculations of isolated plumes with few boreholes could begin to become a reality. Estimates of curie content of leaks could be made using the empirical characterization data instead of basing those estimates on gross assumptions of the contamination distribution such as what was done by the CH2M Hill vadose zone integration team as reported in Field and Jones (2005).

Please note that this recommendation is important for the Tank Closure and Waste Management EIS, where the cumulative impact analysis sought by Washington State and the stakeholders is highly dependent upon estimating the contamination in soil by total curies content – as well as knowing where that contamination is. The use of leak estimates from inventory and tank level measurements that have been shown to be highly manipulated underestimations of tank leaks, will not produce a credible estimate of the vadose zone source term that is used in the contaminant migration modeling and risk assessments.

The variogram or the data structural model, can also be used to produce a 3-d map showing areas of low and high uncertainty in the contaminant concentration determination. Such a map would tell you where to drill to reduce the uncertainty to a specified error level. This process would allow us to statistically say how well we know what we know or how poorly we know what we know for a particular area. ***A geostatistical structural analysis can provide a quantitative measure of the data quality relative to our understanding of the spatial problem.***

In 1996, during the SX Farm vadose zone expert panel review, there was significant discussion of the accuracy of the visualizations that we created from the borehole geophysics data (VZEP, 1996). Our empirical model showed a significantly broad plume of contamination beneath a specific area of the SX Farm. At the time, we were under the assumption that the first confirmation borehole was within the footprint of that broad plume of contamination. Since we did not find contamination in that first borehole, the assumption was that our model was in error and the contamination was, in fact, moving through the vadose zone as narrow vertical zones of preferential and tortuous pathways.

Some argued that our empirical models were totally unrealistic and the contamination plumes were not anywhere close to being as broad as our models showed. This may be part of the reason why the vadose zone integration team maintains a strong prejudice against using the GJO visualizations in their characterization work (RPP-7578).

Part of the misunderstanding arises from the fact that the GJO empirical models were prepared to show the contamination distribution at medium and high concentration levels as well as at very low concentrations. The low concentration level isoplumes primarily show where the contamination has moved under unsaturated flow conditions. These much more broad plumes were largely created after the initial release of the tank liquor by migration induced by soil tension.

The high concentration level isoplumes showed a much more narrow development with more isolated plumes and a more vertical distribution. This likely shows the extent contamination that occurred during the initial tank leak. These plumes show the occurrence of preferential tortuous pathway and minimal horizontal spreading. In fact, if geostatistical structural models could be developed for some of the different plumes in the tank farms, they are likely to show that the high nitrate Redox plumes have a much lower horizontal to vertical anisotropy than the plumes from the bismuth phosphate process waste. I argue in support of preferential pathways, as that is what the empirical data are showing.

When we found that the first borehole was drilled precisely where our model showed no contamination, we started to have more confidence in the spatial relationship that we used to develop the empirical model. As I stated above, the model was based on what was largely a classical statistical correlation that resulted from the subjective assessment and correlation of the log data.

The reason the GJO project was not given the opportunity to develop a comprehensive geostatistical structural model of our data was because CH2M Hill (or Lockheed) had already completed a geostatistical study (Goodman, 2000) that turned out to be of little value. As a result, it was concluded by those at Hanford who do not understand geostatistics, that geostatistics is of little value to vadose zone characterization.

In order to better define the spatial correlation to better understand the tortuosity (new word) of the contaminant migration pathways, a concerted effort must be made to define the geostatistical structure of the data. Such an effort must include drilling a line of very closely spaced boreholes across some of the contamination plumes. Considering the current attitude at Hanford toward geostatistics, obtaining the funding and authority required to do this is now very unlikely.

A line of boreholes with a maximum borehole spacing on the order of 5 ft would probably be adequate based on my qualitative understanding of the contamination distribution. The variogram generated from a horizontal line of sampling points can be compared to the variogram from a vertical borehole, offering a very accurate data set based on a 0.5 ft data spacing. Differences between the variograms will illuminate any horizontal to vertical anisotropy that is present in the contamination plumes.

A proper geostatistical structural analysis of the spectral gamma data completed as recommended above, will permit the quantitative assessment of the quality of the GJO empirical model and it will allow a determination of the quality of the spatial characterization of the various contamination plumes. This would be a major step in the development of an understanding of the nature and extent of contamination at the tank farms. It is also a key item relative to the data quality objectives for the T complex work and for all of the tank farms at Hanford.

Data Quality and Data Cover-up

To discuss data quality objectives for the T complex at Hanford, it is necessary to discuss the greatest obstacle to data quality and performing a comprehensive characterization at Hanford: documented cases of institutional bias, bad science and outright determined cover-up of data and information that challenges the accepted conceptual model.

After 20 years of work on the vadose zone issue at Hanford, I give up any pretense of objectivity relative to this issue. I have developed the understanding and opinion that the DOE is determined not to understand the nature and extent of contamination in the vadose zone. This is not my unique opinion for the GAO reports also show that USDOE is determined not to know. This is because the more that is known, the greater the problem becomes. Whereas, the less that is known or the more that they can justify not knowing, such as in the 100 BC Areas, the smaller the site remediation problem becomes. For the 100 BC Area, for example, the goal of the DQO was to identify the minimum amount of data needed to justify the preconceived remedy selection.

At this point in this report, I have presented my basic recommended approach to site characterization and alluded to a few documented examples of institutional bias and bad science. I now provide examples of the determine cover-up of relevant data and information to show how and why the DQO for the T complex could be affected.

The problem here is the high potential for the DQO to devolve into another argument about why it is not necessary to do a comprehensive characterization of the vadose zone contamination. This is another sordid tale of cover-up and deceit that is more recent.

In 2003, a report was prepared by the GJO vadose zone project staff with Dr. Stan Sobczyk as the lead author (GJO, 2004). This report provided a review of the results of logging for the B-BX-BY waste management area and it included an assessment of the BX-102 tank leak plume.

During the internal review of this report, it appeared there was some controversy as to whether or not the developing plume of uranium in the groundwater originated from the BX-102 tank leak as the GJO report indicated. Specifically, the report traced the uranium contamination from the BX-102 source area to the north and east, and down into the groundwater. This correlation was made using the borehole logs which were limited in spatial extent by the borehole depths and horizontal location. The big controversy was the question of whether or not the cross-borehole correlation could be made between the two north-most boreholes where the last one shows contamination reaching the groundwater.

The vadose zone integration team under CH2M Hill had previously stated in a facility investigation report or FIR (Knepp, 2002) that the uranium in the vadose zone was limited in extent and stable so that it would not reach groundwater within 500 years. Data and correlations in the GJO report indicated otherwise.

So, the vadose zone integration team resolved the issue by not publishing the GJO report. That decision apparently, was DOE's decision (DOE, letter 4/1/05). Dr. Sobczyk was subsequently laid off so he later rewrote the report and had it published by the Umatilla Indian Tribe (Sobczyk 2004).

DOE explains that they did not publish the original report because they "did not believe that the conclusions of the report were supported by all the data available" (DOE, letter 4/1/05). The letter goes on with some nonsense about geostatistics and the expert panel criticism of the Goodman (2000) geostatistical study. The point here is that Dr. Sobczyk's assertions of the uranium migration pathway were based on an interpretation of the log data and have nothing to do with the geostatistics or the method used to calculate the concentration value. Besides that, if the vadose zone integration team had properly integrated the project and allowed the GJO to do a proper geostatistical structural analysis on their data, there wouldn't be any question about the data correlations.

My primary concern with this is the abuse of the scientific method in the assessment of the vadose zone contamination. Rather than getting together like adults and resolving the issue or publishing the report as a differing opinion, the DOE attempted to cover up the report. At the time, the vadose zone integration team was well past the DQO stage in the characterization of the BX-102 plume and the FIR had been completed (Knepp, 2004) and Dr. Sobczyk's analysis was in direct conflict with the FIR.

Normally, the best time and place to bring out large uncertainties in something like the extent of the BX-102 plume would be in the DQO process. However, please keep in mind that the characterization for the B complex FIR (Knepp, 2004) was done under a DQO process and that DQO apparently did not identify the need to characterize the nature and extent of the BX-102 leak. The CH2M Hill vadose zone integration team conducted an exclusive DQO process where GJO baseline characterization project personnel were not asked to participate. This may have caused these uncertainties to be un-addressed in the DQO.

However, much like the old scintillation logging program, not knowing the extent of the uranium plume did not deter the vadose zone integration team from developing the conclusion that the uranium in the tank waste did not reach groundwater.
This poor level of knowledge or lack of understanding of the uranium plume distribution was the same level of knowledge on which the vadose zone integration team based their objections to Dr. Sobczyk's original report (GJO, 2004). Basically, a myth was created that the uranium was stable and had not reached groundwater. That myth was based on an absence of data to the contrary.

Isotopic analysis of the uranium plume data in question eventually confirmed the connection between the groundwater contamination and the BX-102 leak (Christensen, et al 2004).

However, there are still questions about the spatial distribution and analysis of the uranium plume. Those questions could easily be answered by defining the spatial distribution of the uranium in the vadose zone with a few low-cost pile driven boreholes.

Relative to the T complex DQO process, this problem of preconditioning the DQO with selective information and selective participation can only be prevented by independent analysis of all the data and information in the T complex. As a result, it will require significant resources to effectively participate in a DQO process. The problem of exclusive participation in the DQO process of both on-site and external organizations can only be corrected by DOE or the vadose zone integration team. These problems are likely to effect the proper development of a DQO for the T complex.

Let me now take the uncertainties of the BX-102 plume just a little further. The borehole closest to the BX-102 leak source (21-02-04) with the spectral gamma log shown in Fig 2 a,b,c, showed the highest vadose zone contamination concentrations in the B complex. This borehole was sampled when it was drilled in 1970. In 1976 the borehole was double cased and grouted because there was suspicion of borehole contamination causing contamination of the groundwater.

When the borehole was drilled, principal contamination areas were from 40 to 68 ft with less contamination found between 105 and 118 ft. In addition, sediment samples obtained during drilling and assessed with a hand held detector using a minimum detection level exceeding about 10,000 pCi/g, showed ^{137}Cs contamination in the formation sediment at discrete depths from 200 ft to 254 ft as well as in the groundwater. This deep vadose zone contamination was not discussed or included in Womack and Larkin (1971) and the groundwater contamination was explained as having originated from the "B cribs". No basis for that conclusion is provided in any of the documentation.

In the initial GJO assessment of the BX-102 tank leak (GJO 1997) we concluded:

> "^{137}Cs contamination is assumed to exist throughout the only deep borehole in the area (21-02-04), but the effects of possible borehole contamination are not known. However, because ^{137}Cs was detected deep in the vadose zone in several boreholes, the existence of a deep ^{137}Cs plume is a near certainty."

This report goes on to recommend this area be drilled out to determine the depth extent of ^{137}Cs immediately adjacent to borehole 21-02-04.

The implications of this leak are the same implications of the deep ^{137}Cs found at the SX tank farm. That is, if the ^{137}Cs is deep, where are the more mobile contaminants like uranium and ^{99}Tc?

So, here we have the second or third largest tank leak at Hanford (depending on who's data one believes) and there is no knowledge of distribution of contaminants through the highest concentration region of that plume. The fact that this was not identified as a critical data need in the DQO process for the FIR (Knepp, 2004) is a testament to the CH2M Hill vadose zone integration team's DQO processes.

The original GJO report also shows a small uranium anomaly in borehole 299-E33-41 just above the groundwater. The fact that we have deep ^{137}Cs contamination in the plume along with uranium in the adjacent groundwater well provides evidence that in the initial release of some 90,000 gal of tank liquor, the pore pressure of the liquid created a near vertical migration of contaminants downward and into the groundwater. It is likely that, both ^{137}Cs and uranium as well as other contaminants reached groundwater immediately after the leak occurred. It is also likely that the vadose zone contamination profile shown in the log of 21-02-04 is the result of deep migration of low-mobility contamination (^{137}Cs).

As pore pressures stabilized, uranium in the pore water appears to have migrated horizontally through the vadose zone sediments to the northeast and downward. This probably occurred under unsaturated soil conditions where the soil tension is a major controlling factor to contamination and moisture migration. The fact that the uranium plume was not detected in the boreholes to the northeast until several years after the leak supports the concept of unsaturated migration and, it is an indication that the uranium in the vadose zone may not be stable.

This information is in first GJO report (GJO 1997) including the recommendation that this area be drilled out to positively determine the nature and extent of contamination through the highest concentration region of the plume. In addition, the recommendations state:

"The contamination plume from BX-102 provides an excellent opportunity to study the migration characteristics of contaminants in the vadose zone at Hanford. This plume is fairly compact, it is intersected by many boreholes, and several different radionuclides are represented. This plume would be an ideal candidate on which to perform a geostatistical structural analysis. Drilling a series of co-linear, closely spaced boreholes would be required to assess the spatial variability of the contaminant concentrations."

Because GJO project personnel did not participate in the DQO process for the BX tank farm FIR the spatial distribution uncertainties associated with the BX-102 uranium plume were not identified and the application of a geostatistical solution to the spatial distribution question was not considered.

Leaker Versus Assumed Sound

My next example of a demonstrated cover-up has to do with the hot topic of whether or not to designate a tank as a leaker.

There are over 30 million gallons of high level nuclear waste remaining in the 149 single shell tanks at Hanford. The DOE's official estimate is that 67 of the tanks have leaked and the volume of waste that leaked is over one million gallons. However, both the number of tanks that leaked and the leak volume estimation are highly suspect and clearly not conservative.

There is also a great debate currently raging over DOE seeking to leave more waste in the SSTs than it is "practicable" to retrieve. "Practicability" is defined to be better than 99% retrieval, and is the standard for retrieval under federal and state hazardous waste laws and the Tri-Party Agreement (which says those standards are to be met).

In the Tank Closure and Waste Management EIS scoping documents, USDOE proposes to leave either 1% or 10% of the waste in the tanks. Yet, the impacts between these two choices vary dramatically depending upon whether it is 3 million gallons or 300,000 or 30,000 gallons that is left behind.

However, to understand the cumulative impacts and whether it is acceptable to leave anything more than one tenth of one percent, it is vital to understand what tanks have leaked, how far those leaks have moved in a few decades, and to understand what and how much waste is in the soil. If you accept the official DOE estimate of 1 million gallons of leakage, that is more than 3% of all the waste still in SSTs that has leaked.

This waste is in the soil, and some contaminants have already reached groundwater. This contamination can never be contained by DOE's closure proposals to add grout to the waste in the tanks. Knowing where the million plus gallons of contamination has spread belies DOE's models claiming that waste left behind will not pose severe risks or impacts.

To add to this contentious issue, first let me say that the tanks are currently not monitored for leaks with any external leak detection logging. The vadose zone monitoring systems that were developed by the GJO for this purpose have not been used in several years due to a lack of support from health physics technicians. This is also the reason that many of the in-tank monitoring instrumentation packages are also not working. That includes solid and interstitial liquid level measurements. ***For many single shell tanks, there is virtually no leak detection capability.***

Under normal RCRA regulations, this would be a clear violation of about 10 different requirements for monitoring dangerous waste storage tanks. But, because they are high-level nuclear waste tanks that are buried and they do not have the required double containment systems, these tanks violate the RCRA regulations anyway. WA Dept. of Ecology appears to have little authority to require leak detection monitoring of these non-compliant tanks and they appear to have little authority over the decision as to whether or not a tank is to be considered sound or a leaker.

The following story of the leak status of TY-102 is an example of DOE's approach to evaluating a tank to determine if it is a leaker. It demonstrates the historical institutional bias as well as bad science that must be considered in the DQO process for site characterization.

When the GJO report was complete on the TY Farm (GJO, 1998), we indicated that the spectral gamma log "profile of the ^{137}Cs concentrations in borehole 52-02-11 *(Fig 3)* at depths between 42 and 53 ft is indicative of contamination from a subsurface source since there is no contamination above or below this interval." In addition, the nearby surface contamination levels were very low and the contamination peak is right at the base of the tank with no contamination between the surface and the tank base. Finally, shape factor analysis indicated that the contamination was in the formation and not the result of the much overworked borehole contamination theory.

In the short version, our conclusion for TY-102 was that the contamination "most likely resulted from leakage from tank TY-102". Our assessment was based on our experience and understanding from analyzing the contamination data at all of the tank farms and from being able to recognize patterns in the contamination distribution.

The problem was that the tank was listed and continues to be listed as a "sound" tank (Hanlon, 1998) because of the inherent institutional bias at the tank farms.

To explain those accusations let me start with a little history.

In the late 1970's, a physicist named Steve Stalos identified serious problems and bias in the tank monitoring and leak designation process. His accusations resulted in his eventual resignation and an investigation by the DOE inspector general.
The inspector general report (DOE IG, 1980) concluded that they

> "… were unable to arrive at a judgment as to whether Mr. Stalos could reasonably have concluded on the basis of the statements made to him that there was a policy of covering up tank leaks. However, our inability to arrive at a judgment in this regard may be less important than it may seem at first glance."
>
> "The word 'cover-up' evokes pictures of people devising strategies and tactics aimed at concealing things which ought not to be concealed. But in the case of Hanford, had there been any officials desiring to minimize publicity about tank leaks, they would have had no real need to engage in conduct which might be considered questionable. This is because Hanford's existing waste management policies and practices have themselves sufficed to keep publicity about possible tank leaks to a minimum".
>
> "Our investigation led us to conclude that certain aspects of Hanford's nuclear waste management policies are in need of change, and we have made recommendations in this regard."

In this report the DOE Inspector General also describes what they called " A disquieting episode relating to the reclassification study" where Hanford management apparently conspired to not reveal a new report that recommended reclassification of six tanks as confirmed leakers. In other words, there was an intentional cover-up of data and information to the DOE IG. "There is in any case no doubt about the fact that these officials did not tell us about the report"… and that "the failure of these officials to have volunteered the report is to us a matter of disappointment and concern".

So, what does this history have to do with TY-102?

When we reported our evidence that TY-102 had leaked, tank farms management under Mr. Dennis Washenfelder called a meeting to evaluate our findings and a working group was formed to address this issue. At the start of the meeting Mr. Washenfelder suggested those responsible in the past for tank status designation knew what they were doing and that unless there is overwhelming evidence to the contrary, we should abide by the existing tank designations. I subsequently brought up the recent history explained in the DOE/IG report arguing that this is a clear indication of past performance and apparent bias toward not classifying tanks as leakers and that Mr. Washenfelder's inferred bias toward maintaining status quo was not necessarily appropriate.

An impasse was quickly reached and it was decided that a new tank leak designation process was needed. So, decision analysis consultants were hired to help put together a new process. The consultant's report and the basis of the new leak detection process is provided in Eppel (et al. 1989). This process was eventually turned into a tank farms procedure HNF-SD-WM-PROC-021 Rev 2A.

Tank TY-102 was put through the new decision analysis process as a test case in the development of the new procedure. This test case came out with levels between 75% and 95% probability that the tank had leaked.

Mr. Washenfelder then called a special meeting of select individuals on the technical group involved with the decision process. In that exclusive meeting, they came up with a new theory that the contamination originated from the surface and migrated down to the top of the dome and then down the side of the tank to the base where it spread horizontally to reach the vicinity of the detection borehole. This theory was called the umbrella theory for discussion purposes. The

TY-102 had an atmospheric condenser on the top of the tank at one time and they postulated that this was a possible source of the contamination.

The problems with that theory are first the problem that there has been no appreciable contamination found on or near the surface. The maximum contamination levels near surface are less than 1 pCi/g of ^{137}Cs while the subsurface contamination at the base of the tank exceeds 100 pCi/g ^{137}Cs. I don't know of any way to transport ^{137}Cs from the surface at low concentration so that it accumulates at a point at a particularly high concentration without leaving a contamination trail.

Secondly, if there was contamination released from an atmospheric condenser, ^{137}Cs would not be in the condensed moisture because it simply does not evaporate and show up in condensate.

Third, if contamination had migrated down as the umbrella theory postulates, it would be seen in the upper portion of the borehole and particularly it would be seen as a small spike at the shoulder of the tank.

There was no discussion of the validity of the umbrella theory and differing opinions on that theory were not present in the exclusive meeting that was held to create that theory. As a result, the umbrella theory remained the basis for the ratings by some of the "experts" on the leak designation decision process panel.

This brought out a major flaw in the new evaluation process. Some subject areas that the experts are asked to review are outside of the individual's area of expertise. For example, the process should not ask an expert on in-tank measurements to proffer an opinion on vadose zone contamination patterns. The new process provided no qualification of the opinion of the individual experts, nor did it assure that the individual "experts" are not highly biased toward not identifying a leak as has been the documented history at Hanford.

One expert who was on the TY-102 evaluation panel told me that he didn't think we should worry so much about whether or not a tank leaked because if it does leak, the contamination doesn't go anywhere anyway. I told him that that was not what the vadose zone characterization data show.

The problem was that the umbrella theory was cooked up by someone as a solution to the tank leak. It was strongly supported by management and then used, by biased experts working outside of their area of expertise to determine whether or not TY-102 had leaked.

A later TY-102 leak status determination was prepared by Mr. Washenfelder in a letter to DOE which states that the

> "… leakage from tank TY-102 is inconclusive. This conclusion is based on the fact that the changes in the Cs-137 contamination zone in drywell 52-02-11 have been episodic…". (Washenfelder for Umek to Kinzer 1998)

It goes on to postulate that the farm had flooded in the mid 1980's and that there was a correlation between the flood and changes in the gross gamma activity of the offending drywell. Because of this, the recommendation was to keep TY-102 as a sound tank.

One must realize that there is no evidence that the farm had flooded. In fact, during a meeting when this was postulated, a picture of a flood at T farm, to the north, was presented as evidence of a flood at TY farm. A site visit to the TY farm reveals that the farm sits about 2 ft above the surrounding area.

This looked to me like an attempted to confuse the matter by postulating the impossible or at least the very improbable. Even if there was flood at TY farm and a corresponding change in the borehole gamma activity, this would not be a surprise. It also would not have anything to do with determining the source of the contamination. It certainly did not come from surface contamination whether driven down by flood water or not.

In summary, the most likely source of the vadose zone contamination at TY-102 is a leak from the tank with the second possibility of a leak from a subsurface pipeline. Either way, the tank should be listed as a leaker and treated as a leaker for purposes of waste retrieval, site characterization, monitoring and performance assessment. Tank TY-102 is clearly looking like a duck and it is quacking like a duck but the DOE, Fluor Daniel and the CH2M Hill vadose zone integration team are all calling it something different.

The current status of the tank as a sound tank is a testament to the institutional bias that appears to continue at the Hanford tank farms as it was discovered in the late 1970's by the DOE inspector general.

During the tank leak designation process for TY-102, a representative from the WA State Department of Ecology regulator was present at one meeting. Ecology did not preside over the review process and apparently was not required to approve the final determination for TY-102.

The implications for the groundwater cleanup at the T complex and the data quality objectives are significant. The most immediate concern is for monitoring the contamination to assure the leak doesn't continue. The next concern is that the leak should be considered and prioritized under the TY farm characterization plan. It is also necessary to develop a vadose zone inventory for TY-102 for inclusion as a source term in the performance assessment. With only a single borehole, defining the spatial extent of the plume and estimating leakage quantity will be difficult without additional characterization data, ie. spatial data.

However, the biggest problem for the T complex DQO will be in overcoming the institutional bias and doing an objective site characterization when pertinent data and information are not disclosed or, like the TY-102 tank leak, the data are intentionally covered up.

Prejudicing TY Tank Farm Characterization

For the TY farm please keep in mind that this farm is considered to be "Controlled, Clean and Stable" under Tank Farms operations language. I am not certain just exactly what that statement means but I do believe that, just like nuclear arms treaties, there is some level of verification required to make that statement.

Data on the TY farm vadose zone contamination can be found in the GJO reports and in reviews provided in the facility investigation report or FIR (Myers, 2005) and in the facility characterization plan Crumpler, 2002 (RPP-7578).

First, let me start the TY farm discussion by prejudicing the reader with some comments on the characterization plan.

Crumpler (2002, RPP-7578) indicates that "Although contamination zones exist in TY tank farm, the only large volume estimates are associated with tanks TY-105 and TY-106. Despite the large volume estimate associated with those tanks, no evidence supports the assumption of a potentially large contaminant inventory in the vadose zone"

In Appendix B, this document goes on to further explain that "Although, the spectral gamma-logging data do not appear to support leak volumes of this magnitude specifically because one would expect to see ^{137}Cs gamma activity around 10^6 or 10^7 pCi/L in some drywells for a 55,000 gal leak." Please note that it is assumed the author meant pCi/g as the appropriate units of measure of activity per bulk soil mass. It is also assumed that 55,000 gal leak volume estimate came from the summation of estimates of TY-105 (35,000) and TY-106 (20,000).

This is bad interpretation of the TY farm contamination and a bad first assumption for a characterization effort. The first reason is that in the TY farm, a leak will not necessarily generate 10^6 or 10^7 pCi/g ^{137}Cs.

For many tank leaks, if you hit the center of the plume where the soil was fully saturated with tank liquor, you won't get ^{137}Cs concentrations that high whether the leak volumes are large or small.

A good series of holes from a plume with tank liquor that was relatively high in ^{137}Cs can be found at BX-111 in boreholes 21-11-03, 21-11-04 and 21-11-05 (Figs. 4, 5, 6). At a distance of about 35 ft between boreholes 21-11-03 and 21-11-05, the contamination decreased at the base of the tank from just under 10^5 pCi/g to about 2 pCi/g. Both holes show contamination below the activity criteria specified in RPP-7578 yet both are clearly an indication of a leak. Also note that the insignificant specs of contamination at 65 ft in 21-11-04 correlates well with the ^{137}Cs profile at 65 ft in borehole 21-11-03.

Several leaks in the U farm produced plumes with no ^{137}Cs including U-107 shown with the correlation plot of logs from 60-07-01, 60-07-10, 60-07-11 (Fig 7). In this case, increased leak volumes apparently will not raise the ^{137}Cs soil concentration to 10^6. If you believe the leak volume estimates in Hanlon (1998), the 4th largest leak at Hanford is the

55,000 gal leak from U-104 where the vadose zone plume is only defined by uranium contamination and does not show any ^{137}Cs.

Some of the U farm plumes are probably closer in ^{137}Cs concentration to those of the TY farm because of tank use history. At this point we can only really say that the log data suggests that the liquor from TY105 and TY-106 was remarkably lower in ^{137}Cs concentration than many other tank leaks. In fact, most of the ^{137}Cs in the vadose zone around the tanks is probably from the TY-103 leak.

Based on empirical spectral gamma log data, it is not so much the concentration of the contamination that is an indication of a leak as much as it is the location of the plume relative to the tank configuration (base elevation) and relative to contamination detected in other nearby boreholes (or not).

The other problem with the RPP-7578 leak designation criteria is the spatial distribution question. There are not enough boreholes in the TY farm and in particular around TY-105, to infer that there has not been a leak of 35,000 gal from TY-105 and 20,000 gal from TY-106. In short, a big plume of high concentration ^{137}Cs wasn't detected because there are no boreholes, not because the leak was necessarily smaller.

I predict that the shallow boreholes currently being installed in this area around the TY tanks will encounter contamination but it too will not show 10^6 pCi/g concentrations of ^{137}Cs. Leak volume estimates based on an assumption requiring high ^{137}Cs concentration to define the extent, will lead to incorrect and very low leak volume estimates.

If I am in error on this last statement I leave it up to those doing the site characterization to work out a spatial calculation with the data to demonstrate where my spatial understanding of this is wrong. Doing that would require the conduct of a geostatistical structural analysis, recommended earlier in this report. If that is not done, there is no basis for assuming a low leak volume estimate as a first assumption for the characterization.

With our current understanding of plume volume, spatial extent and contaminant concentration levels, if an isolated plume of ^{137}Cs is found at the base of the tank and there is no other plausible explanation of how it got there, it is a pretty good indication of a leak. Nothing is ever certain in this business but again when interpreting the vadose zone contamination data, many of us prefer to call it a duck if it looks like a duck and it quacks like a duck. This is why, with the absence of any boreholes adjacent to 52-02-11, or until additional characterization is completed, TY-102 should be designated a leaker.

The low leak volume implication for TY-105 and TY-106 in RPP-7578 also ignores the relatively high concentration of ^{60}Co found in the boreholes around the tanks. This contamination had to come from multiple sources to be so widely distributed and so deep into the Hanford formation and below the Plio-pleistocene unit. Or, it had to be one hell of a leak, perhaps about 55,000 gal. This may have been caused by a large volume of driving water. Perhaps the leaks from these two tanks are better defined by the ^{60}Co and moisture distribution because the ^{137}Cs concentration of the leaked liquor was relatively low. These are all suppositions on my part that must be assessed under the data quality objectives process for a comprehensive characterization before a valid performance assessment can be completed and before the tanks can be closed.

RPP-7578 does not consider the deep ^{60}Co contamination at TY farm in estimating the leak volume. It also does not consider the fact that ^{137}Cs has reached and may be accumulating on top of the Plio-pleistocene unit (borehole 52-06-05, Figures 10a & 10b) and it misses the fact that the data show both ^{137}Cs and ^{60}Co contamination has already reached groundwater (see the borehole log for 52-06-07 in Figures 11a & 11b)).

In RPP-7578, it appears that the low ^{137}Cs concentration and the lack of boreholes and spatial data is something on which they build a foundation for an argument of a low leak volume. Now, this argument does not change the official leak volume estimate, but it was used to justify the prioritization of the characterization tasks and to determine the characterization methodology used in RPP-7578. That prioritization resulted from the implication of minimal risk and no impact to groundwater in spite of the log data that clearly shows the groundwater had already been impacted.

RPP-7578 goes on to explain that the only information on a tank leak from TY-105 and TY-106 is found in the GJO tank farm report (GJO, 1998) as a quote from an informal memorandum (Warrent, 1960). RPP-7578 states that:

"A computer search of the RMIS data base failed to locate any documents written by J.M. Warrent. In addition, General Electric was the prime contractor in 1960. Atlantic Richfield was not onsite until the later 1960's. The validity of the "Warrent" reference appears to be highly questionable. Thus the CHG Tank Farm Vadose Zone team was left to formulate a "plausible" leak history for these two tanks".

So, either the GJO report fabricated the Warrent letter or the vadose zone integration team could have done a better job of integrating the GJO work into the preparation of RPP-7578 as well as the preparation of the report describing subsurface conditions at the TY farm (RPP-7123). Perhaps the GJO vadose zone project review comments on RPP-7578 did not address this issue, or possibly, in their zeal to integrate the GJO work out of the vadose zone work, the CH2M Hill vadose zone integration team did not request a review of their document from GJO.

When the GJO tank farms project began, most of the relevant files from the tank farms monitoring program were purposefully copied on a farm-by-farm and borehole-by-borehole basis. This was about a three day process. It was done in order to capture data and information that was being sorted and purged from the files at that time (1994). Included in the file data was the Warrent reference which is an informal memo and was exactly what was being purged from the tank farms files. That reference is probably still available to the integration team and it may still be in the files at tank farms unless it was purged. It is still in the GJO files and could be made available to the CH2M Hill vadose zone integration team if they really want it.

If this reference is the only documentation remaining on what are believed to be the 5th or 6th largest leak at the Hanford tanks, this is a problem for the T complex DQO. In fact, the RPP-7578 document is right in being skeptical about the tank leak volume. However, it would be preferable if the CH2M Hill vadose zone integration team didn't use the fact that they do not have monitoring boreholes around the tanks and that they do not have any documentation on the leaks as an excuse to bias the tank leak volume estimates downward. Having a high uncertainty on the tank leak volume is one thing, biasing it downward is another. Using this false conjecture to develop a site characterization plan compounds this problem.

The GJO report on TY-105 (GJO,1997 p 10) reports "Tank TY-105 was declared a confirmed leaker in 1960 because of a liquid-level decrease (Warrent 1960). Warrent estimates the leak rate was approximately 180 gal/day."

So apparently the leak was identified by in-tank level measures and it had been leaking for quite some time because elevated count rate was found in boreholes 52-06-05 or 52-06-07 in Sept. 1959. That left at least six months until the leak was discovered. At 180 gal/day, Heart of America estimates a leak volume of 32,850 gal. This is close to and supports the Hanlon document estimate of 35,000 gal.

The Warrant reference apparently did not distinguish between the tanks either. The leak was first discovered in the vadose zone and could not be assigned to a specific tank due to lack of monitoring boreholes. Apparently the volume and leak rate estimate calculations for both tanks were based on the duration and magnitude of unexplained liquid level decreases. At least it appears that early in-tank measures had something to do with the leak volume estimates. Going much further than that with any kind of conclusion is a problem.

This is not much to hang your hat on, especially for nuclear waste tank leaks. One would generally assume that better records would have been maintained. But then, we come back to the history of some of the tank leak issues (DOE/IG, 1980) and we must remember that the DOE is self-regulating relative to radionuclides so the amount of monitoring data available is minimal.

Regardless, the tank leak volume issue begs for additional characterization. But, that additional characterization should be done without biasing the characterization plan from the start as is done with RPP-7578.

On page B-17 of RPP-7578 an argument is proffered for producing high levels of ^{137}Cs from a tank leak. The argument is based on geochemistry studies at the SX tank farm (RPP-7884). Not having had the opportunity to review this reference I cannot comment on that study of the REDOX waste in the vadose zone soil. However, I will say that observations of the empirical spectral gamma data show that a geochemical model of the REDOX tank waste may not be appropriate at several farms including U farm and TY farm. Perhaps the difference is in the type of tank liquor and/or the nitrate molality.

In order to progress with a valid performance assessment and closure of the TY farm it is necessary to develop and confirm a valid conceptual model and to confirm the sources and leak volume estimates and to confirm our general knowledge and understanding of the mobility of contaminants such as ^{99}Tc, Uranium and even ^{137}Cs or ^{90}Sr. These are all data quality objectives that should be included in the future DQO process, prioritized and sorted out.

Current TY Farm Characterization Critique

Items for discussion and resolution under the T-complex DQO are revealed by assessing what the most recent characterization effort described in RPP-7578, did not do. I will start this discussion by saying that the most recent characterization effort at the TY farm a) it has a misdirected focus, b) it does not go deep enough into the vadose zone, c) it uses the wrong instrumentation, and d) it has no monitoring component.

It appears to me that the characterization plan goes after the wrong thing for the wrong reasons, with the wrong instrumentation and they are very liable to come up with the wrong conclusions.

The focus of characterization plan (RPP-7578) for the current effort at the TY farm is on locating the tank leak sources in the shallow vadose zone. Yet, the CH2M Hill vadose zone integration team is looking for 10^6 cesium at the base of the tanks in an effort to define the tank leak extent and volume.

There is nothing wrong with installing a few boreholes to try to identify the source of some tank leaks or at least to confirm the tank leak status and documentation. This should be done at TY-102 as well as at TY-103, TY-105 and TY-106. The problem is that the current characterization is primarily developed and focused on proving an incorrect assumption rather than on simply performing an empirical evaluation of the nature and extent of contamination and then developing conclusions.

When they intercept only moderate levels of ^{137}Cs in the new boreholes, their conceptual model of low leak volumes will be confirmed, the characterization will end and the performance assessment will justify no additional characterization due to low leak volume and low risk. There could even be an attempt to close the farm without determining the nature and extent of contamination. This very thing was done at the 100 BC Area. For the TY farm, the coming DQO offers the opportunity to prevent such a scenario.

In addition to providing near-source distribution information, the characterization should also be focused on assessing the distribution of ^{137}Cs and ^{60}Co above, below and within the Plio-pleistocene and get a handle on the radionuclide inventory in the shallow and deep vadose zone. And, there is also the monitoring concern.

That is a lot to ask for and it obviously could not have been accomplished under the limited characterization effort of RPP-7578. However, this work must be done before the TY farm can be addressed in a performance assessment or an EIS. So, the best approach is to identify the unknowns or that which must be investigated, in the DQO process and proceed with a characterization program that considers all of the data needs and will lead to application of appropriate characterization methods to address those data needs.

Primary uncertainties in the TY Farm and the focus of data quality requirements should be on answering questions about the big unstable plume on the south side of the farm. This appears to be an active groundwater source where we have poor coverage of both groundwater monitoring wells and vadose zone boreholes.

The GJO tank farm report illustrates the problem at the TY farm quite well (GJO, 1998, illustrations provided as Fig 8 & 9 in this report). Details of this model are hard to understand without reviewing the logs so allow me to explain.

There are several large ^{137}Cs plume at the base of the tanks that appear to have originated from leaks of T-103, T-105 and T-106. The extent of the ^{137}Cs plume is poorly known because we have relatively poor borehole coverage in this area. This is also why we do not know the exact sources of those plumes.

The visualizations of Figures 8 & 9 show the ^{137}Cs plume at a low isolevel or a low concentration. This is used to show its approximate horizontal and vertical extent of the contamination. The blue ^{137}Cs is seen as relatively widespread contamination near the surface with limited plumes in the subsurface.

The ^{137}Cs logs show the highest concentrations at the base of the tanks with decreasing concentration with depth. This is typical for tank leaks. However, in the two deepest boreholes (52-06-05 and 52-06-07 in Figures 10 and 11), we find low concentrations of ^{137}Cs as discrete low level detections along the hole and as at least one continuous plume in a thin strata.

Figures 10 and 11 show some of the log data from these boreholes. The deeper ^{137}Cs is also easier to see in the visualization of Fig 9 where the isolated low-level plumes are not covered over by the extensive ^{60}Co plume.

These low level specs of contamination down deep in the vadose zone could easily be dismissed as borehole contamination as it was in the SX Tank Farm in 1996. However, associated with the low ^{137}Cs detections are plumes of spatially continuous ^{60}Co contamination. This ^{60}Co has a high horizontal spatial correlation and a shape factor analysis indicating the ^{60}Co is in the formation and not a borehole effect. So the deep ^{137}Cs cannot be readily dismissed as borehole contamination.

The ^{60}Co contamination is very widespread and very deep. It exhibits a pattern of increasing concentration with depth from the bottom of the tanks to the bottom of the boreholes which is mostly at 100 ft depth. This means that the highest concentration of ^{60}Co or the center of the plume mass is deeper than most of the boreholes.

The visualizations of Figs 8 & 9 show the deep cobalt contamination as layered continuous plumes through the south side of the farm. If you will note that there are no boreholes on the east and southeast side of TY-105 yet the model shows a continuous ^{60}Co plume. This is a result of the large range in the spatial correlation that was calculated from the region around TY-106 and TY-103 where the borehole density is greater. In effect the spatial statistics are predicting this area has ^{60}Co contamination, based on a combination of the spatial statistics from the extensive distribution just to the north and west and on the data from two isolated boreholes.

One might say this phantom contamination should be removed from the visualization and instead be replaced by no contamination. This would certainly show a less widely distributed ^{60}Co plume. However, I believe that we should let the statistics tell us what it has to tell and include the contamination along with an assessment of the uncertainty of the geostatistical model. We should leave the question of whether or not ^{60}Co contamination is actually present on the east side of TY-105 to a future refinement of the spatial correlation after additional data are gathered. In the meantime, the best statistics predict that area to be contaminated so the visualization showing the contamination remains the best representation.

A better solution would be to perform a comprehensive characterization and a geostatistical structural analysis and then produce a 3-D visualization that only shows the calculated level of uncertainty of the model in the different regions of the vadose zone. Then, there would be no argument about the extent of contamination because we will be able to qualify our knowledge of the different plume regions and we could show the uncertainty level for the different regions of the plume.

Or, if there are questions about the best spatial model that has been developed to date (GJO, 1998), let us identify those questions and uncertainties in a data quality objectives process and prioritize and address them in the coming site characterization.

To focus back on the primary uncertainty with the TY farm, the data show that ^{60}Co and ^{137}Cs contamination has moved down deep and into groundwater. The conclusions of the GJO report (GJO, 1998) state:

> "It is clear that ^{60}Co contamination has reached groundwater in this area of the TY Tank Farm, and it is likely that other more mobile contaminants such as ^{99}Tc have also reached groundwater"

^{137}Cs was not included in the above quote from the GJO tank farm report because it was not worth fighting for at a time when the GJO program was being integrated out of the vadose zone work at Hanford. The argument for ^{60}Co was all that was required to map the contamination pathway to groundwater.

The biggest problem in the TY Farm is shown in the logs from the two deepest boreholes, 52-06-07 and 52-06-05 (Figures 10 & 11) where we find the specs of ^{137}Cs as well as a spatially continuous plume of ^{60}Co. Borehole 52-06-07, is the only borehole reaching groundwater levels and contamination is found just above groundwater. This is also the only region in the borehole where detection of low-level formation contamination is possible because the borehole is double cased and grouted to 190 ft.

The deep and spatially continuous ^{60}Co shows that moderately mobile contaminants have reached groundwater in this area. At the TY farm, the ^{60}Co provides a good indication of the contaminant migration pathway. It generally increases in concentration with depth below the tanks and at deeper horizons it correlates very well with high moisture zones identified in neutron-neutron moisture logs. At least it did before much of the ^{60}Co decayed away.

If the ^{60}Co and moisture can be mapped in the subsurface, I would estimate that we could have a pretty good picture and a statistical quantification of the spatial characteristics of the contaminant migration pathway to groundwater. That would be valuable.

The deep ^{137}Cs found just above groundwater in borehole 52-06-07 is a problem because ^{137}Cs is supposed to have a low mobility. I will suggest that something may have helped mobilize ^{137}Cs to allow it to migrate deep, even though it is found only at very low concentration. These data cannot be dismissed as insignificant specs of borehole contamination because it is found within a good ^{60}Co plume at the same horizon.

In addition, this pattern of low-mobility radionuclides sitting just above the groundwater is a classic pattern that we see in many wells in the 200 Areas; especially in the T complex. We call it the bathtub ring. We believe the bathtub ring resulted from conditions where contamination entered the groundwater when the groundwater table was much higher. When ^{137}Cs hits the groundwater it drops out of solution close to the source. Then, as the groundwater table receded, it left the contamination bathtub ring in the soil just above the groundwater. This probably means that the source of the ^{137}Cs is close; like from the TY farm.

Understand that this deep contamination in the TY Farm apparently is dismissed away by the CH2M Hill vadose zone integration team as being insignificant specs of contamination. In reference to the contamination in boreholes 52-06-05 and 52-06-07, Myers (2005) says:

> "These zones are unusually deep and isolated from other more shallow contamination zones near the tank bottoms. The deeper measurements may be false positives created by data synthesis or raw counts near the detection limit."

Actually, the reason they are deep and isolated is because there are no other boreholes that go that deep at the TY Farm. But I can't claim to understand what the false positive statement means. I do know that under the GJO work, we did not synthesize any data. Perhaps the author of that statement knows something more about gamma ray spectrum analysis than the GJO team.

At least it appears from the above statement that they are dismissing this contamination as insignificant noise even though it was well above Minimum Detectable Activity (MDA) levels.

This statement differs considerably from the statement in the GJO TY Farm Report quoted above. This difference should at least be resolved in an investigation of the characterization of the TY Farm or at least considered in the DQO process.

We know there is some level of accumulation of ^{137}Cs and moisture on the Plio-pleistocene unit (borehole 52-06-05, Fig 10 at 110 ft). Perhaps we can even find out what is breaking through the Plio-P, what is distributed in the upper Ringold and what has entered the groundwater. If we have adequate spatial data on both ^{137}Cs and ^{60}Co, we might even be able to make educated guesses, based on the spatial statistics, as to the leak volumes or radionuclide quantities, provided that a geochemistry profile is prepared in a manner similar to that done at SX Tank Farm (see RPP-7884).

Questions remain as to what is in the Ringold E layer below the Plio-P, what is on top of the Plio-P and what is in the deep Hanford formation. Right now there is simply no data other than two boreholes, both of which are indicating groundwater contamination.

If we understand how the easily assayed contamination is distributed at TY farm we can go in and sample the primary regions of interest and obtain samples for assay and geochemistry studies. It would be nice, for instance to obtain samples of the pore water and soil just above the Plio-P to get a workup on the geochemistry. If something is mobilizing ^{137}Cs to cause it to reach groundwater, does this increase the mobility of other radionuclides. If we know where to place these holes, we can minimize the number of these expensive boreholes that are required to complete a comprehensive characterization.

We must also confirm the postulated absence of ^{99}Tc and uranium in the soil at this farm by sampling the soil in different parts of the pathway. We won't know where to sample unless we have done some sort of spatial analysis of the plumes, preferably an analysis based on the easily assayed gamma emitting radionuclides.

RPP-7578 states:

> "Thus, a series of 12 to 18 cone penetrometer pushes are recommended to better delineate the extent of gamma contamination between the surface and the base of the excavation (40 ft bgs) or refusal" (p.B-6 RPP-7578).

(2) So, the current shallow vadose zone soil characterization effort is incorrectly focused on the near surface contamination and is not deep enough. The shallow boreholes should at least reach the Plio-P so that we may answer the spatial distribution question to at least the 110 ft level.

This illustrates there is a characterization objective in RPP-7578, of confirming a preconceived leak volume estimate and a developed theory that the vadose zone contamination resulted from surface leaks and not tank leaks. Penetrometer holes are intended to confirm this by only assessing the near-surface ^{137}Cs distribution. This does nothing to assess the higher ^{60}Co concentration areas that define the extent of the tank leaks and are likely to lead to the location of any ^{99}Tc or uranium in the soil.

The near-surface characterization is likely to better define the tank leak sources if the analysis and tank leak conclusions are not limited to a 10^6 pCi/g concentration level. Again, I predict they will find moderate to low levels of ^{137}Cs at the base of the tank. Below that, they are likely find continuous zones of ^{60}Co, if they intend to investigate that deep.

3) The current characterization effort appears to use the wrong instrumentation (unless the primary purpose is to look for high concentrations of ^{137}Cs).

No information is provided in RPP-7578 or in the sampling and analysis plan (App. A) on the borehole geophysical logging measurements that are being used to assay the subsurface contamination using the small diameter cone penetrometer boreholes. There is no information on what data are obtained, how the data are measured, data quality requirements, measurement strategy, or data analysis. There is also no explanation of what instrumentation is being used. In short, there is no way to determine how they are making the measurements and no way to assess the quality of the characterization data.

Instrumentation that is commonly used with small diameter cone penetrometer systems is limited in gamma assay capability due to detector size and efficiency limitations. ***The minimum detection levels, energy resolution and general performance of these systems do not permit assay quality logging***. ***And, they do not permit assessment of low concentrations of contamination that is found in the vadose zone at the TY farm***. So, it appears that the recent site characterization used the wrong instrumentation.

Regardless of the fact that the penetrometer holes appear to be installed only to 40 ft (RPP-7578) and will miss the primary contamination regions of interest, the data acquisition instrumentation is unlikely to be able to provide an assay of the low levels of gamma emitting contaminants that are requried to assess the contamination distribution.

Remember though, that I am reviewing the characterization work with the coming DQO in mind. My primary objective for the coming characterization effort would be to empirically determine what is in the vadose zone soil and compare that to other data such as the inventory estimates in RPP-7218. Since that is not the objective of the RPP-7578 characterization plan, my concerns over the instrumentation and measurement systems may be entirely inappropriate. For instance, if it turns out that tank leaks are only defined by the 10^6 pCi/g criteria, then the instrumentation used in the cone penetrometer boreholes may be totally appropriate.

But, as I showed above, the 10^6 pCi/g criteria is just plain wrong for the TY farm.

The limitations of the cone penetrometer and instrumentation systems as well as limitations of this characterization method were discussed extensively with DOE personnel in the mid-1990s when a similar characterization effort was being planned for tank AX-104. I found no indication in RPP-7578 that the limitations of that characterization method and the associated instrumentation systems have been resolved. This leads me to conclude that they are using the wrong instrumentation systems.

Under the GJO baseline characterization project, instrumentation systems were used which had relatively high efficiency intrinsic germanium detectors. These were used with counting times specified to allow assay of ^{137}Cs to a minimum detectable activity levels of a few tenths of a pCi/g and a similar level for ^{60}Co. These systems were also run with a maximum data acquisition interval of six inches along the boreholes. Under the baseline characterization program, the low level contamination detection capability and the high vertical spatial resolution were required to assess the contamination migration pathway to groundwater. Again, I refer primarily to the problem of understanding the spatial aspects of that assessment.

But, there is more to it than just having a low-level detection capability. What is required is an assay capable logging program. That means you need a full quality assurance in the measurement with calibration information, error analysis, documented plans and procedures, qualified data analysis and processing methods and records management. All of these are basic requirements for an NQA, "quality" program. None of this is found in the measurement scheme specified in RPP-7578. This entire characterization effort is falling back into the same problems encountered with the "scintillation logging" program of the 1980's.

If you look at individual borehole log data plots produced under the GJO baseline characterization program, you find that each data point plotted as a concentration value along the borehole, also includes a minimum detectable activity (MDA) value and the 1 sigma error estimation bars. Backing up those the data points and associated statistics for each concentration determination is documentation on the calibration, error estimation and all aspects of the measurements.

I did not find any requirements in the TY farm sampling and analysis plan (Appendix B, RPP-7578) that lead me to believe that that characterization effort is being done under any kind of a "Quality" program. If the plan is to sacrifice data quality for borehole installation efficiency, that is okay. But, that strategy probably needs to be explained in the characterization or sampling and analysis plan along with details of how the data are used to satisfy the specific data needs and why the sacrifice in data quality is appropriate for satisfying those data needs.

Vadose Zone Monitoring and Tank Leak Detection

This brings up the final concern of current characterization described in RPP-7578 that must be addressed under the T complex groundwater DQO. That concern has to do with the lack of a monitoring effort as an integral part of the characterization strategy (4).

In the short version, monitoring is a good way to demonstrate that you know what you are talking about in your conceptual model and in your risk assessment. Monitoring is a key component of a defense-in-depth groundwater protection scheme. As with nuclear weapons, verification monitoring goes a long way. Monitoring could also actually allow detection of contamination before it hits the groundwater.

Post closure monitoring is required under both RCRA and CERCLA. But, I already got into that. Post closure monitoring appears to have been completely ignored in the 100 BC Area clean up work (Brodeur, 2005). And, the cone penetrometer borehole installations at the TY farm described in RPP-7578 were removed and decommissioned after completion and were not meant to be used for monitoring.

Minimal funding is required to monitor the existing boreholes using borehole geophysical logging methods.

When the GJO vadose zone project was set up, it was specifically placed under DOE's tank farms operations organization because of operations requirements to verify the controlled, clean, stable status of the tanks.

The objective of the GJO project was to develop a baseline of the subsurface contamination, assess it and then monitor it. In fact, specialized monitoring instrumentation systems and a qualified monitoring program were developed to economically satisfy tank farms operations requirements for tank leak detection as well as vadose zone plume monitoring. The monitoring program was intended to replace the old gross gamma logging, tank farms leak detection effort which focused only on leak detection.

Apparently, the GJO monitoring instrumentation systems have remained unused at Hanford since about 2002 and there is effectively no vadose zone monitoring and no external tank leak detection capability at the single shell tanks.

Yet, many of the tanks still contain large quantities of drainable interstitial liquid. This concept that the tanks are controlled, clean and stable only goes as far as the verification of that can take you. Even the plumes from the large releases that we know have impacted groundwater such as the SX farm and the BX-102 uranium plume are not monitored. If there is a debate about the stability of uranium at BX farm, monitoring would go a long way toward a confident resolution.

There is no better way to prove a conceptual model that says contamination is stable than to provide monitoring data. If that can be demonstrated over the facility closure process time scale, so much the better for any post closure monitoring requirements. Verification of both the conceptual model and the contaminant migration model are important data quality concerns for the T complex DQO process.

Vadose zone monitoring data from TY farm was specifically requested from the CH2M Hill vadose zone integration team for the preparation of this report. No monitoring information was reported in any of the publicly available documents and no monitoring data on TY farm was provided to me.

Fortunately, some limited monitoring data were provided by the Nez Perce ERWM program. I do not know what additional data are available. Interpretation of the data provided by the Nez Perce is very difficult because no additional data are available from surrounding boreholes. This is the same spatial data problem that I discussed above.

Fig 12 shows a combination plot from borehole 52-03-06 located between tanks TY-103 and TY-105. These data resulted from the baseline characterization of this hole in 1996. Fig 13 shows log data from a re-assay logging of that borehole that occurred in 2002 along with the baseline data. The middle two logs on Fig 13 show the ^{137}Cs and ^{60}Co concentrations from the two logging assay events. The right-most log in Fig 13 is a neutron-neutron moisture profile log from that borehole.

I apologize for the poor quality of the plots but this was the only data format available to me. Perhaps the DOE can make this tank monitoring data available to the public.

The data of Fig 13 show there was a rise in ^{137}Cs concentration right at the base of the tanks from an insignificant little spec of about 1 pCi/g in 1996, to a continuous plume of about 50 pCi/g in 2002.

At the base of the tank where the ^{137}Cs increase is found, the ^{60}Co concentration stays about the same. One of the plots is the 1996 plume data that has been decay corrected to allow comparison with the 2002 assay data. However, from about 65 ft down to the bottom of the borehole, it looks as though ^{60}Co concentrations have decreased beyond what would be expected from natural ^{60}Co decay. Also note two new insignificant specs of ^{137}Cs contamination within the deeper ^{60}Co plume at 80 and 85 ft.

The ^{60}Co profile and the neutron moisture log correlate very well. In fact, the statistical correlation between the ^{60}Co profile and the moisture profile clearly warrants intensive analysis on a micro scale or a scale with the resolution of the individual stratum. This could enlighten us as to some of the ^{60}Co/moisture content relationship and possibly even allow co-kriging or other co-relational spatial analysis. In the very least it will provide an excellent set of vertical variograms describing the actual soil moisture variance. This type of analysis is possible because of the high spatial resolution of the log data as provided with the 0.5 ft data acquisition interval. For data quality reasons, I am hoping the standard high spatial resolution data acquisition protocols of the baseline characterization have not changed and that the GJO work has not succumbed to economic pressures to decrease the spatial resolution. Doing so would be very bad for future spatial analysis studies.

The strong correlation between the moisture and ^{60}Co contamination profiles is a good indication of vadose zone transport as opposed to the old borehole contamination theory. If there was vertical movement along the borehole this would be seen in the logs.

Note the rise in moisture and ^{60}Co concentration near the bottom of the borehole at 100 ft. This provides a hint of where to look for the bulk of the moisture and at least the bulk of the ^{60}Co. An understanding of the geochemistry of this plume type could tell us what can be found along with the moisture and ^{60}Co in this region of the plume.

The rise in ^{137}Cs concentration at the base of the tank is caused by a continuing leak from either TY-105 or TY-103 or it is caused by an active redistribution of existing contamination. However, in order for there to be a redistribution of existing contamination, there must be a source of water to drive that redistribution.

In this case, it is extremely unlikely that the contamination originated from the surface and was carried down by drilling or by water flow down the casing. That would have caused a smear of contamination along the borehole depth.

It is possible that a large infiltration event occurred recently, causing the remobilization of the contamination from an old leak. That would be seen as a temporal rise in moisture content profile from the neutron moisture monitoring logs, … if such temporal monitoring data were available.

A neutron moisture log from nearby borehole 52-06-02 (Fig 14), shows a rather large moisture plume, also at the base of the tank. That moisture log correlates fairly well with the ^{137}Cs profile of that borehole which was obtained in 1996 (Fig 15). This and the strong correlation between ^{60}Co and moisture in borehole 52-03-06 suggest that the moisture is old and possibly part of the original leak. Also, the fact that the moisture plume is located at the base of the tank also points to a tank leak source.

According to RPP-7578, raw water lines to the farm were cut and capped and domestic supply was pressure tested in 2001. The increase occurred in May of 2002. Tank TY-103 contains 5000 gal of drainable interstitial liquid and TY-105 has no drainable interstitial liquid (Hanlon, 1994). However, that does not necessarily mean that there is no liquid in the tank or that a continuing leak from either tank is not possible.

The vadose zone baseline characterization data from the TY farm also suggest that the tank liquor that created the vadose zone plumes was low in ^{137}Cs concentration.

With little temporal data and little spatial data on this contamination plume and no apparent water sources, we are pretty much left a continuing leak as to the cause of the increase in ^{137}Cs at the base of the tank.

If this is not a tank leak, it is an active contamination plume that at least warrants monitoring for the reasons discussed above. The vadose zone integration team should be all over this with geochemistry, soil characterization, temporal measurements and spatial assessments. This area should have been targeted for characterization under RPP-7578. Instead, this monitoring data was ignored.

At this point, we cannot conclusively determine the source of this new contamination. And, with DOE's apparent reluctance to report this potential tank leak, and considering the lack of any additional monitoring data as well as an absence of regulatory oversight, all I can say is that this is looking like a duck and it is quacking like a duck.

CH2M Hill did not provide me with a copy of any notifications of this continuing tank leak to the RCRA regulating agency (Ecology) and I could find none in the public occurrence report records. ***Apparently, USDOE and CH2MHill do not believe RCRA requirements for notification of leaks from dangerous waste tanks apply to DOE's nuclear waste tanks***. It is also not reported in the 2002 groundwater monitoring report. This means that it is entirely up to the DOE and the CH2M Hill vadose zone integration team to objectively determine if this is a continuing tank leak or due to something else. Perhaps the CH2M Hill vadose zone integration team can put together an unbiased panel to evaluate this potential leak under the new leak designation process.

I also don't know if the groundwater contamination source at the TY farm described in the 1998 GJO Tank Farm Report was reported to the regulating agency. The custom established in 1997 at the SX tank farm was to report such things in a formal non-conformance report where the non-conformance was with the "Controlled, Clean and Stable" condition of the tank farm.

T-Complex DQO Recommendations and Scope of the Coming EIS

The task of developing an understanding of the active plume or tank leak between TY-103 and TY-105 should be the primary data quality requirement for the T complex DQO process. That DQO should focus on what is needed to perform a comprehensive site characterization. It should prioritize the data needs and go after them with site characterizations that will eventually satisfy all of the data needs. The DQO should not be used as a way to justify not performing a comprehensive characterization as was the case in the 100-BC Area.

Uncertainties at the TY Farm and the focus of data quality requirements should be on answering questions about the nature and extent of all the plumes in the TY farm and defining the contaminant migration pathway. This should include the largest plumes on the south side of the farm. This contamination appears to have already impacted groundwater yet little is know because there is poor coverage of both groundwater monitoring wells and vadose zone boreholes.

The low level specs of contamination down deep in the vadose zone in borehole 52-06-05 and 52-06-07 (Figs 10 & 11) could easily be dismissed as borehole contamination. However, associated with the low ^{137}Cs detections are plumes of spatially continuous ^{60}Co contamination. This ^{60}Co has a relatively high horizontal spatial correlation and a shape factor analysis that indicates the ^{60}Co is in the formation and not a borehole effect. As a result, neither the deep ^{137}Cs nor the deep ^{60}Co can be dismissed as borehole contamination.

The deep ^{137}Cs found just above groundwater in borehole 52-06-07 is a problem because ^{137}Cs is supposed to have a low mobility and should not be in the groundwater. This suggests something has mobilized ^{137}Cs to allow it to migrate deep. This may be due to the type of tank liquor that was released. This low-level ^{137}Cs contamination needs to be mapped spatially and it will require a full geochemistry workup.

The ^{60}Co contamination is very widespread and very deep. It exhibits a pattern of increasing concentration with depth from the bottom of the tanks to the bottom of the boreholes which is mostly at 100 ft. This means that the highest concentration of ^{60}Co or the center of the plume mass is deeper than most of the boreholes. The deep and spatially continuous ^{60}Co clearly identifies that moderately mobile contaminants have reached groundwater in this area.

The ^{60}Co contamination also needs to be mapped and assayed with a spatial assessment because it helps to define the contamination migration pathway. Correlations of ^{60}Co and moisture content would be required to accomplish this.

The deep contamination in the groundwater and in the Ringold E unit should be investigated and quantified along with the contamination on top of the Plio-P and within the Hanford formation. This and other groundwater contamination source investigations should be included in the DQO for the T complex groundwater cleanup work.

Data quality requirements should include the ability to support a geostatistical structural analysis and the development of an empirical vadose zone contamination model. That empirical model should be used to estimate quantities and those quantity estimations should be supported by geostatistically based error estimations.

Soil sampling characterization holes are required for characterization of the non-gamma-emitting radionuclides such as ^{99}Tc, Uranium and ^{129}I. Hopefully, with a good spatial analysis of the plumes, there will be no question as to where to drill these expensive boreholes. This sampling should occur at key locations along the contaminant migration pathway and the sample assay data should be correlated with the gamma-emitting radionuclides that are used to define the pathway.

Finally, the DQO and the site characterization must address monitoring data needs and those data needs must be integrated into the characterization effort. It makes no sense to install temporary cone penetrometer boreholes when there is a demonstrated need for more permanent vadose zone monitoring boreholes to satisfy requirements for tank leak detection as well as for monitoring the contamination that has already been released into the environment. The continuing leak indicated by borehole 52-03-06 is the best argument I can provide to support this data need.

Obviously at the TY farm, and for that matter for the TX and T farms, little to no monitoring has occurred since the baseline was established in the mid 1990's under the GJO program. This information is critical for the closure of the groundwater operable unit in the T complex to demonstrate the stability of the vadose zone contamination. The fact that we are currently not properly monitoring the nuclear waste tanks indicates there is a problem with the regulatory oversight.

This should all be planned and integrated into an economical drilling and characterization plan. If it is not to inconvenient, it would also be nice if this work was integrated across the site by the CH2M Hill vadose zone integration team by sharing it with the public and perhaps even sending the plan to the RCRA regulating agency for their review. The fact that the Atomic Energy Act gives exclusive regulatory authority for radionuclides to the DOE should not be used as an excuse to not report leaks from RCRA regulated underground hazardous waste tanks. The data indicating a continuing leak from tanks TY-103 or TY-105 should be the center of focus for future characterization and monitoring at the TY farm.

Considering what is recommended and in my mind, required at the TY tank farm for a comprehensive site characterization, it will be several years before adequate site characterization data are available to allow an assessment of environmental impacts under the coming EIS. Mind you that the TY tank farm is probably lower on the risk scale than other tank farms but it still will require considerable additional characterization work. Other farms with very high concentrations of deep radionuclides will require a lot more characterization than TY farm. Completing a comprehensive environmental impacts assessment will require several years of intensive characterization work.

I have no idea what sort of time-table the DOE is proposing for the comprehensive EIS. If that time table does not allow at least 5 years of intensive site characterization work, then the EIS should be delayed to allow time to perform comprehensive site characterization. A new time table should include time for characterization work at the crib sites as well.

There have been many false starts at different levels of detail in site characterization work at Hanford. The most recent attempt at TY farm is a perfect example. The attempt at TY farm probably first failed at the DQO stage because of the apparent determined attempt to bias the DQO from the start by having exclusive participation and by not releasing and discussing all of the data available.

Summary Conclusions

The primary conclusions of this report is that one of the biggest obstacles to an effective data quality objectives process for the T complex groundwater operable unit and for the site characterization required for assessment of environmental impacts is likely to be with the institutional bias, bad science and outright determined cover-up of data and information.

I support that statement with recent examples of data cover-up and with examples from the past that clearly demonstrate a continued history of biased assessments, mis-information and just plain not reporting key data to anyone much less the regulating agencies.

I showed how the strict interpretation of the regulations and vigorous application of the Atomic Energy Act cause the continuous argument over the regulation of radionuclides without regard to salient requirements of RCRA and CERCLA. ***DOE's self-regulation of radionuclides appears to have resulted in a situation where we have no valid leak detection capability at the high-level nuclear waste tanks.***

I define the vadose zone problem and explain how we need to map out the contamination plumes and determine the nature and extent of contamination. I also explain why we need that information.

I presented an economical and useful characterization method which can be used to provide much of the required data on the spatial distribution of the contamination. That method involves marrying a pile driven borehole installation method with appropriate borehole geophysical logging tools to allow the direct determination of the contamination profile in the soil. That characterization method was demonstrated at the SX tank farm where it was used to confirm the accuracy of the GJO empirical contamination model.
We could use that characterization method to answer the questions about the distribution of contamination at all of the plumes at the tank farms and crib sites in the 200 Areas. And, if appropriate geostatistical analyses are conducted, we can demonstrate and verify the conceptual models of the contamination distribution.

I have shown in this report where the data clearly implicate TY-102 as having leaked and I have shown how the DOE and Hanford site contractors have covered up this fact by biasing the leak designation process, inventing implausible scenarios such as flooding and by using a tortuous logic to exaggerate the uncertainty associated with the origin of the offending contamination. Having experienced this biased interpretation first hand, I am convinced that the Hanford site personnel have no business designating much of anything about the tanks and I recommend that this task be taken over by the regulators.

I have also presented the data that show that either tank TY-103 or TY-105 continues to leak. This data has apparently not been reported to any of the regulatory agencies nor has it been reported in any of the appropriate environmental monitoring reports. Like the DOE inspector general's conclusions in 1980, this may not be an active, overt attempt to cover up the data, but it is clear that the data were suppressed. Perhaps the most troubling aspect of this continuing leak is the complete lack of monitoring of this active contamination region.

This continuing leak should have been the focus of the most recent attempt to characterize the TY Farm (RPP-7578) and it should be a major focus area of future site characterization.

I have also briefly presented information on the attempted cover-up of the extent of migration of the uranium plume from the BX-102 tank leak and the fact that it has reached groundwater. The problems with the conceptual model at the BX farm are explained much better by Dr. Sobczyk through the Umatilla and the Nez Perce tribe documents to which the reader is referred for more details.

I know that I have shown in this report, that he most recent site characterization work at the TY farm is ineffective and misdirected. This was shown without yet seeing any of the results. They are using the wrong characterization method with the wrong instrumentation, and focusing on the wrong things for the wrong reasons. And, they are likely to come up with the wrong conclusions about the vadose zone contamination from that study.

With that said, the only way that I can perceive to combat the misdirection and the dis-information presented as a part of the DQO, is to perform an independent assessment of all the data and information and then to participate in the DQO process in an attempt to prevent bias. This is difficult if not impossible to do because most organizations don't have the resources required to perform an independent assessment much less participate in such a long involved process. And, if the exclusive nature of the past DQO processes continues, opportunities for participation of key on-site organizations such as the GJO group as well as stakeholder groups will be limited. This exclusive process keeps pertinent data and information from being considered thereby biasing the DQO process and the characterization from the start.

I tried to provide some specific data quality items in this report for the TY tank farm for consideration under the coming T complex DQO. That attempt demonstrates how difficult it is to do a detailed review and it demonstrates how much it is that we do not know about the TY farm.

A similar review of the TX and T farm as well as a review of all of the crib facilities should be completed before the DQO begins. Questions or uncertainties about those facilities should be identified and explained in the DQO for consideration, discussion and appropriate inclusion in the characterization plans.

I also had a lot to say in this report about the importance of monitoring. Monitoring assumes one already has an adequate baseline characterization from which to compare. Monitoring is required for any kind of an environmental risk assessment, it is needed to confirm the conceptual model and it is an integral part of post closure requirements. Monitoring also provides a way to demonstrate the accuracy of the conceptual model and it is a basic requirement under both RCRA and CERCLA.

The only hope I can find for the coming comprehensive environmental impact assessment would be if the DOE delays the EIS until adequate site characterizations are completed at all of the tank farms and at all of the crib sites. This could allow development of accurate and unbiased conceptual models and it could permit accurate assessments to be completed. Delaying the EIS is unlikely to happen because the comprehensive EIS is tied to DOE's ability to construct a massive mixed and low level waste landfill (Integrated Disposal Facility or IDF) and import waste from other sites.

It appears that the only tool or means of preventing another inadequate environmental assessment is with legal action, just as what occurred with the previous EIS. This means that moving forward with clean-up and proper disposal of waste will likely be tied up in the courts for some time.

I am optimistic that an unbiased DQO process could be completed for each tank farm or crib facilities if a few changes were made and appropriate participation is made possible for some on-site and stakeholder organizations. There remains much that we do not know about the subsurface contamination plumes at Hanford. The only way to solve this dilemma is to identify what we don't know up front in the DQO process and get it out on the table for consideration.

This is difficult to do in the chilling work environment created by the DOE and site contractors with a long history where the cover-up of bad data or information is commonplace, lies of omission are standard practice, and people loose their jobs because they disagreed with some of the long-held institutional myths at Hanford.

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Figure 1: Example Variogram

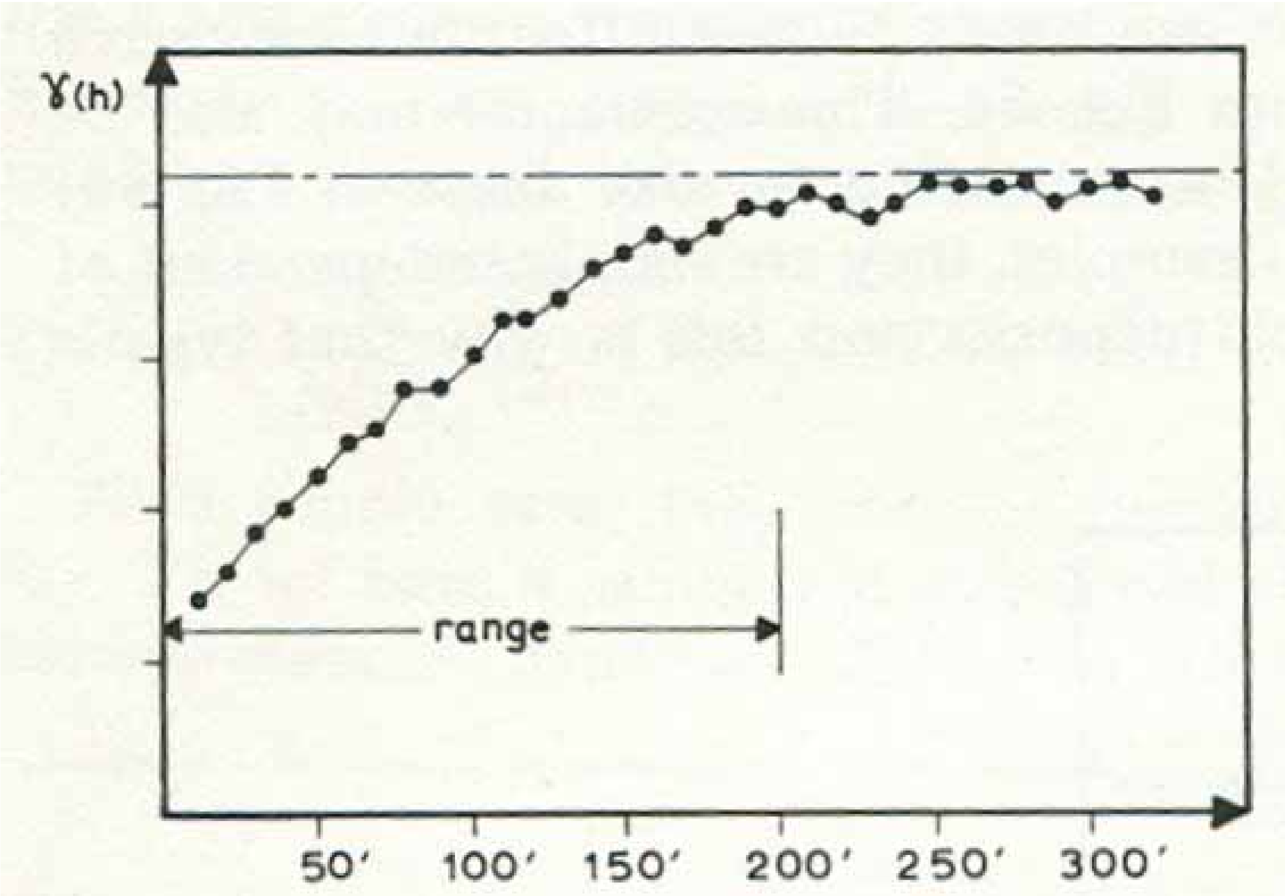

Figure 2a: Spectral Gamma-Ray Combination Plot for Borehole 21-02-04

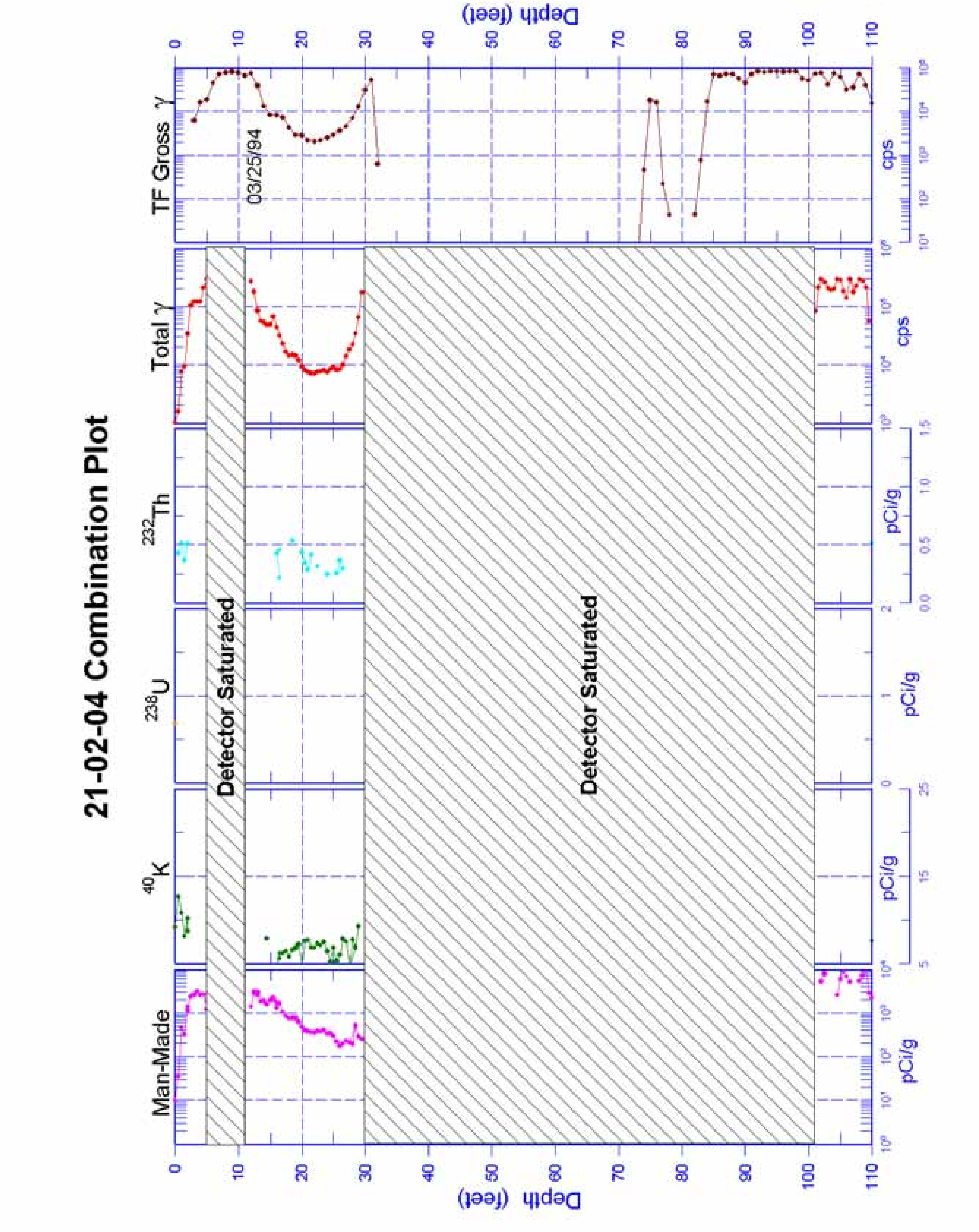

Figure 2b: Spectral Gamma-Ray Combination Plot for Borehole 21-02-04

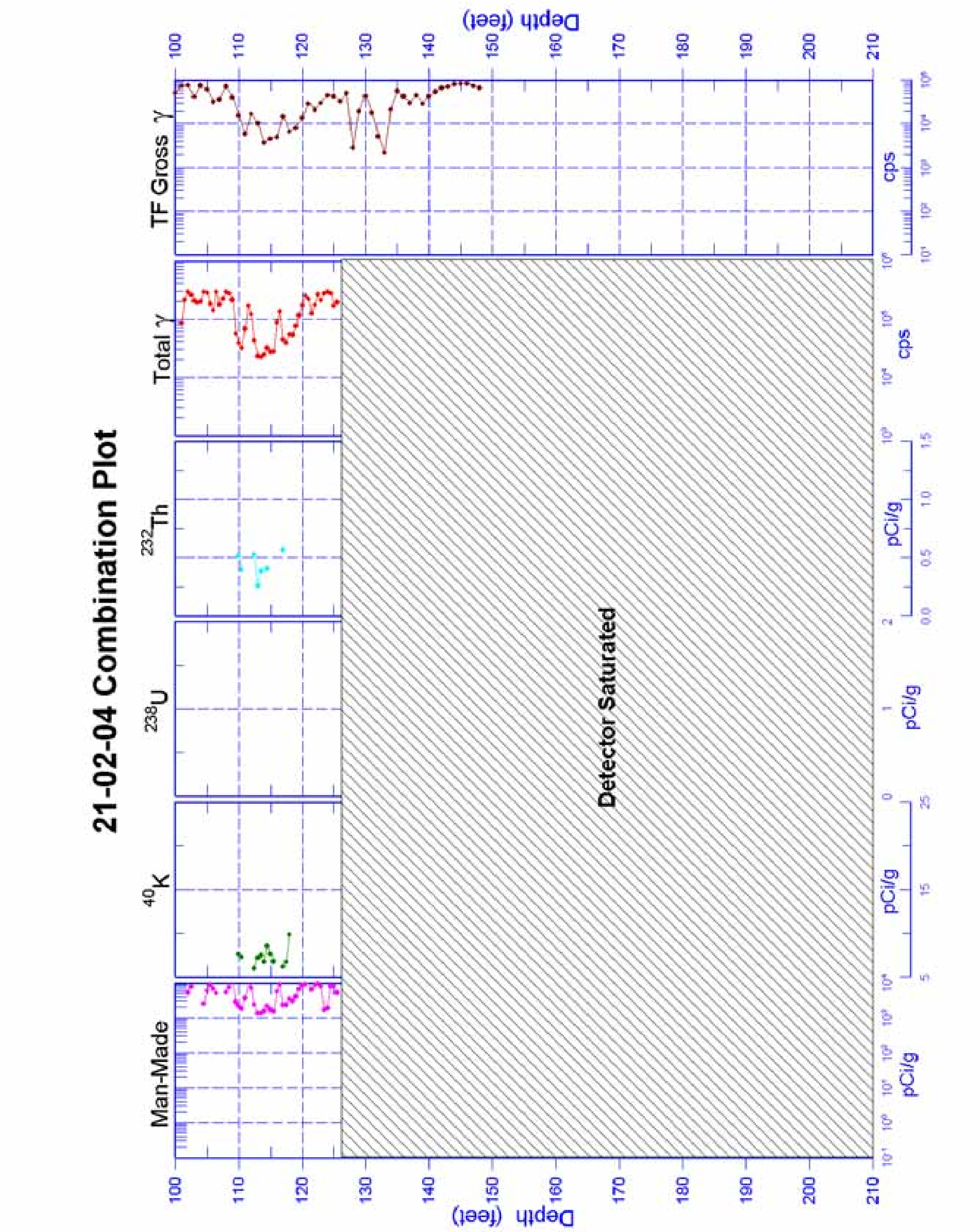

Figure 2c: Spectral Gamma-Ray Combination Plot for Borehole 21-02-04

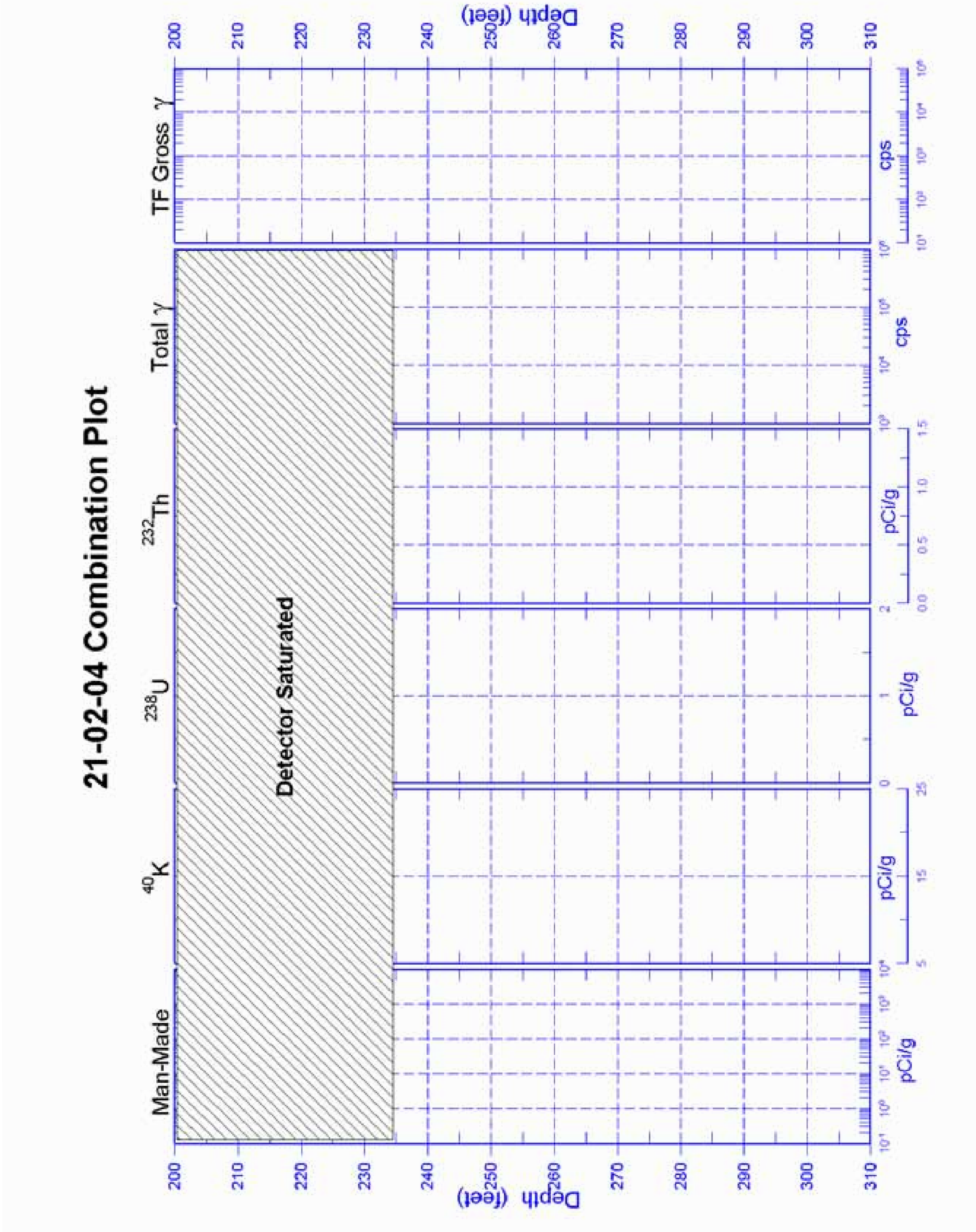

Figure 3: Spectral Gamma-Ray Combination Plot for Borehole 52-02-11

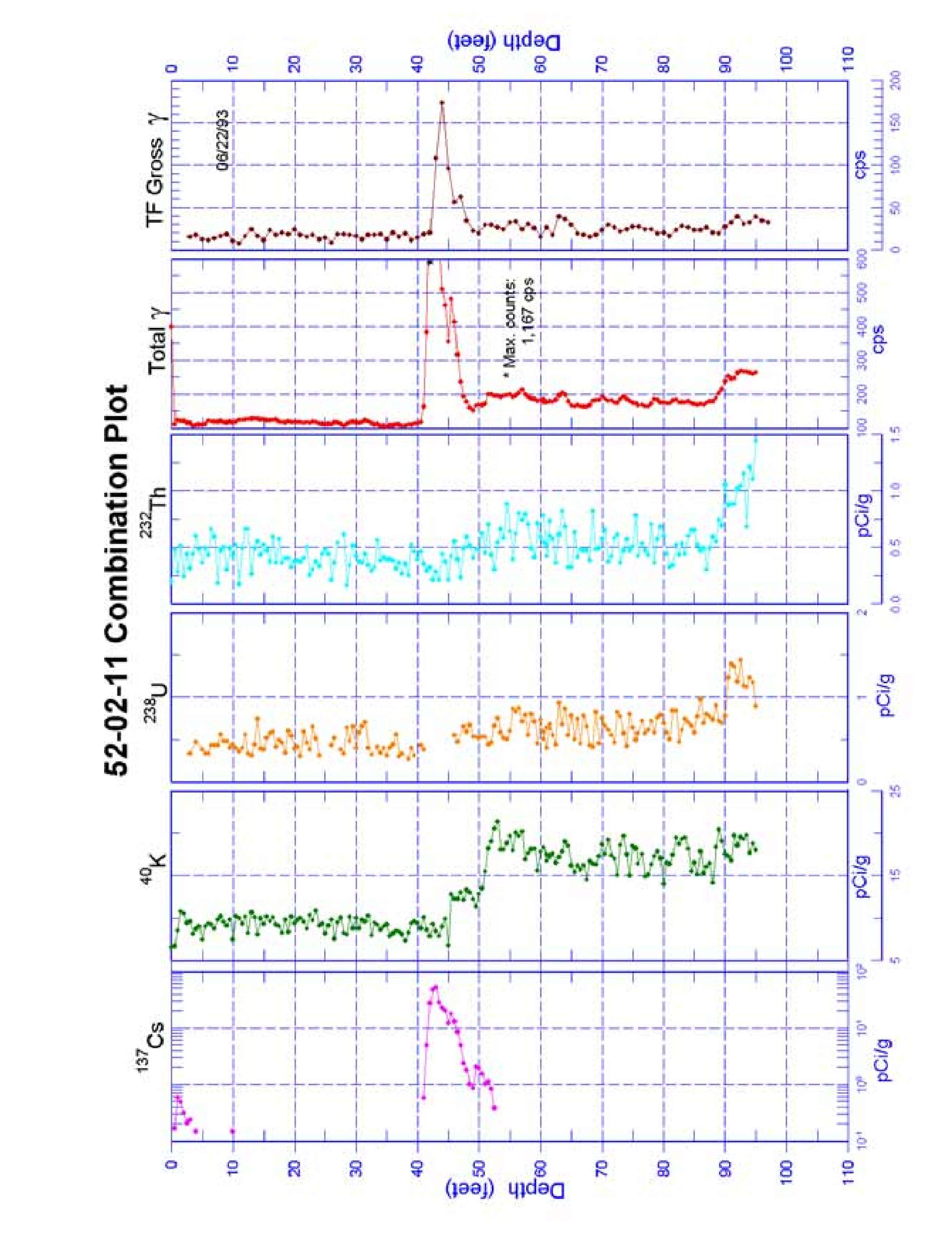

Figure 4: Spectral Gamma-Ray Combination Plot for Borehole 21-11-03

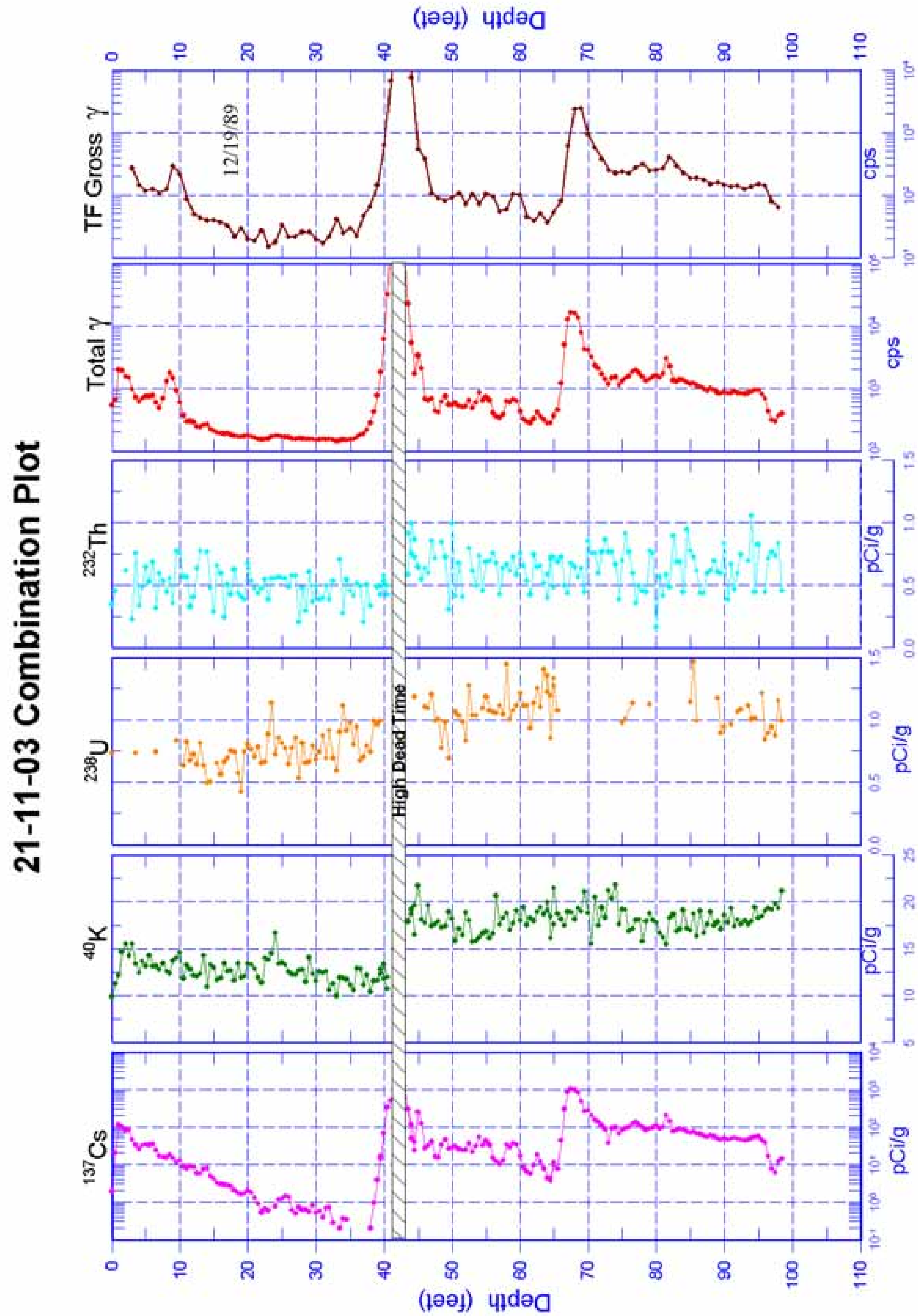

Figure 5: Spectral Gamma-Ray Combination Plot for Borehole 21-11-04

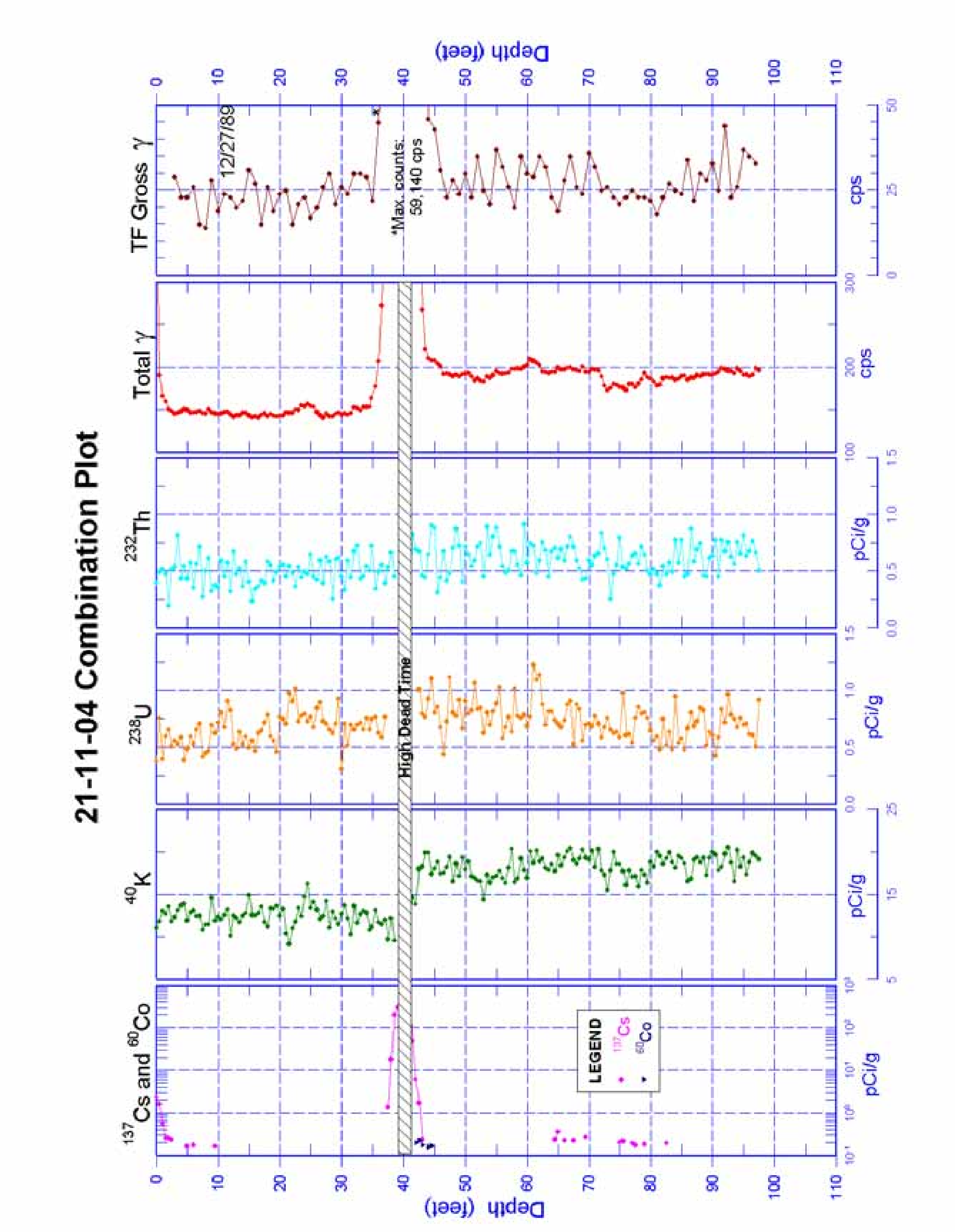

Figure 6: Spectral Gamma-Ray Combination Plot for Borehole 21-11-05

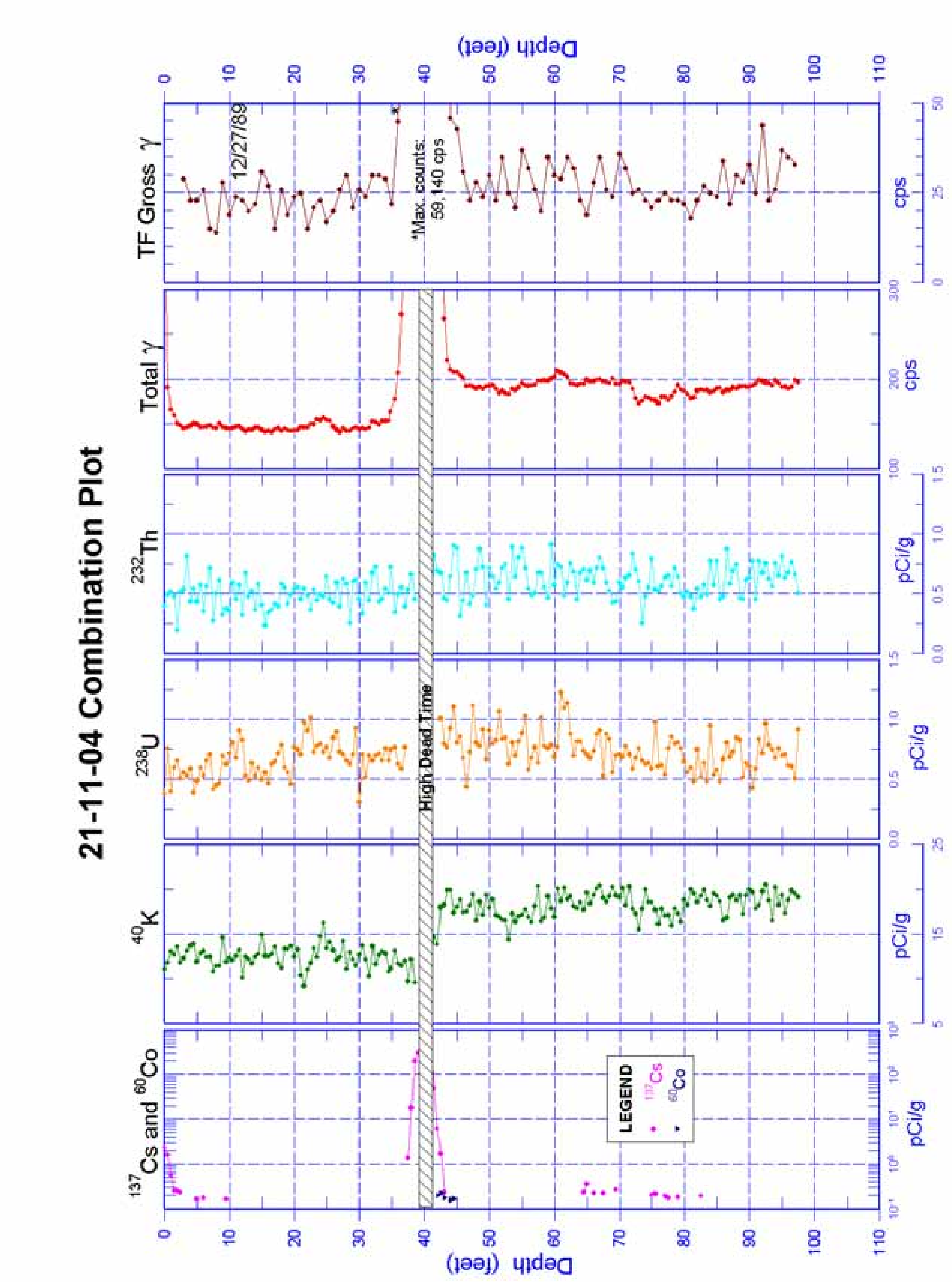

Figure 7: Contamination log Correlation Plot for Tank U-107

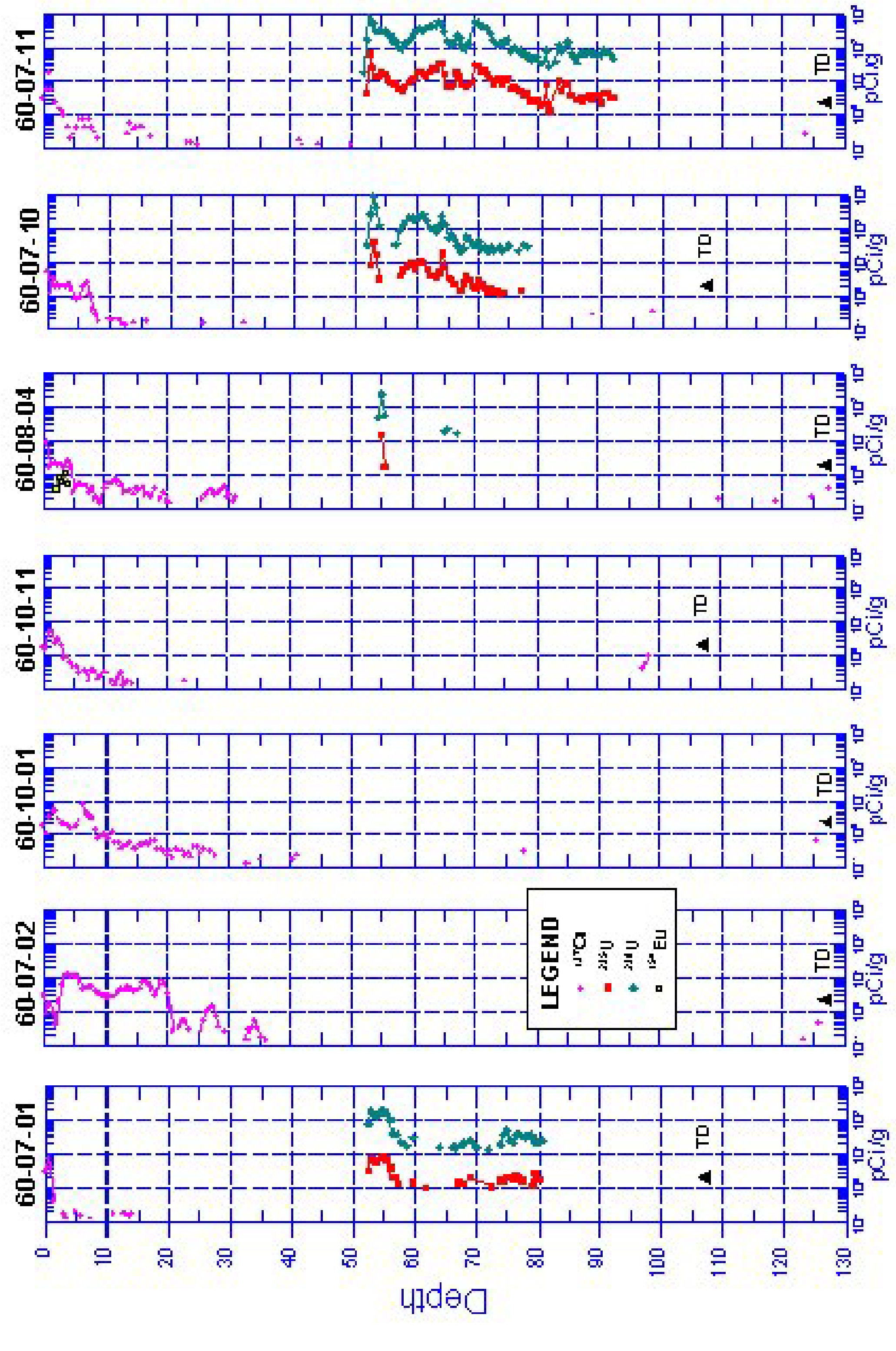

Figure C-7. Correlation Plot of Cs-137, U-235, U-238, and Eu-154 Concentrations in Boreholes Surrounding Tank U-107

Figure 8: Visualization of Contamination at TY Farm Viewed from the Southeast

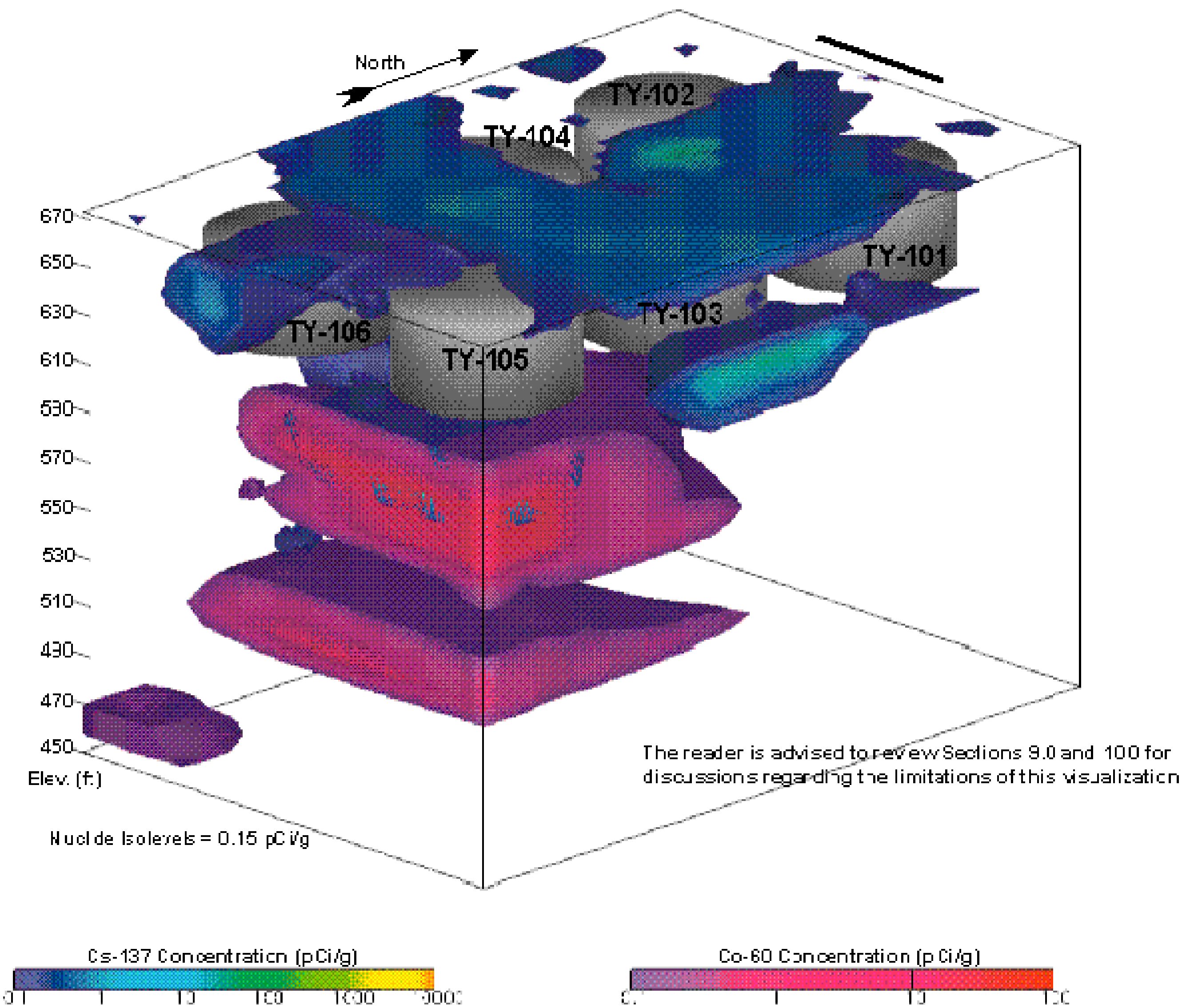

Figure 14-23. Visualization of the Cs-137 and Co-60 Contamination in the TY Tank Farm Viewed From Above the Tanks From the Southeast

Figure 9: Visualization of Contamination at TY Farm Viewed from the Northwest

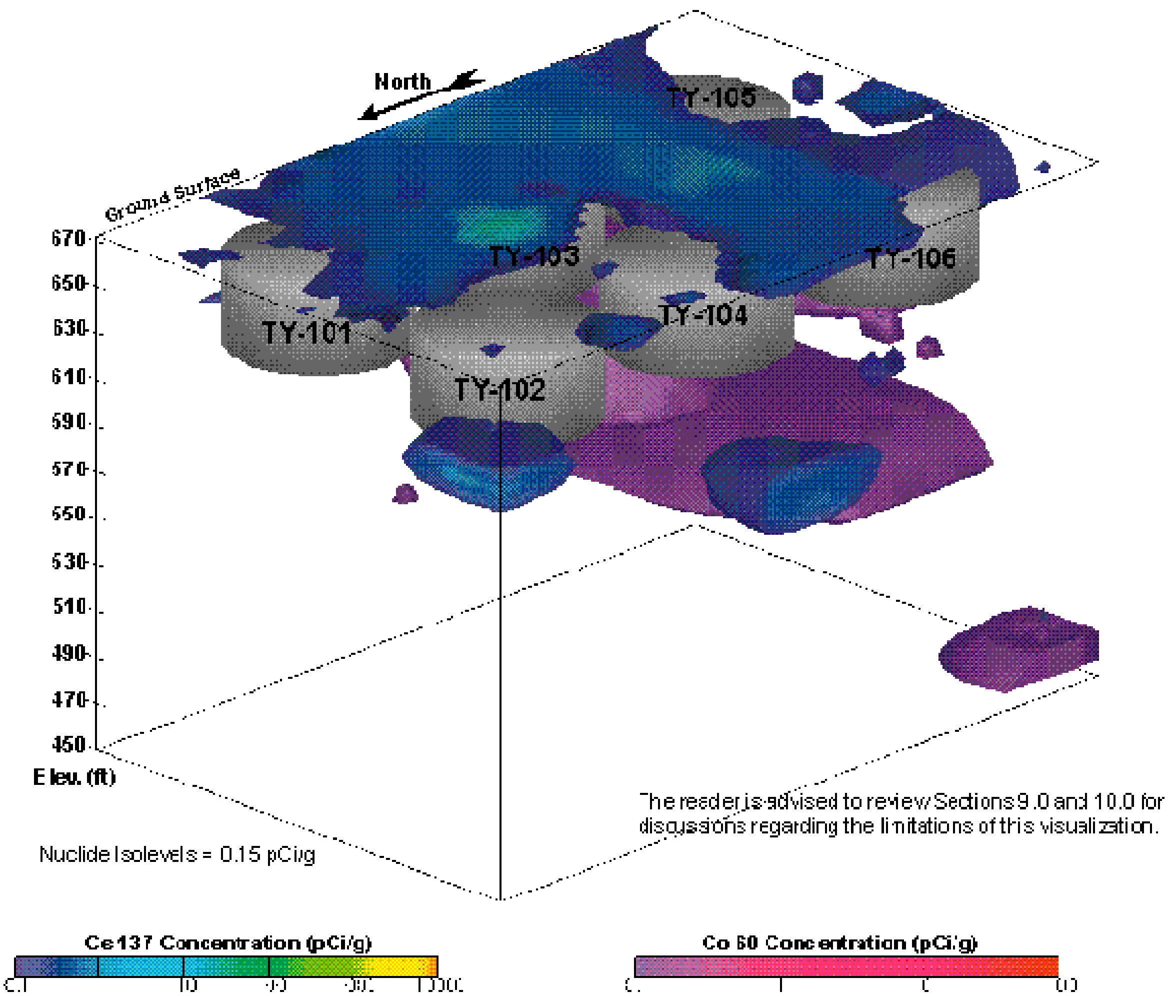

Figure 14-25. Visualization of the Cs-137 and Co-60 Contamination in the TY Tank Farm Viewed From Above the Tanks From the Northwest

Figure 10a: Spectral Gamma-Ray Combination Plot for Borehole 52-06-05

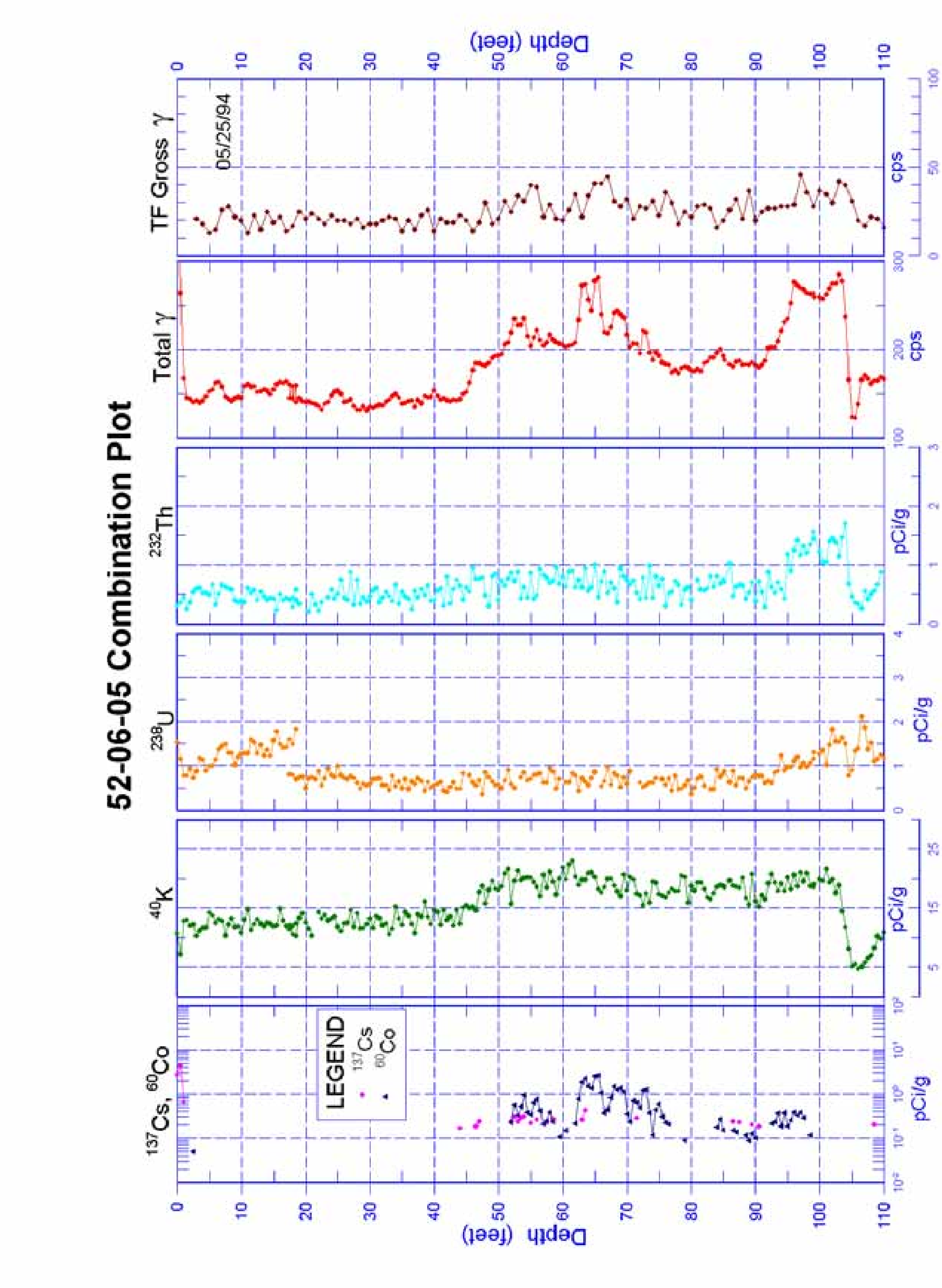

Figure 10b: Spectral Gamma-Ray Combination Plot for Borehole 52-06-05

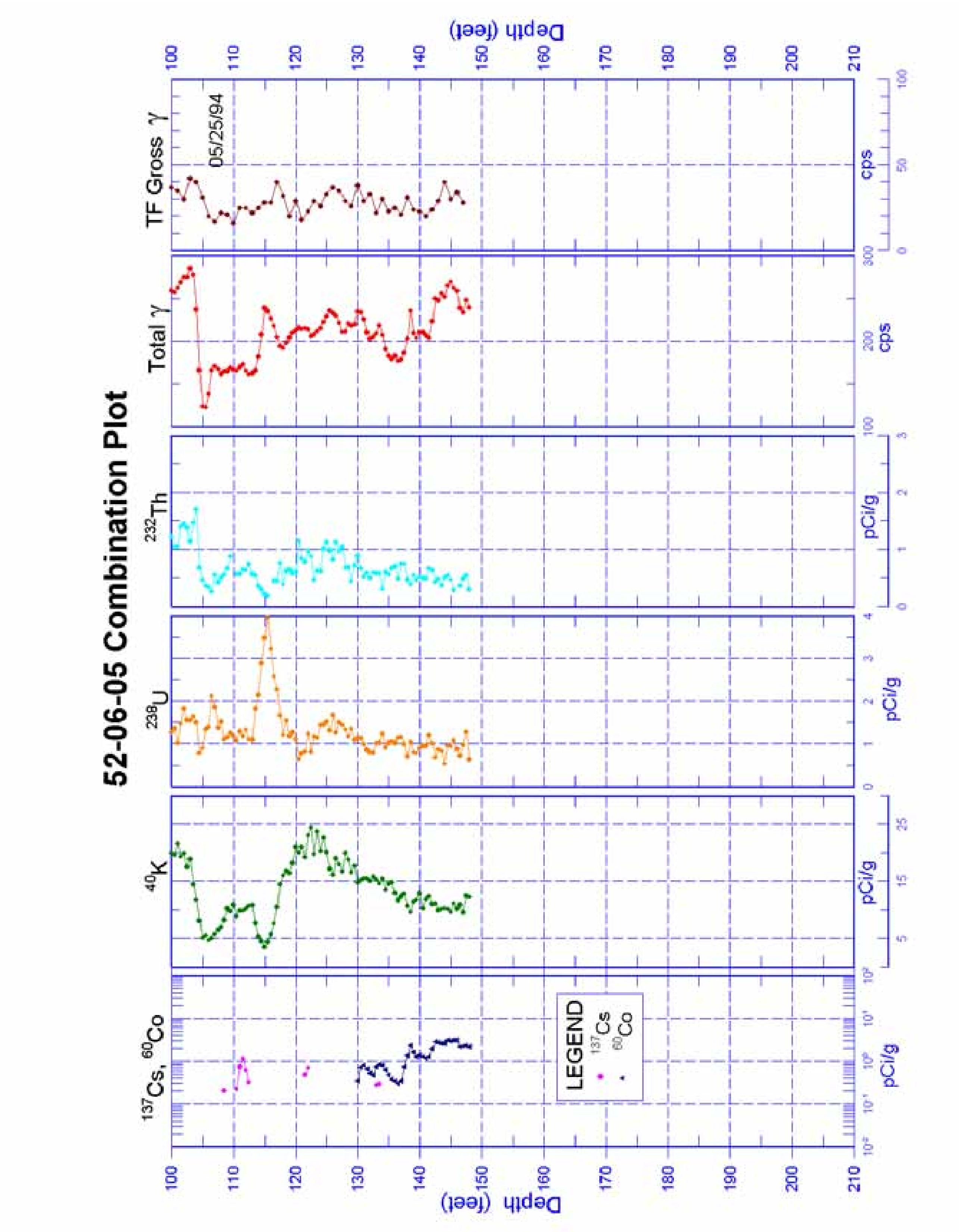

Figure 11a: Spectral Gamma-Ray Combination Plot for Borehole 52-06-07

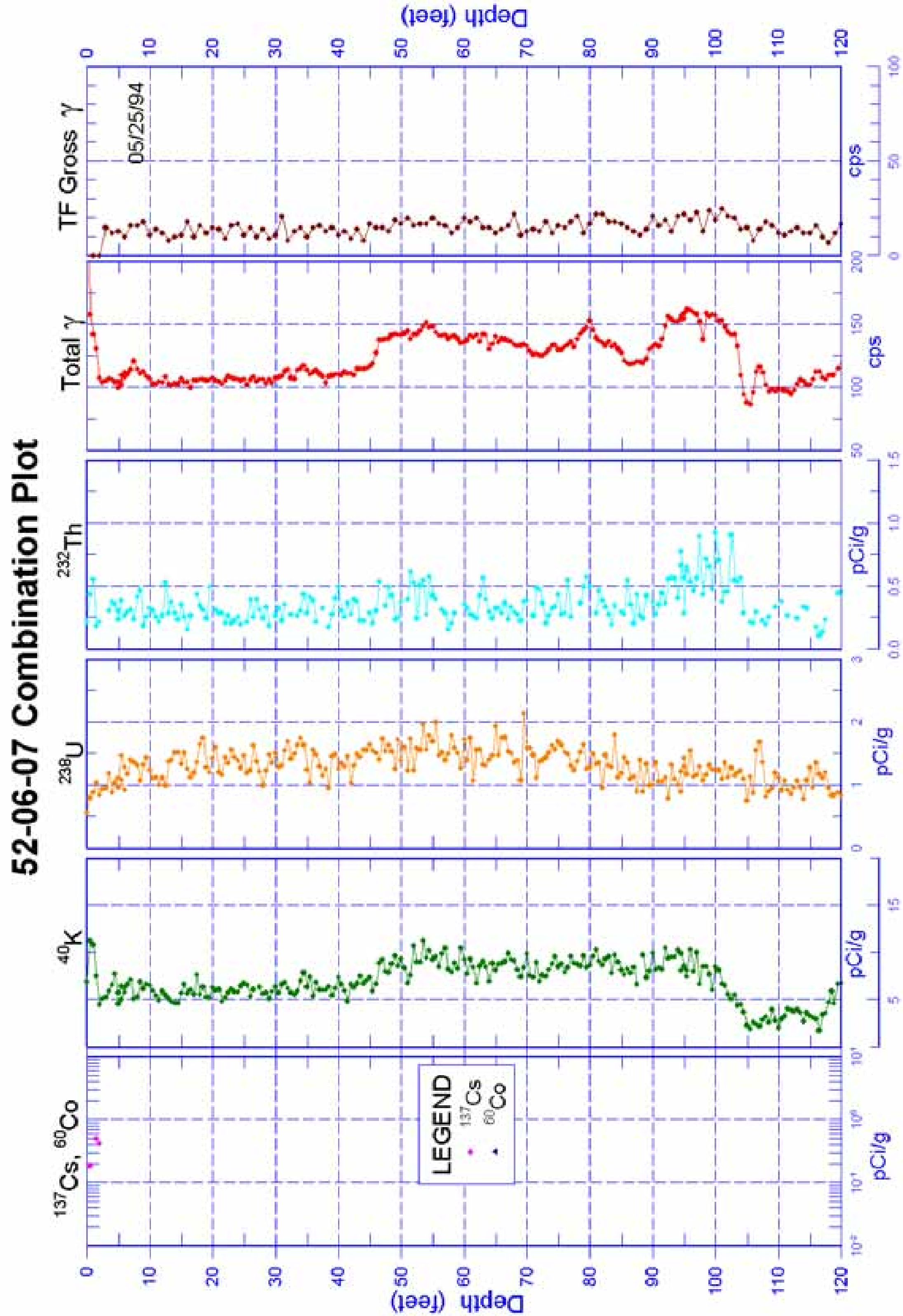

Figure 11b: Spectral Gamma-Ray Combination Plot for Borehole 52-06-07

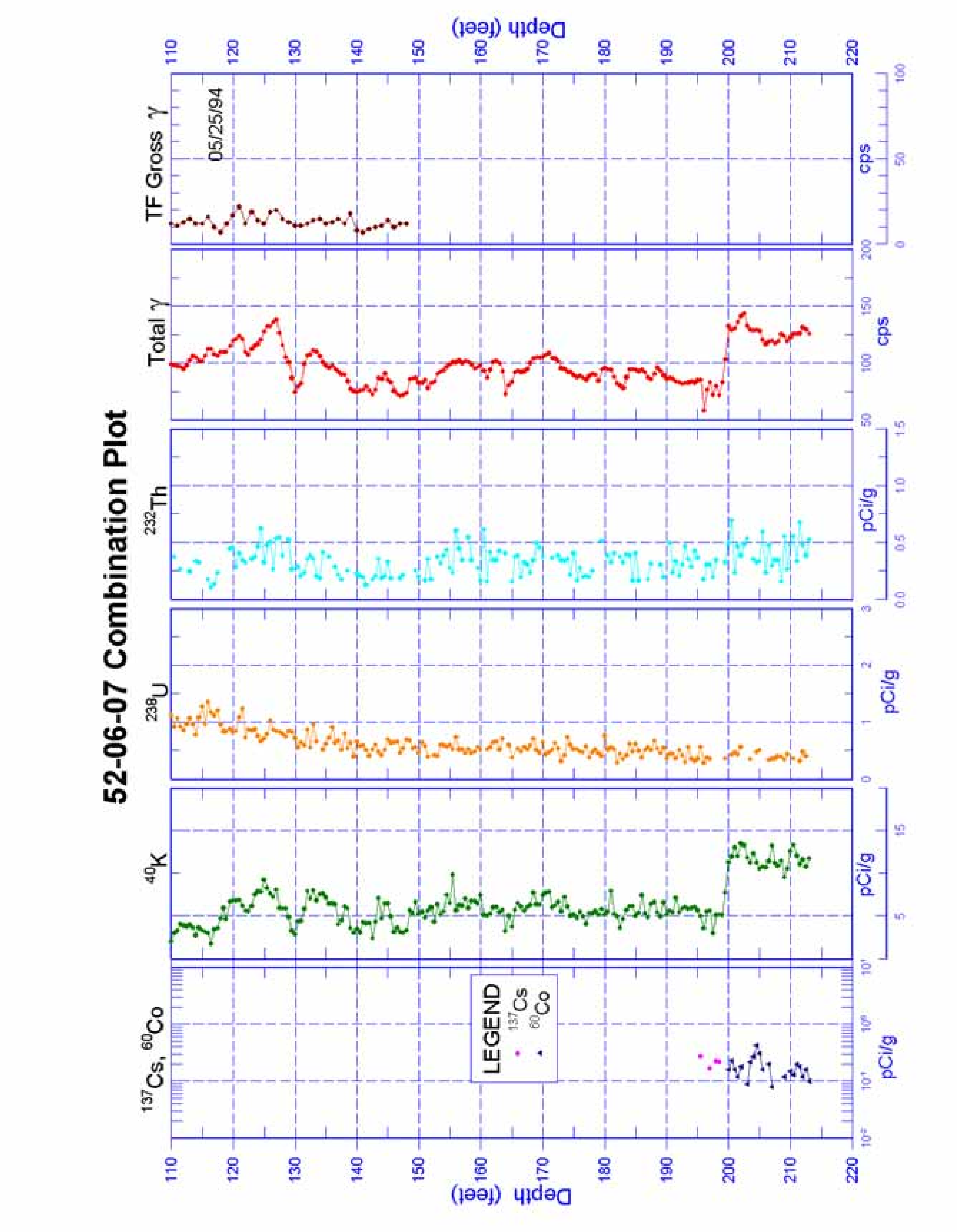

Figure 12: Spectral Gamma-Ray Combination Plot for Borehole 52-03-06

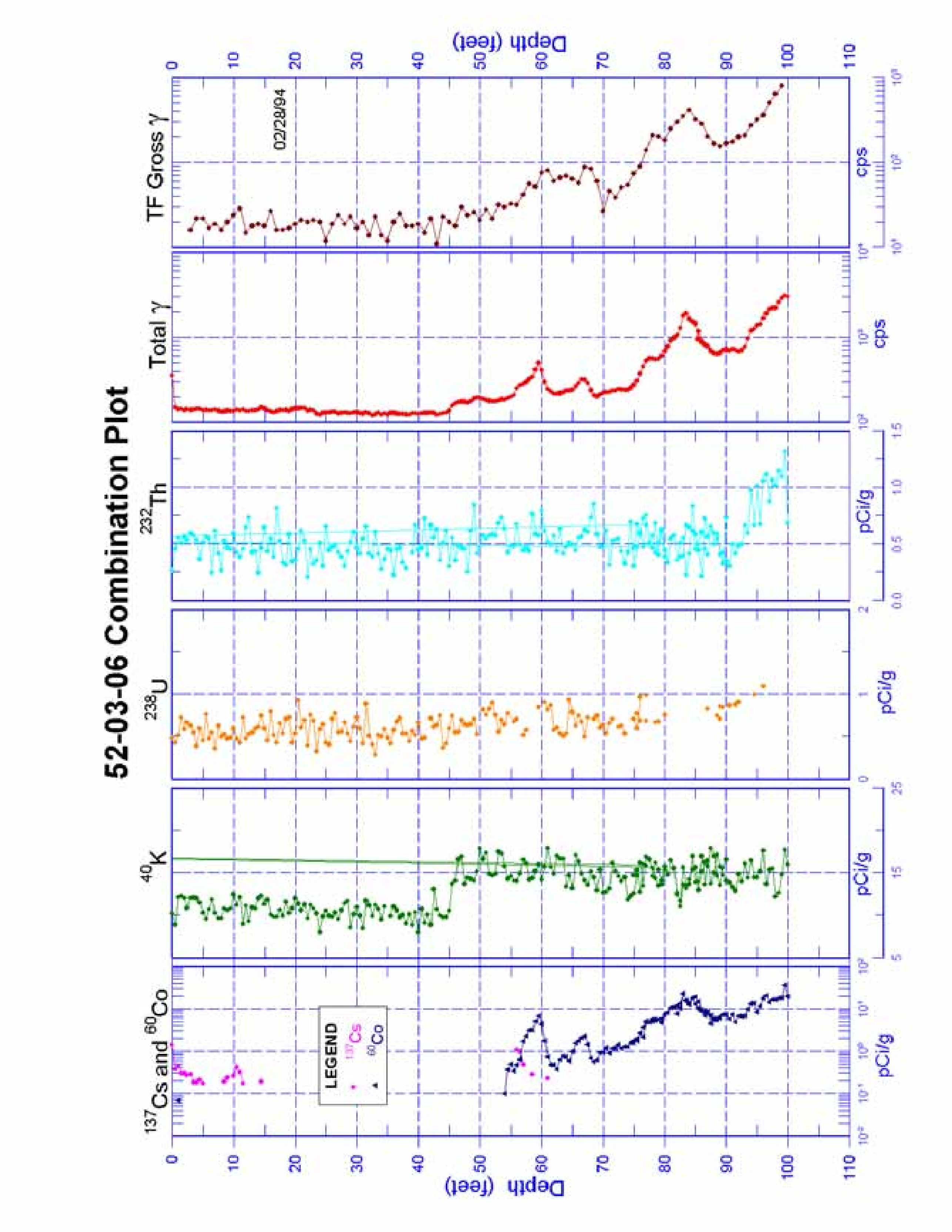

Figure 13: Contamination and Moisture data from Borehole 52-03-06

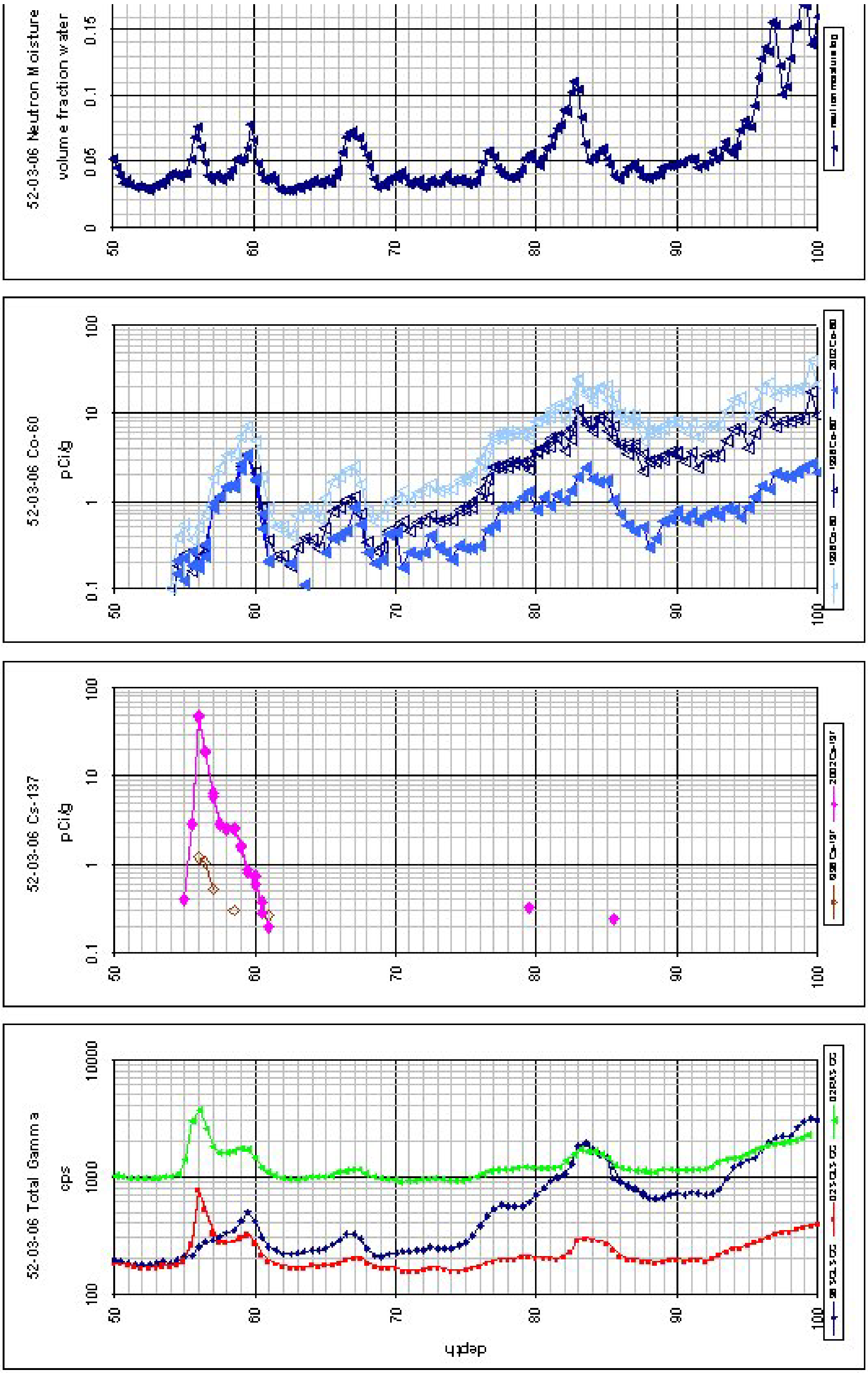

Figure 14: Neutron-Neutron Moisture Log from Borehole 52-06-02

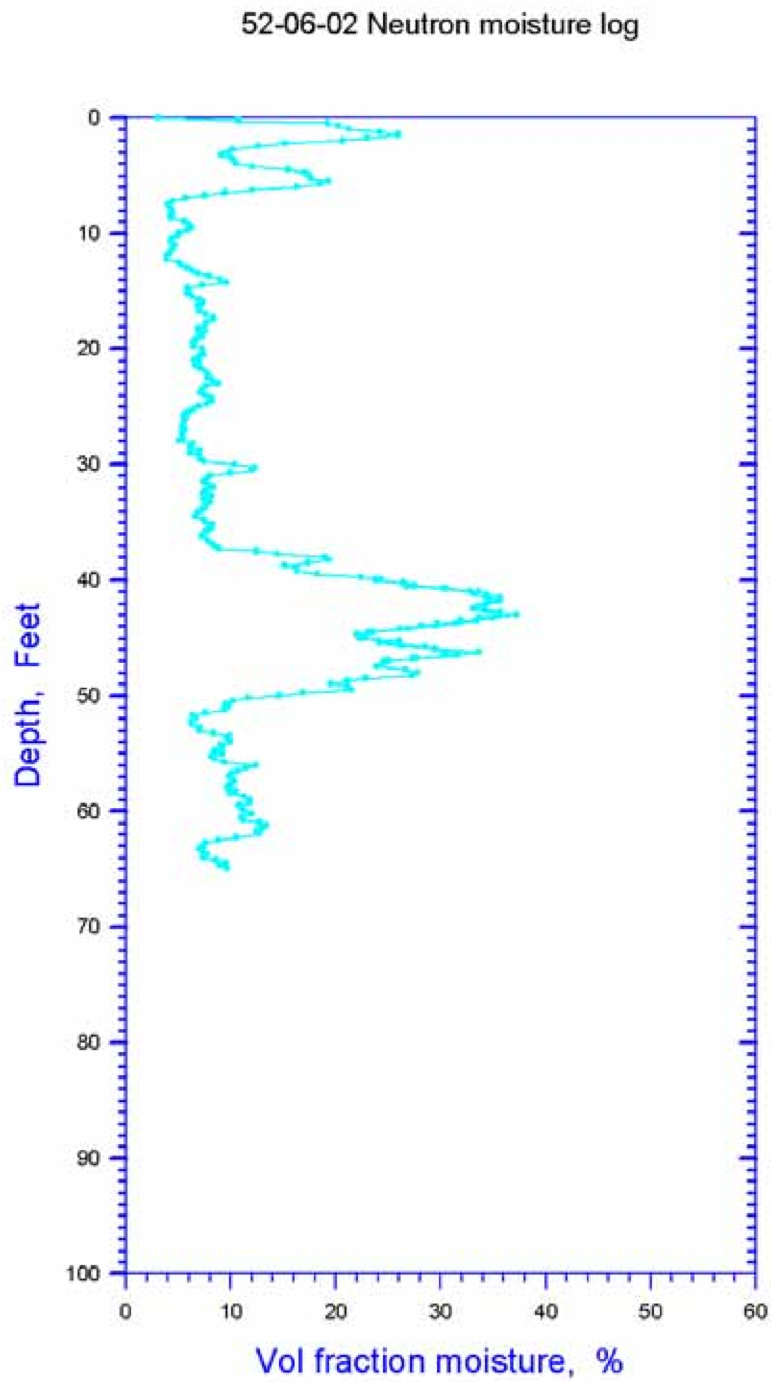

Figure 15: Spectral Gamma-Ray Combination Plot for Borehole 52-06-02

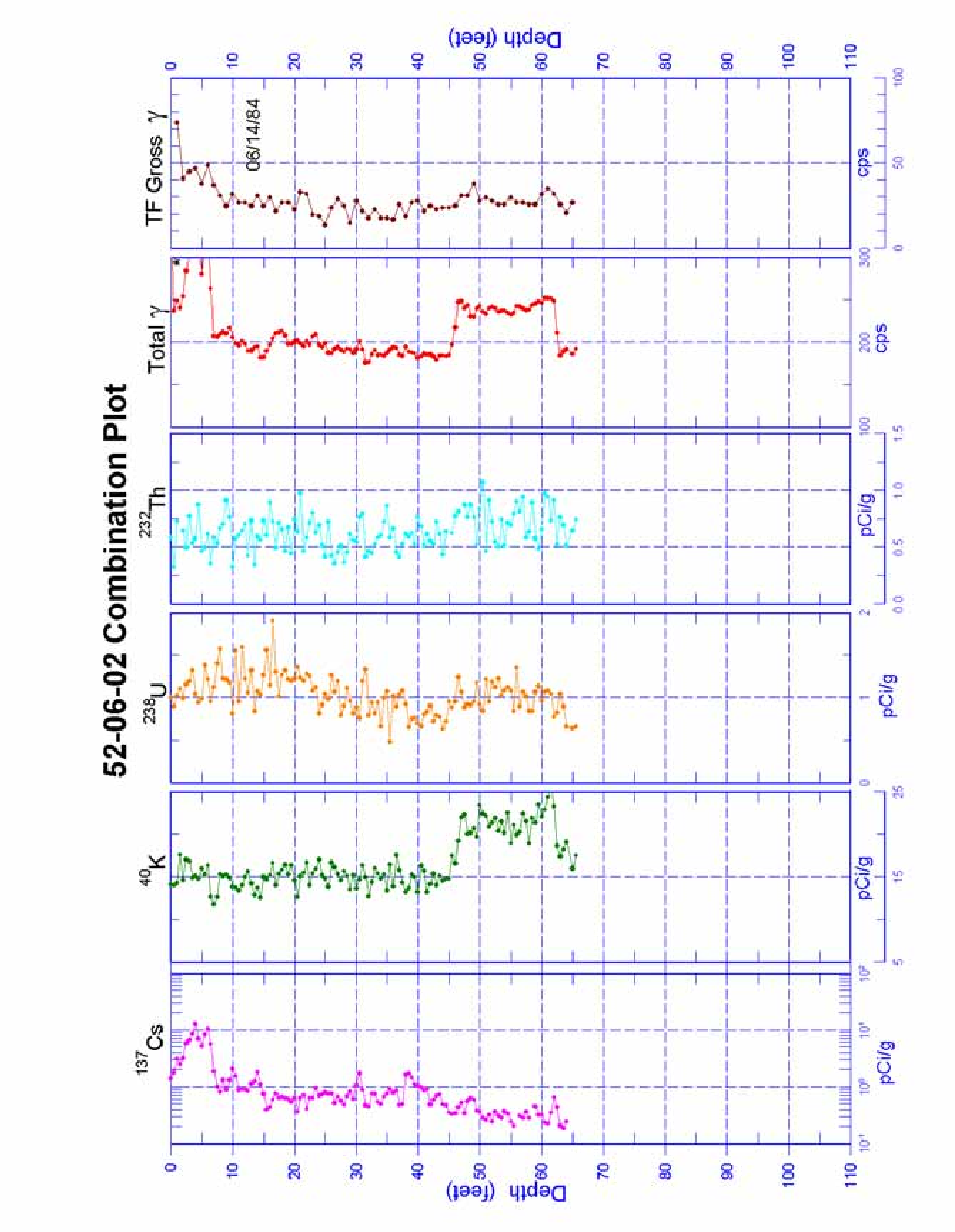

Figure 16: Plan Map of TY Tank Farm