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Technical Memorandum

To: Mr. Bill Gates, Navy Southern Division

From: Dr. Tom Johnston, Tetra Tech, NUS, Inc.

Date: 13 March, 2002

Subject: Installation of Additional Ground Water Monitoring Wells at NSWC Crane SWMU 01, Mustard Gas Burial Ground

1.0 Purpose

This memorandum constitutes a proposal, with supporting rationale, to install and sample two additional ground water monitoring wells at the Naval Surface Warfare Center (NSWC) Crane Solid Waste Management Unit (SWMU) 01, also known as the Mustard Gas Burial Ground (MGBG). The proposed additional wells would be installed to supplement the recent round of sampling conducted in year 2001 under the Phase III Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the MGBG. This RFI is being conducted by Tetra Tech NUS, Inc. (TtNUS) on behalf of the U.S. Navy Southern Division. Also proposed is some additional sampling of existing wells.

This memorandum explains why ground water is the only environmental medium for which additional sampling is recommended at this time. The additional well installation and associated ground water sampling would be used to support the attainment of the following objectives:

1. delineate site contamination,
2. support a screening level human health risk assessment,
3. support a baseline ecological risk assessment, and
4. if chlorinated organic contaminants are detected in ground water at concentrations that pose an unacceptable risk to humans or ecological receptors, collect data that can be used to evaluate whether monitored natural attenuation is a potentially viable remedy for site contamination.

A quantitative risk assessment has not yet been performed. The risk assessment process was suspended pending the decision to install additional wells.

Review and concurrence with this proposal is requested of the Navy Southern Division.

2.0 SWMU 01 Pre-2001 Investigative History

The following MGBG history is summarized from the QAPP for this project (TtNUS, 2001a).

The MGBG located at NSWC Crane, Indiana was used between the end of World War II and the late 1960s as a burial ground for mustard gas bombs, radioactive thorium or thorium-containing chemicals and equipment, and small quantities of several laboratory chemicals. The only documented laboratory chemical disposal occurred in 1967.

Within the MGBG is the Primary Burial Area (PBA) which spans approximately 10% of the total MGBG area. Based on past records and site exhumations, this area is where most, if not all, burials and related activities took place.

In 1974 and 1980, radioactive thorium, mustard gas bombs and related materials were removed from the MGBG. During the 1980 exhumation, some mustard gas (an oily liquid) was released to the soil. The mustard gas was decomposed by chemical treatment soon after the release. After the 1980 exhumation, the MGBG was declared by the U.S. Navy Radiological Affairs Support Office (RASO) to have been cleared of radiological hazards.

A ground water (GW) sampling and analysis program was started in the early 1980s and continued into 1986. During that time 27 wells were installed in three phases. Another well, 01C01, that was not sampled prior to 2001, was installed between 1986 and 1993.

Radiological and chemical measurements were made on the sampled ground water. The only quantitative chemical historical data that are available are the GW chemical concentrations from the 1980s. Those data were collected from 27 of 28 site wells. According to existing reports, those data have not been validated.

In 1995 a geophysical survey identified the presence of two geophysical anomalies, each of which was believed to be trash buried at the site near the PBA (TtNUS, 2001a).

3.0 Historical Data Summary and Initial Conceptual Model

Note: Ground water monitoring wells were originally identified as WES 1-x-yy, where "x" represents a sequential well number and "yy" represents the year the well was installed. Current nomenclature identifies each existing "WES" well as 01-nn, where nn is a sequential well number equal to the one used in the "WES" numbering system. For example, old well number WES 1-1-81 would now be referred to as 01-01. Wells installed by TtNUS in 2001 are labeled as 01Tnn where "nn" is a sequential number ("T" indicates a well installed by TtNUS).

Historical data consist almost entirely of ground-water data. Between 1981 and 1986, the U. S. Army Corps of Engineers (USACE) Waterways Experiment Station (WES) installed 27 monitoring wells (Figure 1, Table 1). Well 01C01 was added later. The MGBG is located on the crest of a topographic ridge that drops off rather steeply to the north-northeast and to the southwest (Figure 1). Most of the monitoring wells are located:

- around the perimeter of the MGBG,
- 100 to 500 feet to the northwest along the crest of the ridge, or
- along the upper slope of the northwest flank of the ridge (ground elevation > 595 feet amsl).

Most of these wells are in areas that represent shallow ground-water flow immediately surrounding the MGBG or shallow flow to the north and northwest directions. Two wells (01-18 and 01-27) are located slightly southwest of the ridge crest on the southwest side of access road H-251 (Figure 1). As described below, these two wells represent shallow ground-water flow in a southwesterly direction.

Shown on Figure 1 are lines of three geologic cross sections. These cross sections are presented in Figures 2 through 4. The ridge is composed of Lower Pennsylvanian-age bedrock of the Mansfield Formation, which consists of irregular beds and lenses of sandstone, siltstone,

and shale from near the ground surface down to an elevation of about 540 feet amsl (Figure 4). It is difficult to correlate individual sandstone, siltstone, or shale units between wells because they change elevation and pinch out rapidly in a lateral direction. There are two thin coal seams that were encountered at elevations of approximately 615 and 562 feet amsl (Figure 4). Because of the irregularities in the extent and thickness of each lithologic unit, and the variability in the permeability and yield of ground water for each well, it is not possible to divide the Pennsylvanian-age rock at this site into distinct "aquifers" or "water-bearing units". In general, the ground water is likely moving along fractures, joints, and bedding planes, and not through a porous matrix, as is commonly the case with unconsolidated deposits. The coal seams are the most likely candidates to act like horizontal "aquifers" because they are often more continuous and permeable than the other lithologies, but they are also thin.

Because shales and clay units are less competent and relatively "soft", joints and fractures in these layers tend to reseal over time and tend to be less permeable, but not always. As will be discussed below, it appears that the fractures and joints in shales and clays are sealed at this site and these units are acting as aquitards (i.e., resistant to ground water flow).

Limestone beds were encountered in wells 01-06 and 01-10 (Figure 4) and 01-C01 (Figure 3) below an elevation of approximately 540 feet amsl. The limestone probably represents the uppermost Mississippian-age rock at this location. The exact formation within the Mississippian System is still being determined, but the uppermost limestone is probably part of the Glen Dean or Golconda Limestones of the Stevensport Group. The uppermost Mississippian Limestone is considered to be an aquifer, separate from the Pennsylvanian rocks above. Altogether, there is about 120 to 130 feet of Pennsylvanian rock overlying the Mississippian limestones and shales. The bedrock units dip slightly to the west or southwest.

The ridge is the result of a long period of erosion following the deposition, consolidation, and subsequent uplifting of the Pennsylvanian rocks. As the Pennsylvanian rocks were eroded away, a layer of residual soil developed on the ridge crest and on the flanks of the ridge. As shown in Figures 2 through 4, the thickness of the residual soil on the ridge crest is typically 2 to 10 feet thick. On the flanks of the ridge, the residual soil thickness is generally less than 4 feet thick.

The ground water levels measured in monitoring wells located on the ridge crest or upper flanks of the ridge were between 9 and 40 feet below ground surface (bgs). These wells are all screened in the upper or middle portions of the Pennsylvanian strata. A potentiometric surface map for the ground water elevations measured in these wells in September 1983 is presented as Figure 5. The shallow ground water elevation is highest in well 01-01 located on the southeast side of the MGBG. The high groundwater elevations continue in the northwest direction along the ridge crest, as would be expected. On the northeast ridge flank, the ground water elevations decline rapidly to the north and northeast in the direction of the intermittent stream channel. Between 01-02 and 01-09, groundwater elevations drop approximately 60 feet. Few wells are located on the southwest side of the ridge, but it is assumed that ground water elevations are declining steeply in a southwesterly direction, as well. Based on Figure 5, the steepest hydraulic gradients are toward the north and toward the southwest away from the MGBG. There is a much gentler hydraulic gradient toward the northwest.

A tag map of the 1980s ground water VOC data, as excerpted from the QAPP, is presented in Figure 6. Where it was deemed useful, the concentrations of individual VOCs are presented on Figure 6, however, the total organic halogen (TOX) concentrations were generally plotted in place of individual VOC concentrations. The justification for this is twofold. First, among

individual VOCs and TOX, the TOX data were most comprehensive in terms of the number of rounds of sampling/analyses, and number of wells represented. Second, the 1980 data show that, by far, the bulk of the TOX data comprise chlorinated VOCs. Thus, a presentation of TOX concentrations is a concise way to present the sum of chlorinated VOC concentrations at individual wells. The years in which the data were generated are shown on each tag of Figure 6.

The greatest concentrations of VOCs were consistently detected at well WES 1-2-81 (now called 01-02) in the 1980s. For example, the concentration of 1,1,2,2-tetrachloroethane (PCA) was approximately 600,000 ug/L at that point in 1982. Table 2 is a summary of VOC concentration data from 1980s and 2001 for detected VOCs. Each value in the table is the average of concentrations measured over the course of the indicated years so these concentrations do not necessarily match those plotted on Figure 6. PCA and TCE are highlighted in Table 2 because they were the most frequently detected compounds and are used to establish concentration contours discussed later in this memorandum. Notes are provided in the table to indicate when sample dilutions may have caused elevated detection limits for compounds other than PCA and TCE. Routine method detection limits for year 2001 are also provided in the table as points of reference.

Figure 6 shows sharply decreasing ground water VOC concentrations radially from the area near well 01-02. Many perimeter wells exhibit detectable TOX or VOC concentrations (detection limits were near 1 ug/L). The spatial TOX and VOC concentration distributions are consistent with the expectation that ground water flows toward the northwest. This is especially evident by the decreasing VOC concentrations toward the northwest away from the MGBG and an elongation of the contaminant plume in the northwesterly direction. Also evident was the potential for radial flow from near the PBA because some VOCs were detected in wells WES 1-1-81, WES 1-3-81, and WES 1-4-91 to the southeast, southwest and northeast of the MGBG, respectively.

Fifteen years passed between the 1986 sampling and the current RFI. It was possible that VOC concentrations had changed dramatically during that time period. It was also possible that VOCs had moved significantly outward from the MGBG, especially to the northwest. It was also possible that VOC concentrations had decayed to insignificant levels despite the high concentrations observed in the 1980s.

4.0 Nature and Extent of Contamination in 2001

The QAPP, Section 4, identifies sampling locations and scheduled sample analyses (TtNUS, 2001a). Figure 1 of this memorandum displays site features and sampled locations. No deviations from the QAPP that could affect this technical memorandum are noted. Surface water samples were scheduled to be collected from the drainage channels leading away from the MGBG were, if water was present at the time of sampling. There was no flow present at that time and surface water was not sampled.

Based on the 2001 analytical data and the decision rules outlined in the QAPP (TtNUS, 2001a), the media-specific nature and extent of contamination in soil, ground water, and sediment at the MGBG are discussed in the following subsections. Comparisons of site soil concentrations to background concentrations were made in accordance with the NSWC Crane Basewide Background Soil Investigation Report (TtNUS, 2001b).

The focus of this memorandum is on an evaluation of whether or not additional ground water well installations and sampling are needed to complete the RFI. Therefore, a detailed assessment of ground water contamination is presented here but the extent of contamination in soil and sediment is treated less rigorously. It is expected that the arguments presented for soil and sediment regarding extent of contamination will be self-evident upon inspection of the figures in this memorandum together with the accompanying text.

Several tag maps were used to show the spatial distributions of chemical concentrations at the MGBG. They are referenced in the subsections below where appropriate. Shown on the tags or each map are the screening limits to which the data were compared (e.g., DC, MIG, R9RES, BACK). If a soil metal concentration exceeded the 95% coverage, 95% upper tolerance limit (95/95 UTL) of the NSWC Crane basewide background data set, the tag for that sample indicates "UTL". If an analyte concentration exceeded a risk-based screening limit, this is indicated on the tag by placing the screening limit abbreviation next to the analyte concentration. The screening limit descriptions are provided in a legend on each figure.

4.1. Surface Soil

As displayed by Figure 7, arsenic, selenium, thallium, and iron were the only metals detected at concentrations in excess of both background and risk-based screening levels. Concentrations of arsenic, selenium, and thallium in samples taken from the site perimeter are in excess of the risk-based screening levels, hence contamination is not bounded with respect to those screening levels. Nevertheless, arsenic concentrations are not viewed to be greater than background for reasons discussed in Attachment 1. The observed thallium concentrations are suspected to be analytical artifacts and select samples are being reanalyzed for thallium to determine whether this is true. Selenium and iron concentrations are not recommended for further investigation because they are not expected to pose a significant risk-related concern. This is discussed further in Section 6.

Figure 8 shows that several soil sampling locations exhibit thorium-230 concentrations in excess of background concentrations. However, there is no facility-wide thorium-230 background data set and the observed background exceedances are based on comparison to a single background soil sample from soil boring 01SB21. All other radionuclides are less than background concentrations and it is questionable whether thorium-230 actually exceeds background concentrations. Nevertheless, none of the observed thorium-230 concentrations exceeds the conservative US EPA soil screening level (SSL). Thus, additional investigation of radionuclides is not recommended.

As displayed by Figure 9, methylene chloride was the only volatile organic compound detected in surface soil at concentrations in excess of the USEPA Soil Screening Level (SSL) for migration to groundwater [dilution attenuation factor (DAF) of 1] of 1 ug/kg. There is no spatial trend in the methylene chloride concentrations to suggest a source of contamination for this compound. Whether the observed methylene chloride concentrations could be laboratory contamination is being investigated.

Isosafrole, a naturally occurring semivolatile organic compound (SVOC) used in the food and fragrance industries, was detected in a few surface soil samples (01SS050002, 01SS060002, 01SS11000201SS180002, 01SS200002, 01TPS04) at concentrations ranging from 150 ug/kg to 46,000 ug/kg. All but one of the concentrations (46,000 ug/kg in 01SS050002) were less than

the 9,940 ug/kg ecological screening level presented in Table 1-5 of the QAPP (TtNUS, 2001a). Additionally, the measured concentrations do not exceed human health risk-based screening level of 611,000 ug/kg derived by TtNUS based on toxicity studies (calculations and reference will be provided in the RFI report). There has been no U.S. EPA Region 3 or IDEM risk-based screening level developed for isosafrole to date. No other organic compounds were detected in MGBG surface soils in excess of any risk-based screening levels and the continued investigation of surface soils for organic compounds is not recommended.

4.2. Subsurface Soil

As displayed in Figure 7, arsenic, cadmium, chromium, nickel, selenium, thallium, and iron were the only metals detected in subsurface soil samples at concentrations in excess of background and risk-based screening levels. Similar to surface soils, the observed arsenic concentrations are either demonstrably comparable to background levels when site-specific factors are considered, or they are suspected of being analytical artifacts and are under investigation. There are no patterns of the spatial distributions for any of these metals to suggest the presence of a contaminant source. The concentrations of these metals do exceed background levels and, in some locations, risk-based screening levels. Although these chemicals are not bounded relative to the conservative screening levels, the concentrations do not appear to be elevated enough to cause an unacceptable human health or ecological risk (See Section 6). Therefore, continued investigation of metals in subsurface soil is not recommended.

The evaluation of radiological chemicals in subsurface soils was similar to that for surface soils (Figure 8). No radiological chemicals exceeded background radioactivity levels and risk-based screening levels. Therefore, continued investigation of radiological chemicals is not recommended.

As displayed by Figure 9, methylene chloride, PCA, and a few polycyclic aromatic hydrocarbons (PAHs) were the only organic compounds detected in subsurface soil at concentrations in excess of risk-based screening levels. Methylene chloride is suspected to be a laboratory artifact and this is being investigated. PCA was only detected in sample 01SB090206 at a concentration of 2 ug/kg. This concentration exceeds the USEPA SSL for migration to groundwater (DAF of 1). However, this contaminant is considered to be laterally bounded in soil and is not expected to pose an unacceptable human health or ecological risk at the observed concentration. PCA was detected in groundwater at a concentration of 38000 ug/L. It is likely that the presence of PCA in soil and ground water is related to past site disposal activities, but the soil interval exhibiting the 2 ug/kg PCA sits atop bedrock and therefore, cannot be bounded vertically in soil.

Benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene were each detected in only one sample, 01SB090206, which is located within the PBA (Figure 9). This is the same location where the PCA was detected in subsurface soil. Concentrations of benzo(a)anthracene and benzo(b)fluoranthene were in excess of USEPA SSL for migration to groundwater (DAF of 1) and the concentration of benzo(a)pyrene was in excess of IDEM Tier I Default Residential and Commercial/Industrial Soil Closure Levels. The infrequent presence of PAHs cast doubt as to whether these chemicals are related to site operations. Furthermore, the infrequent detections of these chemicals in subsurface soil do not appear to represent a significant risk concern (See Section 6). Additional sampling to bound the extent of organic chemicals in subsurface soil is not recommended.

4.3 Sediment

Note: Because the drainage channels were dry at the time of sampling and the "sediments" in those channels are not covered by water for 30 or more consecutive days during any year, the "sediments" may be considered to be soil. Therefore, sediment data are currently being evaluated against surface soils of the basewide background study to determine whether the observed inorganic chemical concentrations are similar to NSWC Crane surface soils.

A single sediment sample (01SD01) was collected upgradient of the MGBG site samples. This upgradient sample was treated as background for MGBG sediments, and direct comparisons of site sediment concentrations to this upgradient sample were made.

As displayed by Figure 10, antimony, barium, chromium, iron, selenium, and thallium were the only metals detected at concentrations in excess of background and risk-based screening levels. Arsenic and nickel concentrations were in excess of risk-based screening levels, but not background concentrations, and hence will not be discussed any further. Thallium was detected in six of seven samples at concentrations ranging from 0.57 mg/kg to 7.1 mg/kg but the observed concentrations are suspected of being laboratory artifacts and are under investigation. Concentrations of antimony, barium, chromium, and selenium were in excess of USEPA SSL for migration to groundwater (DAF of 1). Iron was detected in all seven samples at concentrations ranging from 12,300 mg/kg to 76,900 mg/kg. Concentrations of iron were in excess of the USEPA Region IX PRG for residential land use.

Concentrations of these metals are similar to concentrations detected in surface and subsurface soil samples. There is no pattern with respect to the spatial distribution of these metals. Concentrations of metals present in the most downgradient sample location (01SD02) were in most cases greater than in the other sediment samples, hence contamination is not bounded with respect to conservative risk-based screening levels. Nevertheless, the observed concentrations are not expected to raise a significant risk concern. Additional sampling of sediments, therefore, is not recommended. This is explained in more detail in Section 6.

Concentrations of radionuclides in sediment were less than all risk-based screening levels and additional sediment sampling to bound radiological contaminants is not necessary.

The isosafrole concentration of sediment sample 01SD06 (7,600 ug/kg) is in large excess of the 4.12 ug/kg sediment risk-based target level presented in Table 1-5 of the QAPP. However, the sediments at this site more closely resemble soils and the observed concentration is less than the soil risk-based target level. Furthermore, only a single detection of isosafrole in the drainage ditches was observed. Continued investigation of SVOCs in sediments is not recommended.

As displayed by Figure 10, PCA was the only organic compound detected in sediment at concentrations in excess of risk-based screening levels. This compound was detected in only sample 01SD03 at a concentration of 7 ug/kg, which is in excess of USEPA SSL for migration to groundwater (DAF of 1). This compound was also detected in subsurface soil samples at a maximum concentration of 2 ug/kg and in ground water at a maximum concentration of 38,000 ug/L. It is likely that the presence of PCA is related to past site disposal activities. Nevertheless, PCA contamination in sediment is bounded and continued investigation of sediment for organic chemicals is not necessary.

4.4 Ground Water

As displayed in Figure 11, arsenic, manganese, iron, and thallium were the only metals detected at concentrations in excess of risk-based screening levels. There is no background well for the MGBG because the well (01T02) that was intended to serve as a side-gradient (i.e., background) well is actually located hydraulically downgradient of the MGBG. Thallium (total) and thallium (dissolved) concentrations are in excess of USEPA Region IX Tap water PRG, IDEM Tier I Default Residential and Commercial/Industrial Ground Water Closure Level, and Federal MCL. Arsenic (total) concentrations are in excess of USEPA Region IX Tap water PRG and Federal MCL. Dissolved arsenic concentrations exceed only the USEPA Region IX Tap water PRG. Manganese (total) and manganese (dissolved) concentrations are in excess of USEPA Region IX Tap water PRG.

Arsenic and iron were also detected in surface and subsurface soil samples at concentrations in excess of risk-based screening levels. There is no pattern with respect to spatial distribution of arsenic, manganese, iron, and thallium concentrations. Metals contamination is not bounded laterally with respect to risk-based screening levels, but for reasons presented in Section 6, these metals are not believed to pose unacceptable risks.

Concentrations of the radionuclides in ground water were similar to or less than all risk-based screening levels except for gross beta detected in well 01-25 at a concentration of 50.2 pCi/L (not shown on Figure 11), which is just great enough to warrant re-analysis to verify this concentration (Figure 11). Re-analysis is currently under way.

Two "background" ground water samples were collected from well 01T02 with the intent of using them to evaluate site contaminants. These "background" samples, however, were not used for background comparisons because the recent hydrogeologic data support the view that radial flow of GW from the PBA exists at the MGBG (Figure 12). This radial flow places well 01T02 downgradient of the MGBG and suggests that installation of an upgradient well at the MGBG is not possible. The 2001 potentiometric surface data are discussed further in following sections of this memorandum.

As displayed in Figure 13, bis(2-ethylhexyl)phthalate was detected at concentrations exceeding the USEPA Region IX Tap water PRG, the IDEM Tier I Default Residential and Commercial/Industrial Ground Water Closure Level, and the Federal MCL. Bis-(2-ethylhexyl)phthalate was detected in three of eleven samples analyzed at concentrations ranging from 5 ug/L to 15 ug/L. Hexachloroethane was detected in well 01-02 at a concentration of 5 ug/L, which is in excess of the USEPA Region IX Tap water PRG. Heptachlor was also detected at concentration in excess of the USEPA Region IX Tap water PRG. Heptachlor was detected in wells 01C01 and 01-11 at concentrations of 0.017 ug/L and 0.023 ug/L, respectively. Concentrations of bis(2-ethylhexyl)phthalate, hexachloroethane, and heptachlor are bounded laterally with respect to the applicable screening limits. Furthermore, the concentrations of these chemicals, while in excess of select risk-based screening levels, do not appear to pose an unacceptable risk (See Section 6.0).

Figure 13 shows that several chlorinated VOCs were detected in ground water at concentrations in excess of risk-based screening levels (VOC concentrations are not shown for well 01T02 on that figure; see Table 2 for the concentrations). These VOCs were detected in five to 18 of the 28 ground water samples collected. Concentrations of chlorinated VOCs range from 0.1 ug/L

(chloroform) to 38,000 ug/L (PCA). Wells 01-05, 01-02, 01-15, and 01-19 contained concentrations of chlorinated VOCs in excess of 300 ug/L. Concentrations of chlorinated VOCs were in excess of one or all of the following risk-based screening levels:

- USEPA Region IX Tap water PRGs,
- IDEM Tier I Default Residential and Commercial/Industrial Ground Water Closure Levels, and
- Federal Maximum Contaminant Levels (MCLs).

Concentration contour maps of PCA and TCE based on 1980s based on ground water samples collected in the 1980s and 2001, and are shown on Figures 14 and 15 (1980s), and 16 and 17 (2001). The data for these figures were taken from Table 2. Only the most recent year for which data are available were used to generate the contours. Because data from multiple years was used for generating the Figure 14 and 15, the date associated with each concentration value is presented on the tags in those figures.

The greatest concentrations of groundwater contamination are found in well 01-02 for both chemicals in both sampling rounds. Concentrations of PCA at 66,000 ug/l and TCE at 30,000 ug/l were measured in well 01-02 in 1986, and were almost 50% less in 2001 (38,000 ug/l and 16,000 ug/l, respectively). Moderate contaminant concentrations were detected in wells 01-11 and 01-14 for both VOCs. These concentrations decreased between 1986 and 2001. Lesser concentrations of both VOCs were detected in wells 01-15, 01-19, and 01-22; however a decreasing trend in contaminant concentrations over time is not as evident in these wells when compared to wells further to the east, closer to well 01-02. Low concentrations of contaminants were detected in perimeter wells sampled during 2001 including wells 01-05, 01-8, 01-10, 01-18, 01-24; which serve to identify the boundary of shallow groundwater contamination.

Figure 17, which is a time series plot of yearly average VOC concentrations for PCA and TCE in wells 01-02 and 01-05 depicts the dramatic decrease in VOC concentrations in the center of the plume over the past 20 years. Table 2 is a presentation of the supporting data for these figures and serves to identify other concentrations of individual VOCs in the historical data. It must be remembered that the quality of the data prior to 1986 is unknown, so Figures 18a and 18b and Table 2 are provided only to serve as gross indications of the dramatic changes in chemical concentrations over time.

In general, the isoconcentration contour maps depict an oblong-shaped shallow groundwater plume with a west-northwest to south-southeast trending axis, which appears to be decreasing in concentration from 1986 to 2001. The greatest concentrations of groundwater contamination are clearly evident at well 01-02. The lateral extent of the contaminant plume is generally well defined with respect to risk-based screening levels. Low to undetectable concentrations of organic contaminants are evident in shallow perimeter wells, with the exception of well 01-25. The dotted (rather than solid line) isopleths near that well depicts this on Figures 16 and 17.

Taken together, the data from the 1980s and the 2001 data indicate that the plume is essentially static with regard to lateral position. The vertical extent of VOC contamination can not be said to be well bounded because there are not enough deep wells in the appropriate locations to demonstrate that vertical migration of VOCs is not occurring. In particular, the VOC plume extends toward the west-northwest, however, there should be deep wells along this axis that can demonstrate that VOCs have not migrated to lower elevations. This is especially significant given that the VOCs of interest have a specific gravity greater than 1.0 and would be expected to sink to lower elevations over time if they are present as nonaqueous phase liquids.

4.5 Summary of Environmental Contamination

The 2001 sampling and analyses revealed the continued presence of VOCs in ground water at the MGBG, albeit at generally lesser concentrations than in the 1980s. In the 1980s the VOC plume extended primarily to the northwest of the MGBG. This plume configuration is still evident today. Based on a review of the 2001 data, all other chemicals that were investigated meet one or more of the following conditions and do not warrant further investigation in any media except in select cases:

1. they are not detectable using routine chemical and radiological analytical methods,
2. the observed concentrations are commensurate with background concentrations,
3. the chemicals are present at concentrations that are less than applicable risk-based screening levels,
4. the chemicals are present at elevated concentrations but the concentrations do not appear to be elevated enough to represent an unacceptable human health or ecological risk.
5. the chemicals are present at elevated concentrations, but the observed concentrations are thought to be due to laboratory contamination (e.g., methylene chloride) or to analytical artifacts (e.g., thallium).

5.0 Current Conceptual Site Model

During the installation of soil borings in 2001, an effort was made to recover perched ground water at the overburden-bedrock interface at the MGBG. It was planned that this water could be used as an integrator of contamination that might collect at low points in the bedrock surface to increase the likelihood that overburden contamination would be detected if it were present. No water was found at the bedrock-overburden interface. This, coupled with geologic information, indicates that groundwater is present only in the bedrock beneath the site.

Hydrogeologic cross sections are presented in Figures 2, 3, and 4. Locations of the Hydrogeologic cross sections are shown on Figure 1.

As described in Section 3.0, only wells 01-06 and 01C01 monitor deeper groundwater in the bedrock. Shallow groundwater depths range from approximately 10 feet beneath the ground surface to greater than 30 feet beneath the ground surface, depending on topography. Shallow ground water flow patterns are expected to mimic topography, highest ground water elevations are typically found along ridge crests, and ground water flow is lateral toward the major stream or tributary valleys.

Well 01T02 was installed in 2001 by TtNUS about 800 feet to the southeast of the MGBG (Figure 1). The additional water level information obtained from this well has provided an improved understanding of MGBG hydrology and the ground water elevation contours have been updated to reflect this (Figure 12). Radial shallow groundwater flow in all directions is demonstrated by the 2001 water level measurements. Groundwater migration in the bedrock is expected to follow higher permeability pathways including lateral flow along bedding planes, as well as vertical flow along joints and fractures. The observed elongation of VOC contamination west of the PBA suggests that ground water could be migrating through fractures in this direction.

The wells used to create Figure 12 are all screened in Pennsylvanian rock above an elevation of 571 feet amsl. One of the original wells (01-06) is screened about 60 to 90 feet deeper than the other monitoring wells (screen elevation: 511 – 521 feet amsl). The ground water elevation measured in this well in 1983 was 61 feet deeper than the next deepest water level. The large difference between water levels in the shallow wells and the potentiometric levels in the deeper strata indicate that one or more of the following conditions exists:

- There is a large vertical hydraulic gradient within the ridge (nearly 1 foot/foot) that should be causing some portion of ground water within the ridge to be flowing downward.
- The fractures and joints within the shale and clay strata may be sufficiently sealed such that the vertical permeability through these lithologies is extremely low and they are acting as aquitards; i.e., they impede the downward flow of ground water and enhance the lateral flow toward the ridge flanks.
- The ground water in the Pennsylvanian rocks is perched above the uppermost Mississippian aquifer, and the Mississippian aquifer acts as an underdrain for the ridge.

Shallow groundwater contamination still appears to originate from an area in the vicinity of well 01-02, and is migrating laterally in a west-northwest direction. The potentiometric surface maps show a predominantly north – northeast flow component, but the westward dipping bedrock may act to divert groundwater flow to the northwest, resulting in contaminant migration in this direction. Shallow groundwater may also be migrating vertically in a downward direction along preferential pathways of lower hydraulic conductivity, namely joints and fractures. There is little to no lateral contaminant migration evident in the other directions from the MGBG.

Deep wells 01C01 and 01-06, are off the center axis of the ground water VOC plume, which elongates toward the west. Well 01C01 shows concentrations of naphthalene between 0.017 ug/L heptachlor and 0.108 ug/L of acenaphthene. Well 01-06 shows 0.08 ug/L of naphthalene. No other organic chemicals were detected in these wells and neither of these two wells showed detectable concentrations of volatile organic chemicals, which comprise the plume of interest. These and the other perimeter wells provide good indications that off-axis VOC concentrations have not migrated deep into the bedrock. However, the primary flow direction of VOC contamination in groundwater is toward the west-northwest and there are no deep wells in that direction. This lack of deeper wells along the long axis of the VOC plume where VOC concentrations are greatest makes it difficult to assess with a satisfactory level of confidence whether the VOCs have migrated downward in the bedrock. The implication of this is that deeper ground water contamination could be moving away from the MGBG without detection. The direction of shallow ground water is such that contaminated ground water would be moving further onto the Base, but the deeper ground water flow system is not understood as well as shallow flow. Without an understanding of deeper GW contamination, an evaluation of future risk and potential remedial actions is hampered. Risk assessment concerns are addressed briefly in the next section.

6.0 Risk Assessment Data Gaps

This section evaluates the environmental data collected to date to determine whether adequate data have been collected at the MGBG for purposes of conducting a human health risk assessment. The discussion is presented by environmental medium. The evaluation was conducted as required by the decision rules presented in the QAPP for the MGBG, but is an abbreviated evaluation designed to support the intent of this memorandum. A complete risk assessment will be conducted in accord with the QAPP at the appropriate time. The following factors were considered to determine whether data gaps exist:

- Contaminant levels in an environmental medium versus concentrations detected in the corresponding background environmental medium collected for Crane NSWC.

- Contaminant levels in an environmental medium versus risk-based concentrations and criteria specified in the QAPP for the MGBG.

- The spatial pattern of contamination (i.e., does the pattern of contamination suggest that the chemical or radiological contamination is site related?).

6.1 Data Gaps for Soils

As discussed in Section 4, radionuclides were not detected at concentrations exceeding base-wide background soil concentrations or background concentrations presented in the literature. Additionally, they do not exceed radiological soil screening levels. While some inorganic concentrations may exceed background concentrations, the exceedances generally appear to be marginal and the pattern of contamination does not suggest that the MGBG is a significant source of environmental contamination, if any source at all. The organic contamination detected in the soils is low-level (typically less than 1 mg/kg; frequently less than 100 ug/kg) and, in some cases (e.g., the PAHs), may reflect non-site related anthropogenic sources of contamination. Risk estimates based on analytical data for samples collected along the boundaries of the site would not exceed risk benchmarks for further nature and extent sampling established in the decision rules for the QAPP. Therefore, additional soil sampling for purposes of delineating the vertical/horizontal extent of contamination or conducting human health risk assessment is not recommended.

Although there are some exceedances of ecological screening levels at boundary locations (e.g., selenium), the magnitudes of the exceedances, the spatial distributions, and the exposure unit considerations are such that additional soil data are not needed to complete the baseline ecological risk assessment.

6.2 Data Gaps for Sediments

Although the thorium concentrations detected in the sediment samples exceed the concentration detected at background sediment sampling location 01SD01, the concentrations detected do not exceed background soil concentrations. Additionally, as noted above, radiological contaminants were not detected in source area soil samples at concentrations exceeding basewide background soil concentrations. As noted with the soil organic contamination detected in the sediments is low-level (typically less than 100 ug/kg; frequently less than 10 ug/kg) and, in some cases (e.g., the PAHs), may reflect non-site related anthropogenic sources of contamination. For example, contaminants observed in sediments near the MGBG access road and downgradient of debris piles located to the southeast of the MGBG are indicative of contamination that may be related to traffic and the accumulation of debris rather than MGBG operations. While some inorganic detections may exceed background, the pattern of contamination does not suggest that the site is a significant source area. Risk estimates based on analytical data for the samples collected would not exceed risk benchmarks for further nature and extent sampling established in the decision rules for the QAPP. Additional sediment sampling for purposes of delineating the vertical/horizontal extent of contamination or conducting human health risk assessment is not recommended.

Although there are some exceedances of ecological screening levels at boundary locations (e.g., selenium), the magnitudes of the exceedances, the spatial distributions, and the exposure unit considerations are such that additional soil data are not needed to complete the baseline ecological risk assessment.

6.3 Data Gaps for Groundwater

In contrast to the analytical data collected for soil and sediment, the available groundwater data suggest that the extent of volatile organic contamination has not been adequately delineated and additional investigation is warranted.

The available data for the shallow groundwater aquifer indicate that this natural resource is not suitable as a domestic water supply source. As shown in Figure 8, several VOCs have been detected in the shallow aquifer at concentrations exceeding risk-based concentrations and criteria (e.g., Federal Safe Drinking Water Act maximum contaminant levels) presented for domestic consumption of a water supply in the QAPP. Exceedances are noted in several wells including the wells most distant from the source (i.e., the horizontal extent of contamination has not been defined). However, environmental sampling over the past two decades also indicates that contaminant concentrations in the shallow aquifer have stabilized (and the plume is diminishing in concentration and lateral size). Furthermore, significant contaminant migration to a facility boundary (a potential receptor) is not likely because the ground water flow is toward the northwest toward the center of the NSWC Crane.

In contrast, only limited sampling of the deeper aquifer has been conducted and knowledge of the physical characteristics of the deeper aquifer is more limited (e.g., ground water flow direction; contamination, if any). The vertical extent of groundwater contamination has not been defined and risks to future on-site or off-site human receptors potentially using the deeper aquifer can not be estimated at this time. Consequently, a comprehensive baseline risk assessment (i.e., one that addresses all plausible receptors) can not be completed at this time and risk management decisions may be more limited than necessary as a result of this data gap. For example, if dense, nonaqueous phase liquids are present, the potential for contaminant migration off site would need to be evaluated. This is especially important when the proximity of the MGBG to the facility boundary is noted along with the potential for flow of ground water in different directions at different elevations. The ground water flow at the deeper elevations has not been characterized to date for the MGBG.

Additional groundwater sampling for purposes of delineating the vertical extent of VOC contamination and conducting human health risk assessment is recommended. This information will allow the refinement of the risk conceptual model for the site and the completion of the human health risk assessment. The additional information may also have an impact on remediation decisions for the site. The other organic chemicals, inorganics, and radiologicals detected in the groundwater samples to date (see Figures 7 and 8 and Section 4.0) are not significant site-related contaminants based on comparisons to background data, comparisons to risk-based screening levels, and based on the spatial distributions of the chemicals. Additional sampling and analysis for chemicals other than the volatile organic chemicals is not recommended.

7.0 Proposed Additional Field Work

It is proposed that two additional monitoring wells be installed to define the vertical extent of contamination beneath the shallow groundwater plume that exists at the site. These wells are intended to be installed in a deeper water yielding zone, in the anticipation of collecting groundwater samples that would yield no or very low concentrations of groundwater contamination. Success in achieving acceptably low levels of VOCs would constitute vertical bounding of the extent of organic chemical contamination at the MGBG.

The two wells will be installed as clusters adjacent to shallow wells 01-02 and 01-15. The well borings will be cored continuously to observe the subsurface conditions for the presence of a water yielding zones during drilling. The borings will be extended to at least 30 feet deeper than the adjacent shallow well but no deeper than 150 feet beneath the ground surface, depending on subsurface conditions. Well 01-06 monitors a groundwater zone in limestone at an approximate elevation of 510 feet amsl. This zone appears to be hydraulically lower from the shallow groundwater monitored by the remaining wells at the site (see the potentiometric surface elevations shown on Figure 12). This zone may be targeted for deep monitoring wells, in the event that no significant water yielding zones worthy of monitoring are encountered at shallower depths during well drilling.

It is proposed that vertical profiling of VOCs be conducted by scanning the rock cores with an organic vapor monitor. This profiling, supplemented with visual inspection, will yield information concerning the elevations at which VOCs may be present. It is proposed that aquifer testing (e.g., slug testing) be performed to establish bedrock permeabilities in this region of the MGBG.

Pending the investigation of potential analysis artifacts a minimal number of additional analyses may also be proposed to resolve questions concerning the presence of, or concentrations of, contaminants in other environmental media. In addition, natural attenuation parameters will be measured in accordance with the QAPP.

References

TtNUS, 2001a. Quality Assurance Project Plan for the Mustard Gas Burial Ground Resource Conservation and Recovery Act Phase III RCRA Facility Investigation, Surface Warfare Center Crane, Crane, Indiana, prepared by Tetra Tech NUS, Inc. for Southern Division, Naval Facilities Engineering Command under Contract Number N62467-94-D-0888, Contract Task Order number 0131 and 0158.

TtNUS, 2001b. Basewde Soil Background Report Naval Surface Warfare Center Crane, Crane, Indiana, prepared by Tetra Tech NUS, Inc. for Southern Division, Naval Facilities Engineering Command under Contract Number N62467-94-D-0888, Contract Task Order number 0083.

TABLE 1

SUMMARY OF MONITORING WELL CONSTRUCTION DETAILS
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

Monitoring Well Number[1]	Date Installed	Horizontal Location[2]		Ground Surface Elevation (feet-AMSL)	Top of PVC Casing Elevation (feet-AMSL)	Well Depth from Top of PVC Casing (feet)	Screen Length (feet)	Well Screen Interval		Well Screen Interval		Ground water Depth & Elevation		
		Northing	Easting					Depth to Top (feet-bgs)	Depth to Bottom (feet-bgs)	Elevation of Top (feet-AMSL)	Elevation of Bottom (feet-AMSL)	Date Measured[3]	Depth to Water (feet)	Ground water Elevation[4] (feet-AMSL)
WES-1-1-81	1981	460547	578084	683.14	686.14	51.0	9.63	33.14	42.77	650.00	640.37	09/14/83	26.05	660.09
WES-1-2-81	1981	460856	577831	664.04	667.04	25.8	9.36	8.24	17.60	655.80	646.44	09/14/83	13.50	653.54
WES-1-3-81	1981	460596	577746	667.43	670.43	21.6	9.42	3.99	13.41	663.44	654.02	09/14/83	12.53	657.90
WES-1-4-81	1981	460800	577998	669.95	672.95	34.0	9.21	16.47	25.68	653.48	644.27	09/14/83	16.28	656.67
WES-1-5-81	1981	460831	577913	665.69	668.69	33.6	9.12	16.18	25.30	649.51	640.39	09/14/83	15.35	653.34
WES-1-6-82	11/12/82	461115	577955	596.02	599.02	93.0	9.38	75.02	84.40	521.00	511.62	07/20/83	69.70	529.32
WES-1-7-82	11/14/82	461184	577674	603.45	606.45	31.0	9.38	12.61	21.99	590.84	581.46	09/14/83	17.94	588.51
WES-1-8-82	11/15/82	461099	577833	601.99	604.99	31.2	9.32	13.63	22.95	588.36	579.04	09/14/83	15.67	589.32
WES-1-9-82	11/17/82	461048	577939	610.18	613.18	35.0	9.38	17.40	26.78	592.78	583.40	09/14/83	22.38	590.80
WES-1-10-82	01/22/83	460960	577916	636.77	639.77	43.0	9.40	25.25	34.65	611.52	602.12	09/14/83	26.45	613.32
WES-1-11-82	01/08/83	460880	577737	656.34	659.34	22.6	8.63	6.72	15.35	649.62	640.99	09/14/83	9.04	650.30
WES-1-12-83	01/19/83	461011	577714	634.05	637.05	41.0	9.41	23.26	32.67	610.79	601.38	09/14/83	25.85	611.20
WES-1-13-83	01/22/83	460993	577809	634.98	637.98	38.0	9.45	19.97	29.42	615.01	605.56	09/14/83	25.08	612.90
WES-1-14-83	01/26/83	460924	577635	656.14	659.14	39.0	9.53	21.12	30.65	635.02	625.49	09/14/83	16.84	642.30
WES-1-15-83	02/10/83	460965	577543	663.01	666.01	40.0	9.50	22.10	31.60	640.91	631.41	09/14/83	27.03	638.98
WES-1-16-83	02/11/83	461069	577611	641.94	644.94	41.5	9.25	23.75	33.00	618.19	608.94	09/14/83	35.25	609.69
WES-1-17-83	02/12/83	460823	577609	662.54	665.54	41.0	9.30	23.25	32.55	639.29	629.99	09/14/83	19.70	645.84
WES-1-18-83	06/18/83	460685	577538	658.40	661.40	32.0	9.29	14.3	23.59	644.10	634.81	09/14/83	14.58	646.82
WES-1-19-83	06/18/83	461000	577478	656.79	659.79	33.2	9.0	15.7	24.70	641.09	632.09	09/14/83	20.35	639.44
WES-1-20-83	06/21/83	461131	577516	631.35	634.35	39.1	9.34	21.35	30.69	610.00	600.66	09/14/83	28.00	606.35
WES-1-21-83	06/21/83	461225	577587	603.82	606.82	41.2	9.01	23.74	32.75	580.08	571.07	09/14/83	18.24	588.58
WES-1-22-83	07/09/83	461034	577355	653.55	656.55	38.0	9.15	20.5	29.65	633.05	623.90	09/14/83	17.55	639.00
WES-1-23-83	07/11/83	461152	577419	625.81	628.81	48.0	9.07	30.51	39.58	595.30	586.23	09/14/83	40.05	588.76
WES-1-24-83	07/09/83	461267	577496	600.57	603.57	33.4	9.41	15.62	25.03	584.95	575.54	09/14/83	15.18	588.39
WES-1-25-83	08/06/83	461072	577259	654.16	657.16	34.2	8.37	17.42	25.79	636.74	628.37	09/14/83	20.10	637.06
WES-1-26-83	08/06/83	460954	577245	670.21	673.21	58.0	9.12	40.45	49.57	629.76	620.64	09/14/83	35.25	637.96
WES-1-27-83	08/10/83	460776	577381	659.75	662.75	43.0	9.0	25.55	34.55	634.20	625.20	09/14/83	23.86	638.89
1C01-93	1993	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

1 All wells were installed by the USACEWES and screened in the Pennsylvanian formation.
2 Referenced to the Indiana State Plane Coordinates, Zone 1302 (West), NAD 83.
3 Most recent round of water level data (Dunbar, April 1984, Appendix D).
4 Referenced to top of PVC casing.

Notes:
BGS - below ground surface
AMSL - Above mean sea level
PVC - polyvinyl chloride
NA - not available
Elevations are relative to Mean Sea Level, NGVD 29.

Table 2
Concentrations (ug/L) of Detected VOCs Over Past 20 Years

Well	Parameter	Year					2001 MDL	Notes
		1982	1983	1985	1986	2001		
01-01	METHYLENE CHLORIDE	8.0				1U		
	TETRACHLOROETHENE	0.1				0.5U		
01-02	1,1,2,2-TETRACHLOROETHANE	312500		525	66000	38000		
	1,1,2-TRICHLOROETHANE			2.2			1000	Sample dil'n
	1,1-DICHLOROETHENE	65.0					500	Sample dil'n
	1,2-DICHLOROETHANE	3090					500	Sample dil'n
	BROMOFORM	8600					500	Sample dil'n
	CARBON TETRACHLORIDE	34.0					500	Sample dil'n
	CHLOROBENZENE	6.0					500	Sample dil'n
	CHLORODIBROMOMETHANE	3040					500	Sample dil'n
	CHLOROFORM	2000				840		
	METHYLENE CHLORIDE	47.0					1000	Sample dil'n
	TETRACHLOROETHENE	3450		187.0		370		
	TRANS-1,2-DICHLOROETHENE	2475		24.3			1000	Sample dil'n
	TRICHLOROETHENE	87500		1180	30000	16000		
01-03	1,1,2,2-TETRACHLOROETHANE	20.0					0.5	
	TRICHLOROETHENE	3.0					0.6	
01-04	METHYLENE CHLORIDE	1.0					5	
01-05	1,1,2,2-TETRACHLOROETHANE	58.0		85.9	7.0	9.0		
	1,1,2-TRICHLOROETHANE			4.6	5.0	9.0		
	1,1-DICHLOROETHENE					0.2		
	CIS-1,2-DICHLOROETHENE					2.0		
	TETRACHLOROETHENE					2.0		
	TETRAHYDROFURAN				11.0			Not analyzed in 2001
	TRANS-1,2-DICHLOROETHENE					0.3		
	TRICHLOROETHENE	2900		1010	380	550		
01-06	METHYLENE CHLORIDE	3.0					3	
01-07	METHYLENE CHLORIDE	40.0					1	
	TOLUENE					1.0		
	TRICHLOROETHENE	3.0					0.5	
01-08	1,1,2-TRICHLOROETHANE					0.6		
	METHYLENE CHLORIDE	2.0					1	
	TRICHLOROETHENE	1.0				4.0		
01-09	METHYLENE CHLORIDE	5.0					0.8	
	TRICHLOROETHENE	5.0					0.5	
01-10	1,1,1-TRICHLOROETHANE		5.0				0.5	
	BENZENE		1.0				0.5	
	METHYLENE CHLORIDE		6.0				0.5	
	TETRACHLOROETHENE		1.0				0.5	
	TRICHLOROETHENE		8.0			0.4		

Table 2
Concentrations of Detected VOCs Over Past 20 Years

Well	Parameter	Year					2001 MDL	Notes
		1982	1983	1985	1986	2001		
01-11	1,1,1,2-TETRACHLOROETHANE					3.0		
	1,1,2,2-TETRACHLOROETHANE			138	760	170		
	1,1,2-TRICHLOROETHANE			101	12.0	5.0		
	1,1-DICHLOROETHENE					0.7		
	1,2-DICHLOROETHANE					4.0		
	CHLOROFORM				20.0	15.0		
	CIS-1,2-DICHLOROETHENE					5.0		
	TETRACHLOROETHENE			5.2	10.0	6.0		
	TRANS-1,2-DICHLOROETHENE		4.0		17.0	2.0		
	TRICHLOROETHENE		150		500	180		
	TRICHLOROFLUOROMETHANE		4.0				1	
01-12	1,1,1-TRICHLOROETHANE		6.0				7	
	1,1,2,2-TETRACHLOROETHANE		6000	518	280	230		
	1,1,2-TRICHLOROETHANE		341		7.0		13	
	1,2-DICHLOROETHANE		28.0				7	
	CHLORODIBROMOMETHANE			61.0			7	
	CHLOROFORM		53.0	13.0	5.0	9.0		
	METHYLENE CHLORIDE		5.0				5	
	TETRACHLOROETHENE			1.4			7	
	TRANS-1,2-DICHLOROETHENE		24.0	19.3	6.0		13	
	TRICHLOROETHENE		2300		180	190		
01-13	1,1,2,2-TETRACHLOROETHANE					9.0		
	TRICHLOROETHENE					8.0		
01-14	1,1,1-TRICHLOROETHANE		29.0				0.5	
	1,1,2,2-TETRACHLOROETHANE		320	64.8	570	8.0		
	1,1,2-TRICHLOROETHANE				15.0	0.4		
	1,2-DICHLOROETHANE		4.0		14.0	0.3		
	CHLOROFORM		7.0	3.3	24.0	0.1		
	CIS-1,2-DICHLOROETHENE					0.9		
	METHYLENE CHLORIDE		7.0				2	
	TRANS-1,2-DICHLOROETHENE		3.0	3.6	16.0	0.3		
	TRICHLOROETHENE		92.0	53.1	320	20.0		
	TRICHLOROFLUOROMETHANE		19.0				1	

Table 2
Concentrations of Detected VOCs Over Past 20 Years

Well	Parameter	Year					2001 MDL	Notes
		1982	1983	1985	1986	2001		
01-15	1,1,1-TRICHLOROETHANE		7.0				13	
	1,1,2,2-TETRACHLOROETHANE		1480	230	27.0	250		
	1,1,2-TRICHLOROETHANE		17.0	12.6		14.0		
	1,1-DICHLOROETHENE		2.0				25	
	1,2-DICHLOROETHANE		32.0				13	
	CHLOROFORM		23.5	13.8			18	
	METHYLENE CHLORIDE		3.0				53	
	TETRACHLOROETHENE			3.5			13	
	TETRAHYDROFURAN				93.0			Not analyzed in 2001
	TRANS-1,2-DICHLOROETHENE		18.0	14.8			25	
	TRICHLOROETHENE		238	301	12.0	310		
01-16	1,1,1-TRICHLOROETHANE		23.0			Dry		
	1,1,2,2-TETRACHLOROETHANE		5400			Dry		
	1,1-DICHLOROETHENE		1.0			Dry		
	1,2-DICHLOROETHANE		23.0			Dry		
	1,3-DICHLOROPROPENE		1000			Dry		
	CHLOROFORM		43.0			Dry		
	METHYLENE CHLORIDE		7.0			Dry		
	TRICHLOROETHENE			513		Dry		
01-17	1,1,1,2-TETRACHLOROETHANE					0.3		
	1,1,1-TRICHLOROETHANE		23.0				0.5	
	1,1,2,2-TETRACHLOROETHANE				32.0	10.0		
	1,1,2-TRICHLOROETHANE					0.8		
	1,1-DICHLOROETHENE					0.4		
	1,2-DICHLOROETHANE		5.0			1.0		
	CHLOROFORM		5.0			4.0		
	CIS-1,2-DICHLOROETHENE					1.0		
	METHYLENE CHLORIDE		7.0				1	
	TETRACHLOROETHENE		37.0			1.0		
	TRANS-1,2-DICHLOROETHENE					0.7		
	TRICHLOROETHENE		62.5		52.0	45.0		
	TRICHLOROFLUOROMETHANE		4.0				1	
01-18	1,1,2,2-TETRACHLOROETHANE					0.3		
	METHYLENE CHLORIDE					0.2		
	TRICHLOROETHENE					5.0		

Table 2
Concentrations of Detected VOCs Over Past 20 Years

Well	Parameter	Year					2001 MDL	Notes
		1982	1983	1985	1986	2001		
01-19	1,1,1,2-TETRACHLOROETHANE					5.0		
	1,1,2,2-TETRACHLOROETHANE			146	300	270		
	1,1,2-TRICHLOROETHANE			5.7	9.0	9.0		
	1,1-DICHLOROETHENE					2.0		
	1,2-DICHLOROETHANE		19.0		10.0	10.0		
	CHLOROFORM		15.0	10.0	14.0	27.0		
	CIS-1,2-DICHLOROETHENE					8.0		
	METHYLENE CHLORIDE					0.4		
	TETRACHLOROETHANE			7.1				Not analyzed in 2001
	TETRACHLOROETHENE					6.0		
	TOLUENE			5.0			0.5	
	TRANS-1,2-DICHLOROETHENE			12.0	8.0	3.0		
	TRICHLOROETHENE		180	221	240	300		
	TRICHLOROFLUOROMETHANE		2.0				1	
01-20	1,1,1-TRICHLOROETHANE		1.0				0.5	
	1,1,2,2-TETRACHLOROETHANE				160	30.0		
	1,1,2-TRICHLOROETHANE					0.6		
	1,1-DICHLOROETHENE		6.0				1	
	METHYLENE CHLORIDE					0.3		
	TRICHLOROETHENE		430		75.0	30.0		
01-21	1,1,1-TRICHLOROETHANE		1.0				0.5	
	BENZENE		2.0				0.5	
	METHYLENE CHLORIDE		3.0				0.5	
01-22	1,1,1,2-TETRACHLOROETHANE					2.0		
	1,1,1-TRICHLOROETHANE		2.0				0.5	
	1,1,2,2-TETRACHLOROETHANE		50.0	65.3	1200	150		
	1,1,2-TRICHLOROETHANE					4.0		
	1,1-DICHLOROETHENE					0.8		
	1,2-DICHLOROETHANE		3.0				0.5	
	BENZENE		3.0				0.5	
	CHLOROFORM		4.0	4.4	8.0	15.0		
	CIS-1,2-DICHLOROETHENE					4.0		
	ETHYLBENZENE			10.5			0.5	
	METHYLENE CHLORIDE					0.3		
	TETRACHLOROETHENE					3.0		
	TOLUENE			5.1			0.5	
	TRANS-1,2-DICHLOROETHENE			7.1		2.0		
	TRICHLOROETHENE		80.0	117	140	120		

Table 2
Concentrations of Detected VOCs Over Past 20 Years

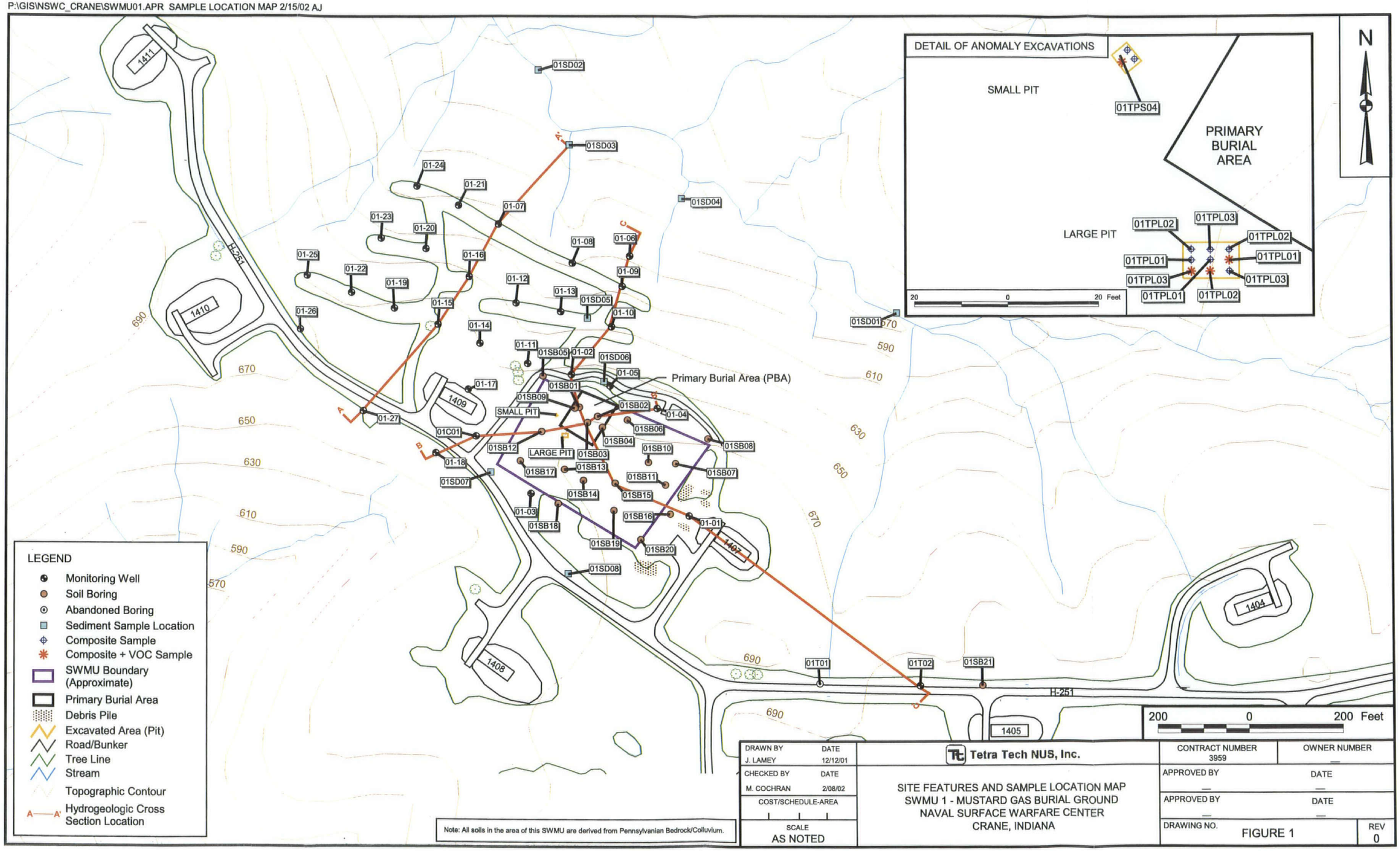
Well	Parameter	Year					2001 MDL	Notes
		1982	1983	1985	1986	2001		
01-23	1,1,1-TRICHLOROETHANE		2.0				0.5	
	CHLOROFORM		2.0				0.5	
	METHYLENE CHLORIDE		6.0				0.2	
	TRICHLOROETHENE		2.0				0.5	
01-24	1,1,1-TRICHLOROETHANE		1.0				0.5	
	METHYLENE CHLORIDE		2.0				1	
	TRICHLOROETHENE					0.4		
01-25	1,1,1,2-TETRACHLOROETHANE					2.0		
	1,1,2,2-TETRACHLOROETHANE				42.0	32.0		
	CHLOROFORM					7.0		
	TRICHLOROETHENE				59.0	65.0	0.5	
01-26	BENZENE				5.0		0.5	
01-27	TETRAHYDROFURAN				49.0			Not analyzed in 2001
01C01	All analytes	NA	NA	NA	NA	ND		
01T02	CHLOROFORM					0.3		
	METHYLENE CHLORIDE					0.2		
	TOLUENE					0.6		
	TRICHLOROETHENE					0.2		

NA = Not applicable
ND = No detections

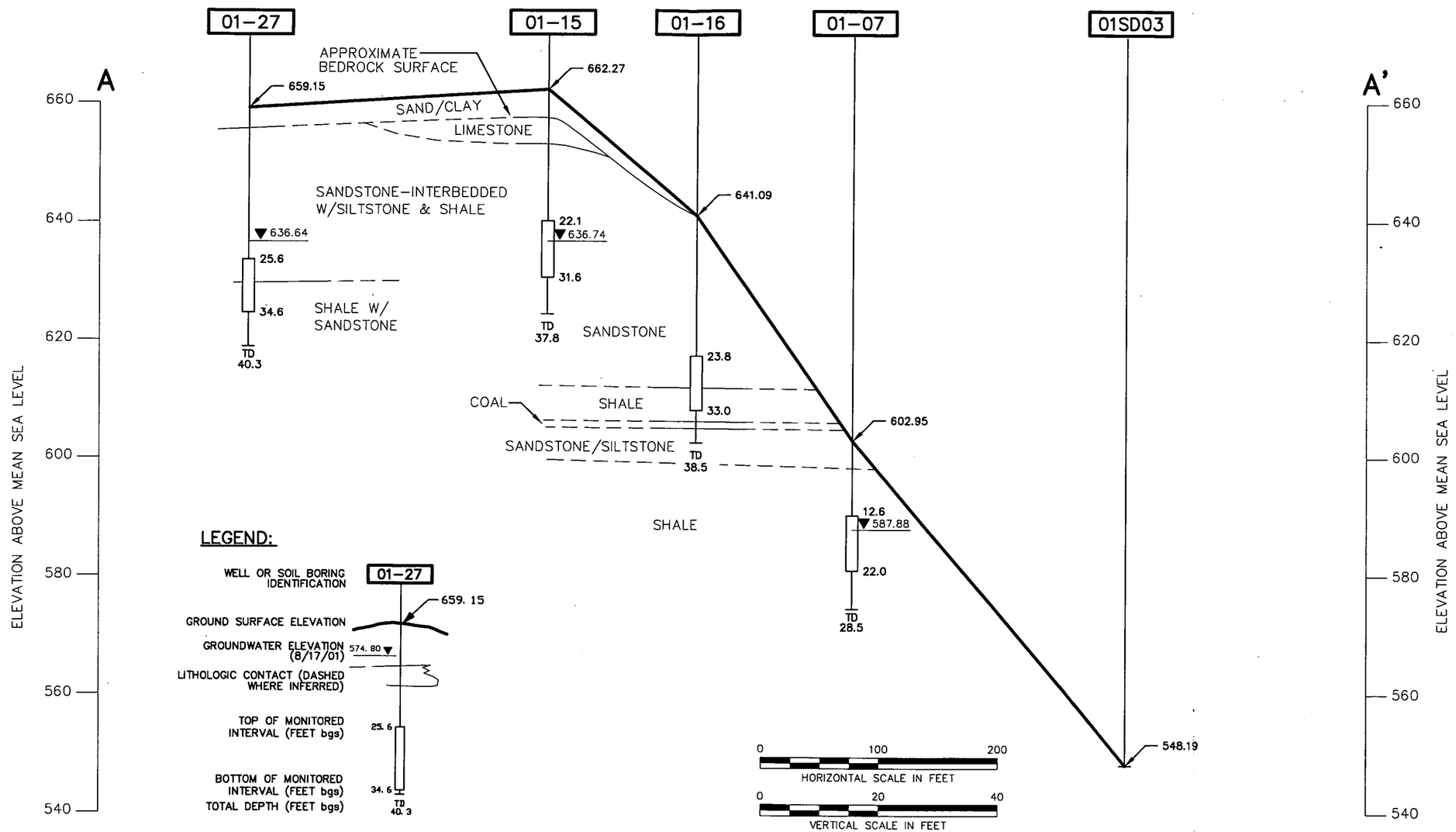
List of Figures.

Figure Number	Description
Figure 1	Site Features and Sampling Locations.
Figure 2	Hydrogeological Cross Section #1.
Figure 3	Hydrogeological Cross Section #2.
Figure 4	Hydrogeological Cross Section #3.
Figure 5	1980s Water Levels.
Figure 6	1980s TOX.VOC Concentrations.
Figure 7	Soil Inorganics: All positive detections above facility-wide background with exceedances of pertinent human health and ecological criteria indicated.
Figure 8	Soil Radiologicals: All positive detections above site-specific background with exceedances of pertinent soil screening level indicated.
Figure 9	Soil Organics: All positive detections with exceedances of pertinent human health and ecological criteria indicated.
Figure 10	Sediment All Contaminants: All positive detections with exceedances of site-specific background as well as pertinent human health and ecological criteria indicated.
Figure 11	Ground water Inorganics and Radiologicals: All positive detections with exceedances of pertinent human health and ecological criteria indicated.
Figure 12	2001 Water Levels.
Figure 13	Ground Water Organics: All positive detections with exceedances of pertinent human health and ecological criteria indicated.
Figure 14	1980s PCA Isopleths.
Figure 15	1980s TCE Isopleths.
Figure 16	2001PCA Isopleths.
Figure 17	2001 TCE Isopleths.
Figure 18	Time series of select VOC concentrations in the two most contaminated wells: a. Well 01-02; b. Well 01-05. Plotted concentrations are averages over all sampling rounds within each year.

P:\GIS\NSWC_CRANE\SWMU01.APR SAMPLE LOCATION MAP 2/15/02 AJ



ACAD: 3959GX01.DWG 03/13/02 MF PIT



LEGEND:

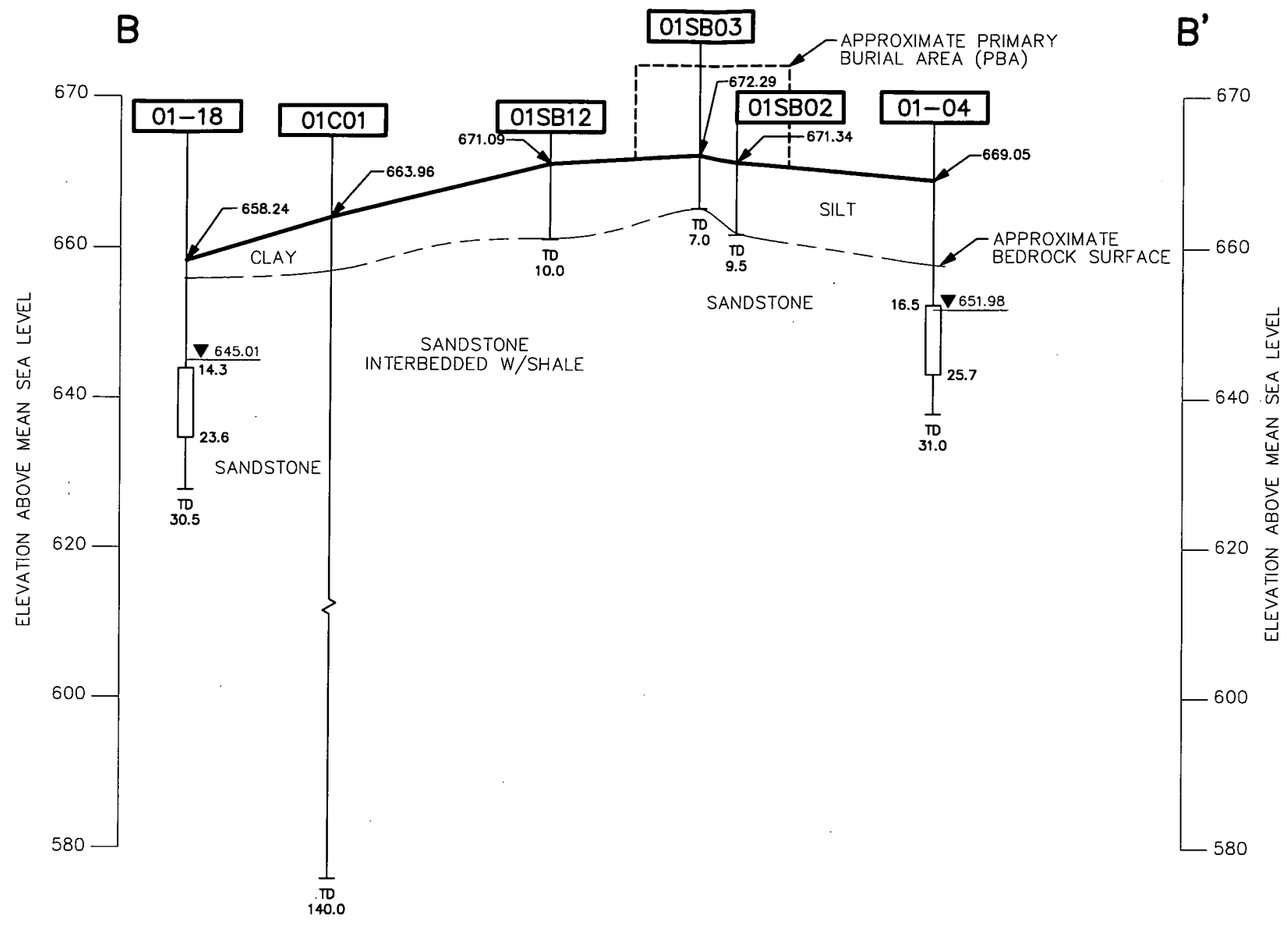
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

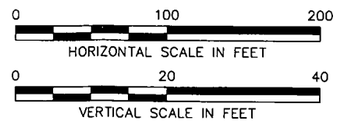
DRAWN BY DM DATE 1/31/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

GENERALIZED HYDROGEOLOGIC CROSS SECTION A-A'
SWMU1 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 2
REV. 0

FORM CADD NO. SDIV_BH.DWG REV 0 1/20/98





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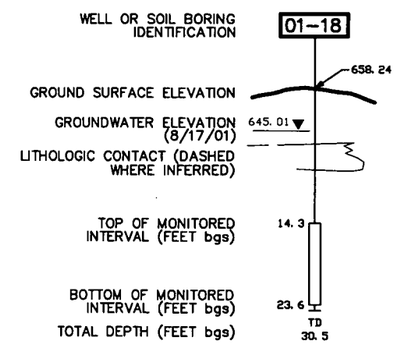


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

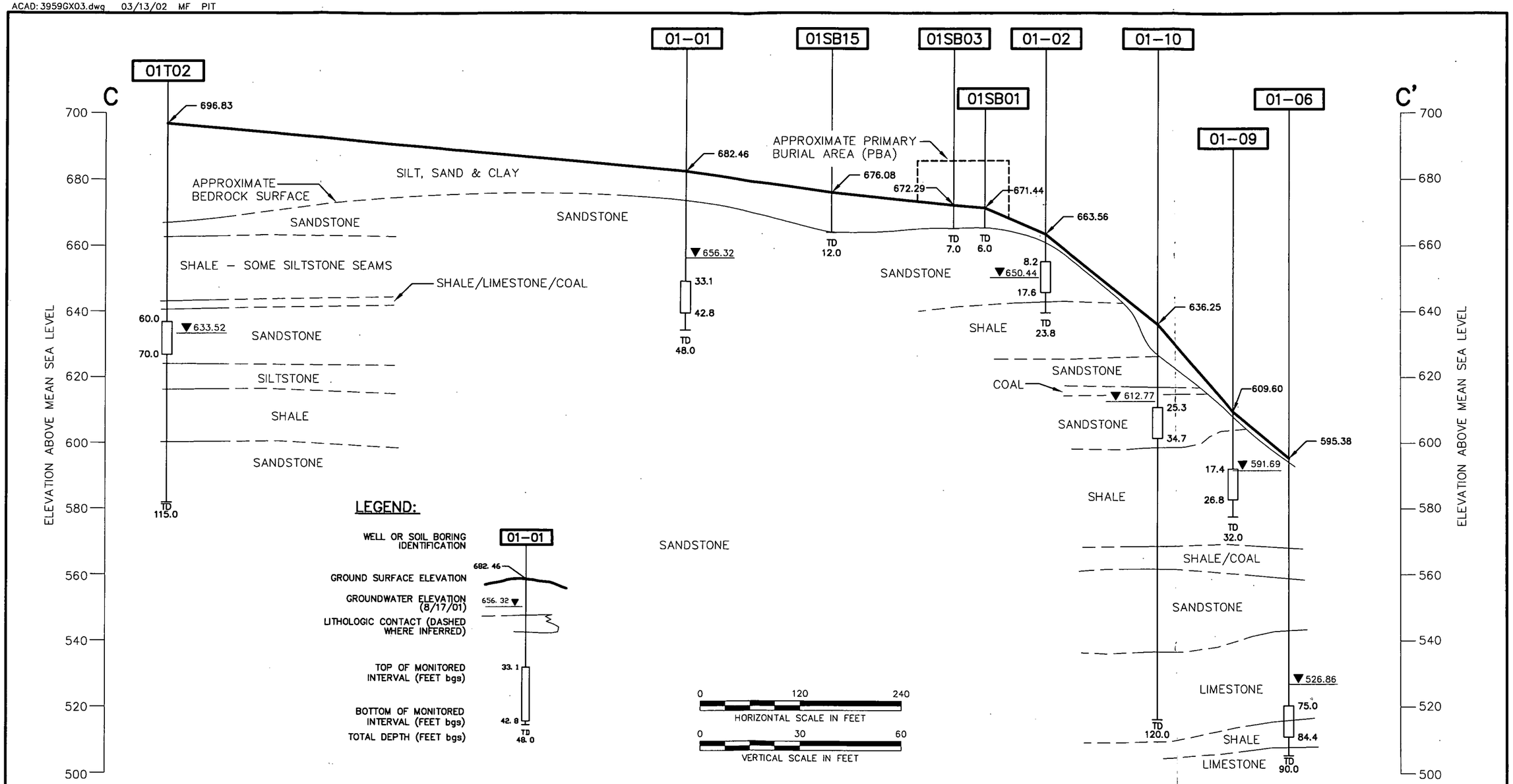
DRAWN BY DM DATE 1/31/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

GENERALIZED HYDROGEOLOGIC CROSS-SECTION B-B'
SWMU1 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 3
REV. 0

FORM CADD NO. SDIV_BH.DWG REV 0 1/20/98

ACAD: 3959GX03.dwg 03/13/02 MF PIT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DM DATE 1/31/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

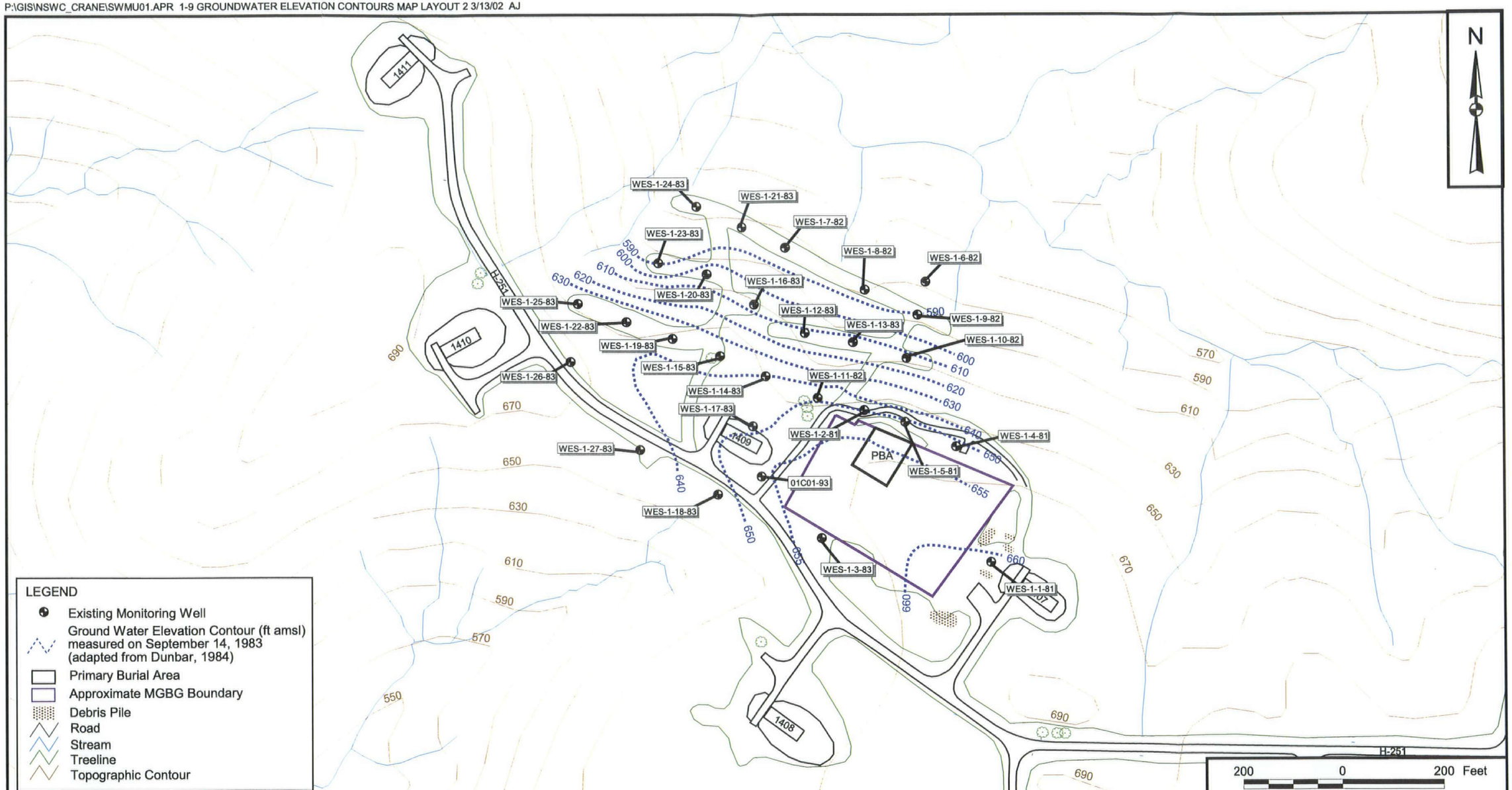
DEPARTMENT OF THE NAVY – SOUTHERN DIV FACILITIES ENGINEERING COMD

GENERALIZED HYDROGEOLOGIC CROSS SECTION C–C'
SWMU1 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 4
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

P:\GIS\NSWC_CRANE\SWMU01.APR 1-9 GROUNDWATER ELEVATION CONTOURS MAP LAYOUT 2 3/13/02 AJ



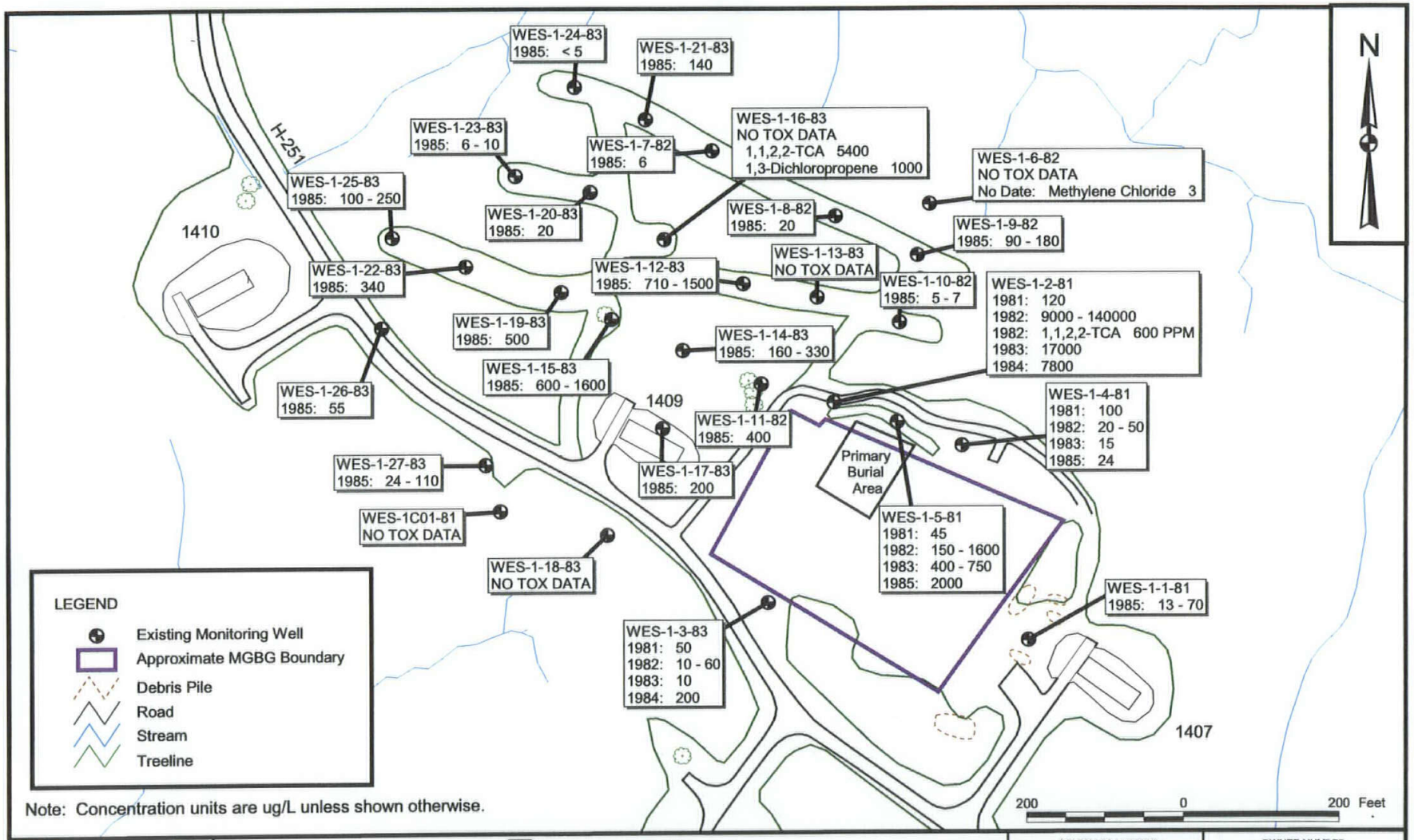
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY J. LAMEY	DATE 4/3/00
CHECKED BY J. SCHUBERT	DATE 5/7/01
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

1983 POTENTIOMETRIC SURFACE CONTOUR MAP
MUSTARD GAS BURIAL GROUND
NSWC CRANE, CRANE, INDIANA

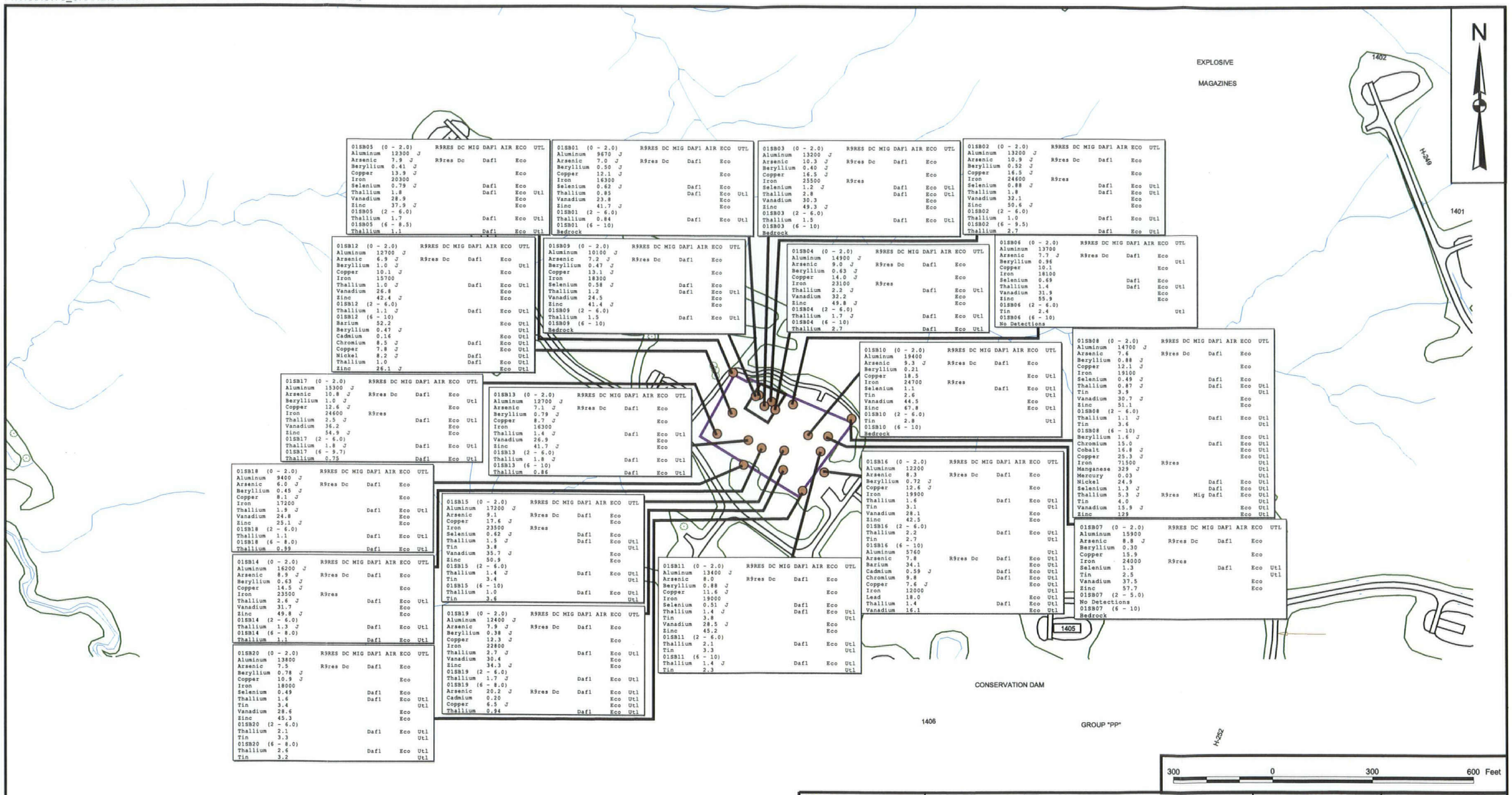
CONTRACT NUMBER 0504	OWNER NUMBER 0131
APPROVED BY T. JOHNSTON	DATE 5/7/01
APPROVED BY —	DATE —
DRAWING NO. FIGURE 5	REV 0



Note: Concentration units are ug/L unless shown otherwise.

DRAWN BY J. LAMEY — DATE 3/22/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0504	OWNER NUMBER 0131
CHECKED BY J. SCHUBERT — DATE 5/7/01	MONITORING WELLS AND ASSOCIATED TOTAL ORGANIC HALOGEN (TOX) DATA (APPROXIMATE) 1981 - 1986 MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY T. JOHNSTON	DATE 5/7/01
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 6	REV 0

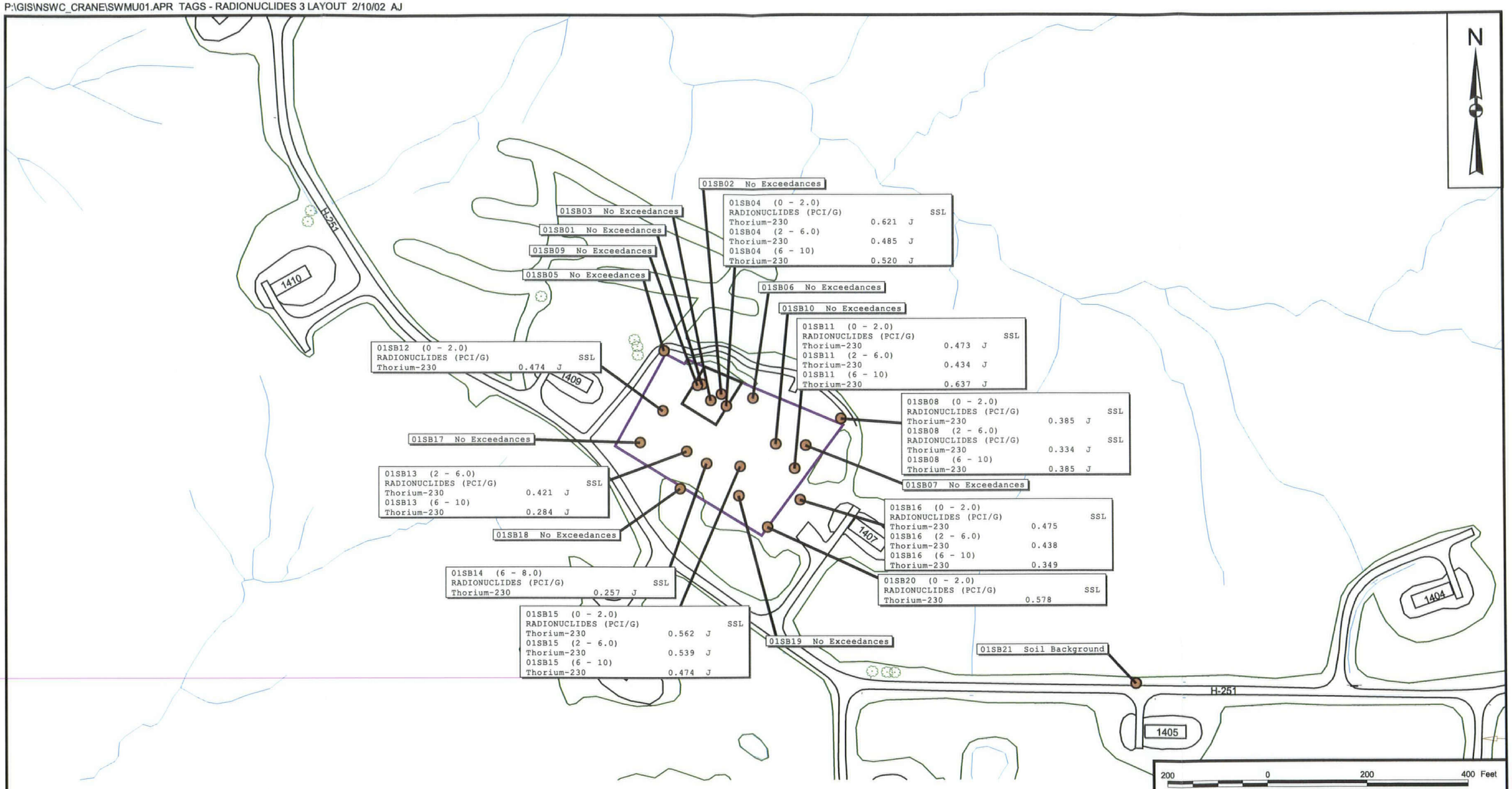
P:\GIS\NSWC_CRANE\SWMU01.APR TOTAL ORGANIC HALOGEN DATA 5/7/01 JAL



SOIL ORGANICS
R9RES = EPA Region 9 Residential Preliminary Remediation Goal.
DC = IDEM Tier 1 Direct Contact Valves.
MIG = IDEM Tier 1 Migration to Groundwater Values.
DAF1 = U.S. EPA SSL Migration to Groundwater DAF of 1.
AIR = U.S. EPA Generic SSL Inhalation Screening Level.
ECO = EPA Region 5 Ecological Data Quality Level.

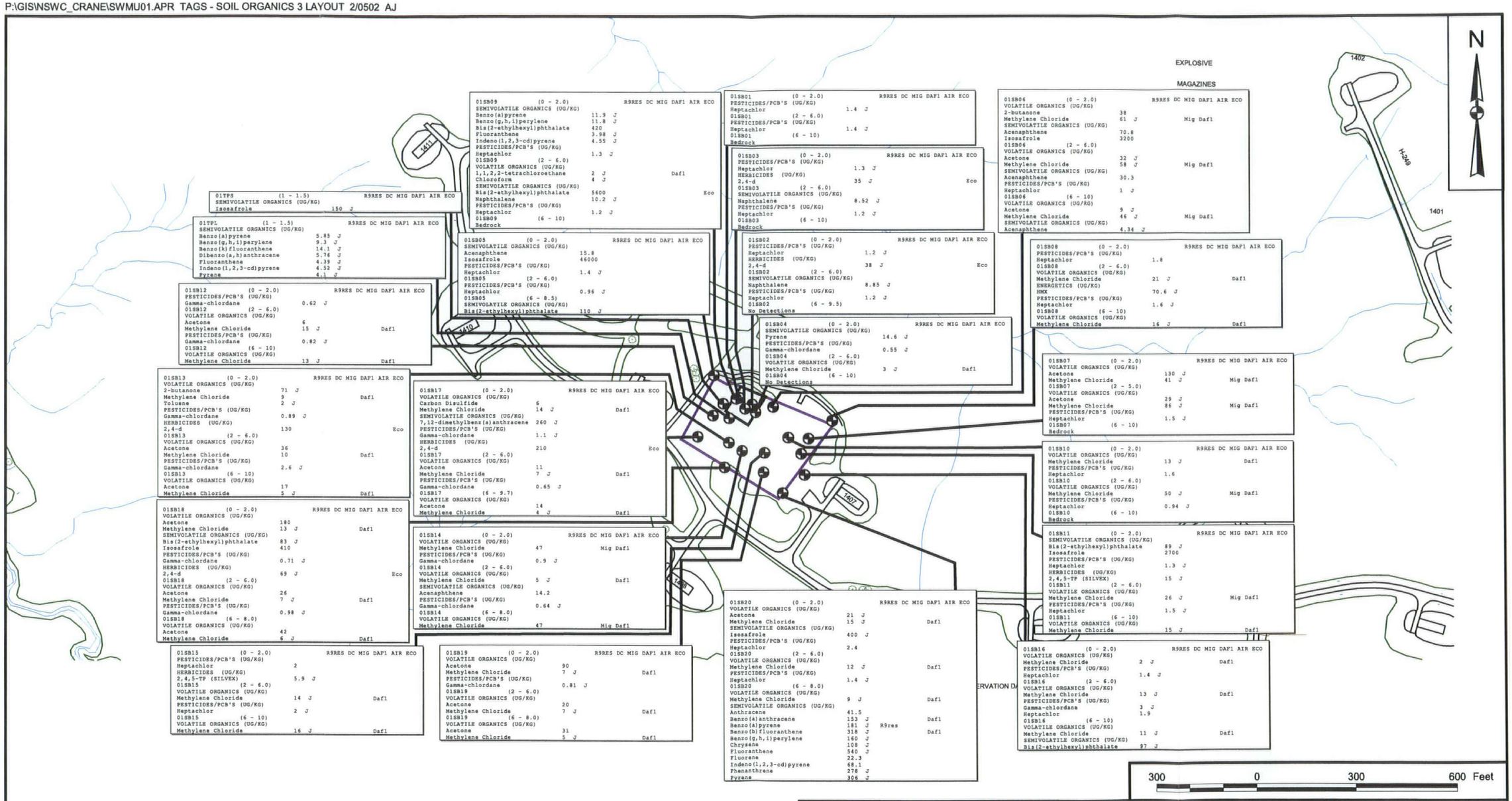
DRAWN BY A. JANOCHA	DATE 1/31/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959	OWNER NUMBER —
CHECKED BY T. JOHNSTON	DATE 2/11/02	POSITIVE METAL DETECTIONS, mg/kg, GREATER THAN BACKGROUND IN SOIL SAMPLES SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 7	REV 1

P:\GIS\NSWC_CRANE\SWMU01.APR TAGS - RADIONUCLIDES 3 LAYOUT 2/10/02 AJ



SOIL RADIONUCLIDES
SSL = U.S. EPA Soil Screening Level.

DRAWN BY A. JANOCHA	DATE 2/10/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959 / OWNER NUMBER —
CHECKED BY T. JOHNSTON	DATE 2/10/02	THORIUM ISOTOPES DETECTED IN SOIL SAMPLES SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 8 / REV 1



01SB09 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
SEMIVOLATILE ORGANICS (UG/KG)
Benzo(a)pyrene 11.9 J
Benzo(g,h,i)perylene 11.8 J
Bis(2-ethylhexyl)phthalate 420
Fluoranthene 3.98 J
Indeno(1,2,3-cd)pyrene 4.55 J
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.3 J
01SB09 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
1,1,2,2-tetrachloroethane 2 J Daf1
Chloroform 4 J
SEMIVOLATILE ORGANICS (UG/KG)
Bis(2-ethylhexyl)phthalate 5600 Eco
Naphthalene 10.2 J
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.2 J
01SB09 (6 - 10)
Bedrock

01SB01 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.4 J
01SB01 (2 - 6.0)
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.4 J
01SB01 (6 - 10)
Bedrock

01SB06 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
2-butanone 38
Methylene Chloride 61 J Mig Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Acenaphthene 70.8
Isosafrole 3200
01SB06 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Acetone 32 J
Methylene Chloride 58 J Mig Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Acenaphthene 30.3
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1 J
01SB06 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Acetone 9 J
Methylene Chloride 46 J Mig Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Acenaphthene 4.34 J

01TPS (1 - 1.5) R9RES DC MIG DAF1 AIR ECO
SEMIVOLATILE ORGANICS (UG/KG)
Isosafrole 150 J

01TPL (1 - 1.5) R9RES DC MIG DAF1 AIR ECO
SEMIVOLATILE ORGANICS (UG/KG)
Benzo(a)pyrene 5.85 J
Benzo(g,h,i)perylene 9.3 J
Benzo(k)fluoranthene 14.1 J
Dibenzo(a,h)anthracene 5.76 J
Fluoranthene 4.39 J
Indeno(1,2,3-cd)pyrene 4.52 J
Pyrene 4.1 J

01SB05 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
SEMIVOLATILE ORGANICS (UG/KG)
Acenaphthene 15.8
Isosafrole 46000
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.4 J
01SB05 (2 - 6.0)
PESTICIDES/PCB'S (UG/KG)
Heptachlor 0.96 J
01SB05 (6 - 8.5)
SEMIVOLATILE ORGANICS (UG/KG)
Bis(2-ethylhexyl)phthalate 110 J

01SB03 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.3 J
HERBICIDES (UG/KG)
2,4-d 35 J Eco
01SB03 (2 - 6.0)
SEMIVOLATILE ORGANICS (UG/KG)
Naphthalene 8.52 J
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.2 J
01SB03 (6 - 10)
Bedrock

01SB02 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.2 J
HERBICIDES (UG/KG)
2,4-d 38 J Eco
01SB02 (2 - 6.0)
SEMIVOLATILE ORGANICS (UG/KG)
Naphthalene 8.85 J
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.2 J
01SB02 (6 - 9.5)
No Detections

01SB08 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.8
01SB08 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 21 J Daf1
ENERGETICS (UG/KG)
HMX 70.6 J
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.6 J
01SB08 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 16 J Daf1

01SB04 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
SEMIVOLATILE ORGANICS (UG/KG)
Pyrene 14.6 J
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.55 J
01SB04 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 3 J Daf1
01SB04 (6 - 10)
No Detections

01SB12 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.62 J
01SB12 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Acetone 6
Methylene Chloride 15 J Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.82 J
01SB12 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 13 J Daf1

01SB07 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Acetone 130 J
Methylene Chloride 41 J Mig Daf1
01SB07 (2 - 5.0)
VOLATILE ORGANICS (UG/KG)
Acetone 29 J
Methylene Chloride 86 J Mig Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.5 J
01SB07 (6 - 10)
Bedrock

01SB13 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
2-butanone 71 J
Methylene Chloride 9 Daf1
Toluene 2 J
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.89 J
HERBICIDES (UG/KG)
2,4-d 130 Eco
01SB13 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Acetone 36
Methylene Chloride 10 Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 2.6 J
01SB13 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Acetone 17
Methylene Chloride 5 J Daf1

01SB17 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Carbon Disulfide 6
Methylene Chloride 14 J Daf1
SEMIVOLATILE ORGANICS (UG/KG)
7,12-dimethylbenz(a)anthracene 260 J
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 1.1 J
HERBICIDES (UG/KG)
2,4-d 210 Eco
01SB17 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Acetone 11
Methylene Chloride 7 J Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.65 J
01SB17 (6 - 9.7)
VOLATILE ORGANICS (UG/KG)
Acetone 14
Methylene Chloride 4 J Daf1

01SB10 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 13 J Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.6
01SB10 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 50 J Mig Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 0.94 J
01SB10 (6 - 10)
Bedrock

01SB18 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Acetone 180
Methylene Chloride 13 J Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Bis(2-ethylhexyl)phthalate 83 J
Isosafrole 410
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.71 J
HERBICIDES (UG/KG)
2,4-d 69 J Eco
01SB18 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Acetone 26
Methylene Chloride 7 J Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.98 J
01SB18 (6 - 8.0)
VOLATILE ORGANICS (UG/KG)
Acetone 42
Methylene Chloride 6 J Daf1

01SB14 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 47 Mig Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.9 J
01SB14 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 5 J Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Acenaphthene 14.2
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.64 J
01SB14 (6 - 8.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 47 Mig Daf1

01SB11 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
SEMIVOLATILE ORGANICS (UG/KG)
Bis(2-ethylhexyl)phthalate 89 J
Isosafrole 2700
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.3 J
HERBICIDES (UG/KG)
2,4,5-TP (SILVEX) 15 J
01SB11 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 26 J Mig Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.5 J
01SB11 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 15 J Daf1

01SB20 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Acetone 21 J
Methylene Chloride 15 J Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Isosafrole 400 J
PESTICIDES/PCB'S (UG/KG)
Heptachlor 2.4
01SB20 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 12 J Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.4 J
01SB20 (6 - 8.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 9 J Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Anthracene 41.5
Benzo(a)anthracene 153 J Daf1
Benzo(A)pyrene 181 J R9res
Benzo(b)fluoranthene 318 J Daf1
Benzo(g,h,i)perylene 160 J
Chrysene 108 J
Fluoranthene 540 J
Fluorene 22.3
Indeno(1,2,3-cd)pyrene 68.1
Phenanthrene 278 J
Pyrene 306 J

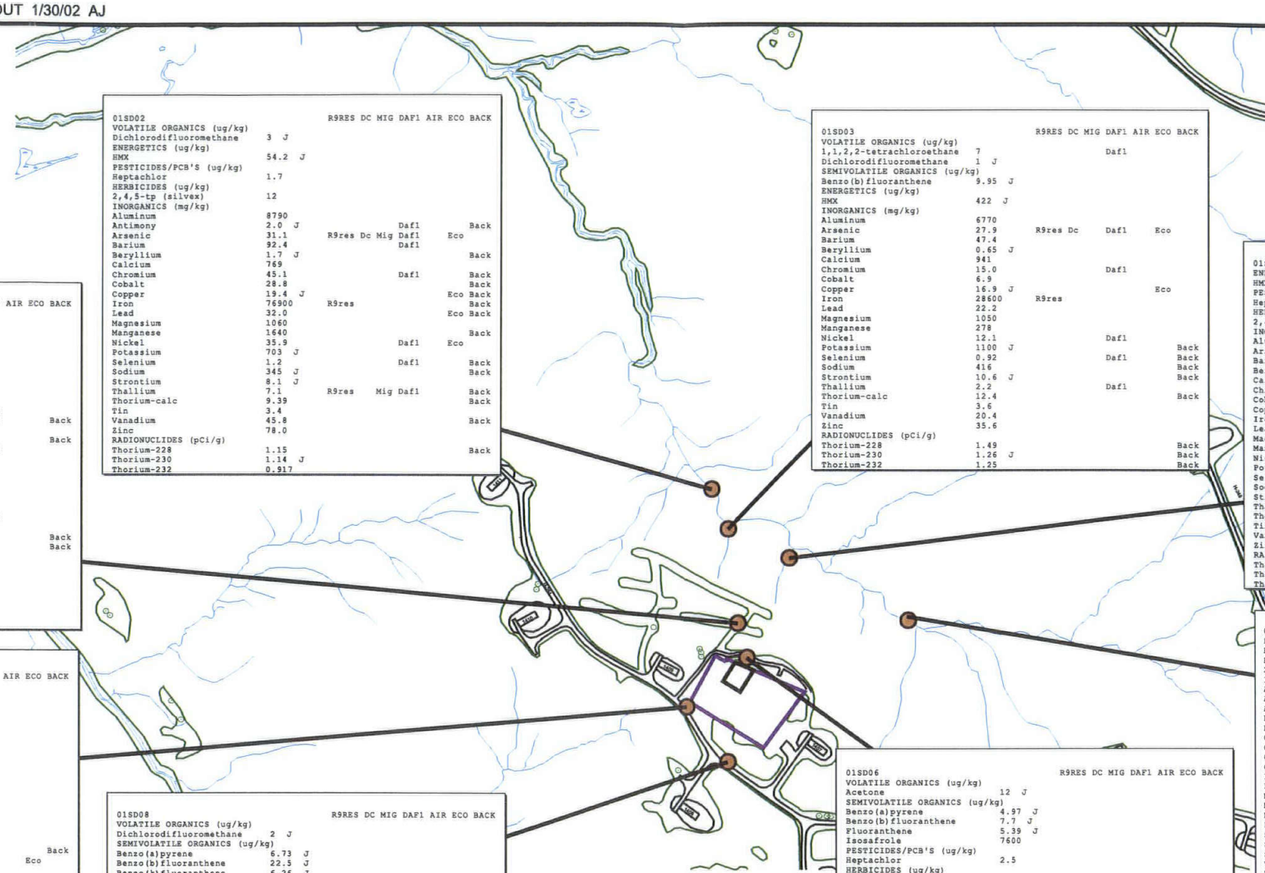
01SB16 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 2 J Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 1.4 J
01SB16 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 13 J Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 3 J
Heptachlor 1.9
01SB16 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 11 J Daf1
SEMIVOLATILE ORGANICS (UG/KG)
Bis(2-ethylhexyl)phthalate 97 J

01SB15 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
PESTICIDES/PCB'S (UG/KG)
Heptachlor 2
HERBICIDES (UG/KG)
2,4,5-TP (SILVEX) 5.9 J
01SB15 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 14 J Daf1
PESTICIDES/PCB'S (UG/KG)
Heptachlor 2 J
01SB15 (6 - 10)
VOLATILE ORGANICS (UG/KG)
Methylene Chloride 16 J Daf1

01SB19 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO
VOLATILE ORGANICS (UG/KG)
Acetone 90
Methylene Chloride 7 J Daf1
PESTICIDES/PCB'S (UG/KG)
Gamma-chlordane 0.81 J
01SB19 (2 - 6.0)
VOLATILE ORGANICS (UG/KG)
Acetone 20
Methylene Chloride 7 J Daf1
01SB19 (6 - 8.0)
VOLATILE ORGANICS (UG/KG)
Acetone 31
Methylene Chloride 5 J Daf1

SOIL ORGANICS
R9RES = EPA Region 9 Residential Preliminary Remediation Goal.
DC = IDEM Tier 1 Direct Contact Valves.
MIG = IDEM Tier 1 Migration to Groundwater Values.
DAF1 = U.S. EPA SSL Migration to Groundwater DAF of 1.
AIR = U.S. EPA Generic SSL Inhalation Screening Level.
ECO = EPA Region 5 Ecological Data Quality Level.

DRAWN BY A. JANOCHA	DATE 1/18/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959 / OWNER NUMBER —
CHECKED BY T. JOHNSTON	DATE 2/11/02	POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN SOIL SAMPLES SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 9 / REV 1



N

01SD02		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
VOLATILE ORGANICS (ug/kg)								
Dichlorodifluoromethane	3 J							
ENERGETICS (ug/kg)								
HMX	54.2 J							
PESTICIDES/PCB'S (ug/kg)								
Heptachlor	1.7							
HERBICIDES (ug/kg)								
2,4,5-tp (silvex)	12							
INORGANICS (mg/kg)								
Aluminum	8790							
Antimony	2.0 J				Daf1			Back
Arsenic	31.1	R9res	Dc	Mig	Daf1		Eco	
Barium	92.4				Daf1			
Beryllium	1.7 J							Back
Calcium	769							
Chromium	45.1				Daf1			Back
Cobalt	28.8							Back
Copper	19.4 J						Eco	Back
Iron	76900	R9res						Back
Lead	32.0						Eco	Back
Magnesium	1060							
Manganese	1640							Back
Nickel	35.9				Daf1		Eco	
Potassium	703 J							
Selenium	1.2				Daf1			Back
Sodium	345 J							Back
Strontium	8.1 J							
Thallium	7.1	R9res		Mig	Daf1			Back
Thorium-calc	9.39							Back
Tin	3.4							
Vanadium	45.8							Back
Zinc	78.0							
RADIONUCLIDES (pCi/g)								
Thorium-228	1.15							Back
Thorium-230	1.14 J							
Thorium-232	0.917							

01SD03		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
VOLATILE ORGANICS (ug/kg)								
1,1,2,2-tetrachloroethane	7				Daf1			
Dichlorodifluoromethane	1 J							
SEMIVOLATILE ORGANICS (ug/kg)								
Benzo(b)fluoranthene	9.95 J							
ENERGETICS (ug/kg)								
HMX	422 J							
INORGANICS (mg/kg)								
Aluminum	6770							
Arsenic	27.9	R9res	Dc		Daf1		Eco	
Barium	47.4							
Beryllium	0.65 J							
Calcium	941							
Chromium	15.0				Daf1			
Cobalt	6.9							
Copper	16.9 J						Eco	
Iron	28600	R9res						
Lead	22.2							
Magnesium	1050							
Manganese	278							
Nickel	12.1				Daf1			
Potassium	1100 J							Back
Selenium	0.92				Daf1			Back
Sodium	416							Back
Strontium	10.6 J							Back
Thallium	2.2				Daf1			
Thorium-calc	12.4							Back
Tin	3.6							
Vanadium	20.4							
Zinc	35.6							
RADIONUCLIDES (pCi/g)								
Thorium-228	1.49							Back
Thorium-230	1.26 J							Back
Thorium-232	1.25							Back

01SD04		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
ENERGETICS (ug/kg)								
HMX	86.7 J							
PESTICIDES/PCB'S (ug/kg)								
Heptachlor	1.4 J							
HERBICIDES (ug/kg)								
2,4,5-t	8.6 J							
INORGANICS (mg/kg)								
Aluminum	7470							
Arsenic	6.5	R9res	Dc		Daf1		Eco	
Barium	105				Daf1			
Beryllium	0.84 J							
Calcium	1690							Back
Chromium	13.5				Daf1			
Cobalt	17.8							
Copper	11.0 J							
Iron	20000							
Lead	19.1							
Magnesium	1030							
Manganese	1230							
Nickel	15.6				Daf1			
Potassium	604 J							
Selenium	0.66				Daf1			
Sodium	334							Back
Strontium	9.6 J							
Thallium	1.2				Daf1			
Thorium-calc	7.74							
Tin	3.4							
Vanadium	20.5							
Zinc	42.5							
RADIONUCLIDES (pCi/g)								
Thorium-228	1.08							Back
Thorium-230	0.832 J							
Thorium-232	0.624							

01SD05		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
SEMIVOLATILE ORGANICS (ug/kg)								
Benzo(a)pyrene	7.05 J							
Benzo(k)fluoranthene	8.96 J							
Fluoranthene	4.93 J							
ENERGETICS (ug/kg)								
HMX	134 J							
PESTICIDES/PCB'S (ug/kg)								
Heptachlor	1.2 J							
INORGANICS (mg/kg)								
Aluminum	9270							
Arsenic	4.4	R9res	Dc		Daf1			
Barium	120				Daf1			Back
Beryllium	0.80 J							
Calcium	2630							Back
Chromium	9.4				Daf1			
Cobalt	15.3							
Copper	10.1 J							
Iron	12500							
Lead	16.1							
Magnesium	1200							
Manganese	1250							
Nickel	13.7				Daf1			
Potassium	623 J							
Sodium	335							Back
Strontium	11.2 J							Back
Thorium-calc	7.54							
Tin	3.1							
Vanadium	18.9							
Zinc	41.2							
RADIONUCLIDES (pCi/g)								
Thorium-228	0.868							
Thorium-230	0.791 J							
Thorium-232	0.791							

01SD01 UPSTREAM SAMPLE		R9RES	DC	MIG	DAF1	AIR	ECO
PESTICIDES/PCB'S (ug/kg)							
Heptachlor	0.95						
HERBICIDES (ug/kg)							
2,4,5-tp (silvex)	16						
INORGANICS (mg/kg)							
Aluminum	9670						
Arsenic	31.9	R9res	Dc	Mig	Daf1		
Antimony	1.2 J				Daf1		
Barium	105				Daf1		
Beryllium	1.4 J				Daf1		
Calcium	1000						
Chromium	30.5				Daf1		
Cobalt	25.0						
Copper	17.6 J						
Iron	45700	R9res					
Lead	24.8						
Magnesium	1520						
Manganese	1490						
Nickel	37.1				Daf1		
Potassium	875 J						
Selenium	0.66				Daf1		
Sodium	265						
Strontium	10.2 J						
Thallium	4.3			Mig	Daf1		
Thorium-calc	9.30						
Tin	3.6						
Vanadium	32.5						
Zinc	79.2						
RADIONUCLIDES (pCi/g)							
Thorium-228	0.937						
Thorium-230	1.20 J						
Thorium-232	1.11						

01SD07		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
SEMIVOLATILE ORGANICS (ug/kg)								
Acenaphthene	139 J							
Benzo(a)anthracene	14.4							
Benzo(a)pyrene	27.5 J							
Benzo(b)fluoranthene	120 J							
Benzo(g,h,i)perylene	21.8 J							
Benzo(k)fluoranthene	14.6 J							
Chrysene	17.3 J							
Fluoranthene	18.4 J							
INDENO(1,2,3-CD)PYRENE	12.8							
Pyrene	24 J							
PESTICIDES/PCB'S (ug/kg)								
Aroclor-1260	19 J							
Heptachlor	1.1 J							
HERBICIDES (ug/kg)								
2,4,5-tp (silvex)	3.1 J							
INORGANICS (mg/kg)								
Aluminum	11700							Back
Arsenic	8.1	R9res	Dc		Daf1		Eco	
Barium	94.6				Daf1			
Beryllium	0.57 J							
Calcium	3020							Back
Chromium	13.7				Daf1			
Cobalt	12.2							
Copper	16.1 J						Eco	
Iron	19900							
Lead	16.5							
Magnesium	1820							Back
Manganese	607							
Nickel	11.9				Daf1			
Potassium	583 J							
Selenium	0.59				Daf1			
Sodium	311							Back
Strontium	8.7 J							
Thallium	2.0				Daf1			
Thorium-calc	6.52							
Tin	3.0							
Vanadium	27.0							
Zinc	46.1							
RADIONUCLIDES (pCi/g)								
Thorium-228	0.694							
Thorium-230	0.937 J							
Thorium-232	0.742							

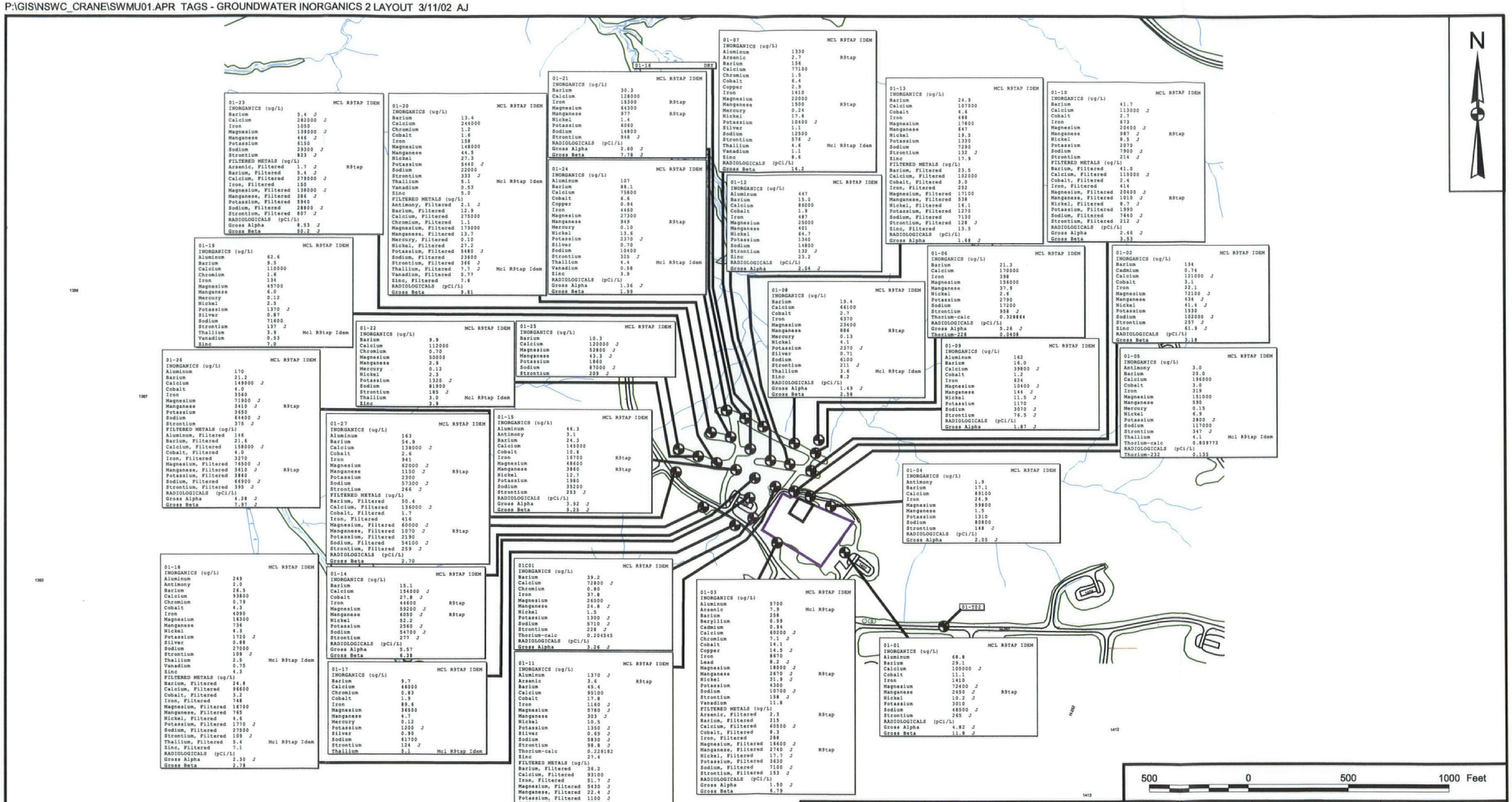
01SD08		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
VOLATILE ORGANICS (ug/kg)								
Dichlorodifluoromethane	2 J							
SEMIVOLATILE ORGANICS (ug/kg)								
Benzo(a)pyrene	6.73 J							
Benzo(b)fluoranthene	22.5 J							
Benzo(k)fluoranthene	6.26 J							
Bis(2-ethylhexyl)phthalate	98 J							
Fluoranthene	7.83 J							
Pyrene	5.31 J							
INORGANICS (mg/kg)								
Aluminum	13700							Back
Arsenic	6.7	R9res	Dc		Daf1		Eco	
Barium	80.7							
Calcium	5520							Back
Chromium	17.4				Daf1			
Cobalt	7.4							
Copper	14.6 J							
Iron	21700							
Lead	28.2							Back
Magnesium	1940							Back
Manganese	341							
Nickel	13.7				Daf1			
Potassium	915 J							Back
Selenium	1.0				Daf1			Back
Sodium	402							Back
Strontium	14.5 J							Back
Thallium	1.5				Daf1			
Thorium-calc	7.31							
Tin	3.7							Back
Vanadium	31.5							
Zinc	70.2							
RADIONUCLIDES (pCi/g)								
Thorium-228	0.781							
Thorium-230	1.05 J							
Thorium-232	0.828							

01SD06		R9RES	DC	MIG	DAF1	AIR	ECO	BACK
VOLATILE ORGANICS (ug/kg)								
Acetone	12 J							
SEMIVOLATILE ORGANICS (ug/kg)								
Benzo(a)pyrene	4.97 J							
Benzo(b)fluoranthene	7.7 J							
Fluoranthene	5.39 J							
Isosafrole	7600							
PESTICIDES/PCB'S (ug/kg)								
Heptachlor	2.5							
HERBICIDES (ug/kg)								
2,4,5-tp (silvex)	11 J							
INORGANICS (mg/kg)								
Aluminum	8190							
Arsenic	5.5	R9res	Dc		Daf1			
Barium	120				Daf1			Back
Beryllium	0.78 J							
Cadmium	0.39 J							Back
Calcium	1960							Back
Chromium	10.2				Daf1			
Cobalt	17.5							
Copper	9.5 J							
Iron	12300							
Lead	26.7							Back
Magnesium	1090							
Manganese	1330							
Nickel	11.3				Daf1			
Potassium	497 J							
Selenium	0.45				Daf1			
Sodium	298							Back
Strontium	8.2 J							
Thallium	0.57				Daf1			
Thorium-calc	6.46							
Tin	3.2							
Vanadium	19.6							
Zinc	47.8							
RADIONUCLIDES (pCi/g)								
Thorium-228	0.705							
Thorium-230	1.08 J							
Thorium-232	0.718							

600 0 600 1200 Feet

SOIL ORGANICS
R9RES = EPA Region 9 Residential Preliminary Remediation Goal.
DC = IDEM Tier 1 Direct Contact Valves.
MIG = IDEM Tier 1 Migration to Groundwater Values.
DAF1 = U.S. EPA SSL Migration to Groundwater DAF of 1.
AIR = U.S. EPA Generic SSL Inhalation Screening Level.
ECO = EPA Region 5 Ecological Data Quality Level.

DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959	OWNER NUMBER
A. JANOCHA	1/18/02	SEDIMENT ORGANIC AND INORGANIC POSITIVE DETECTIONS GREATER THAN UPSTREAM CONCENTRATIONS SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
CHECKED BY	DATE		APPROVED BY —	DATE —
T. JOHNSTON	2/11/02		DRAWING NO. FIGURE 10	REV 1
COST/SCHEDULE-AREA				
SCALE AS NOTED				



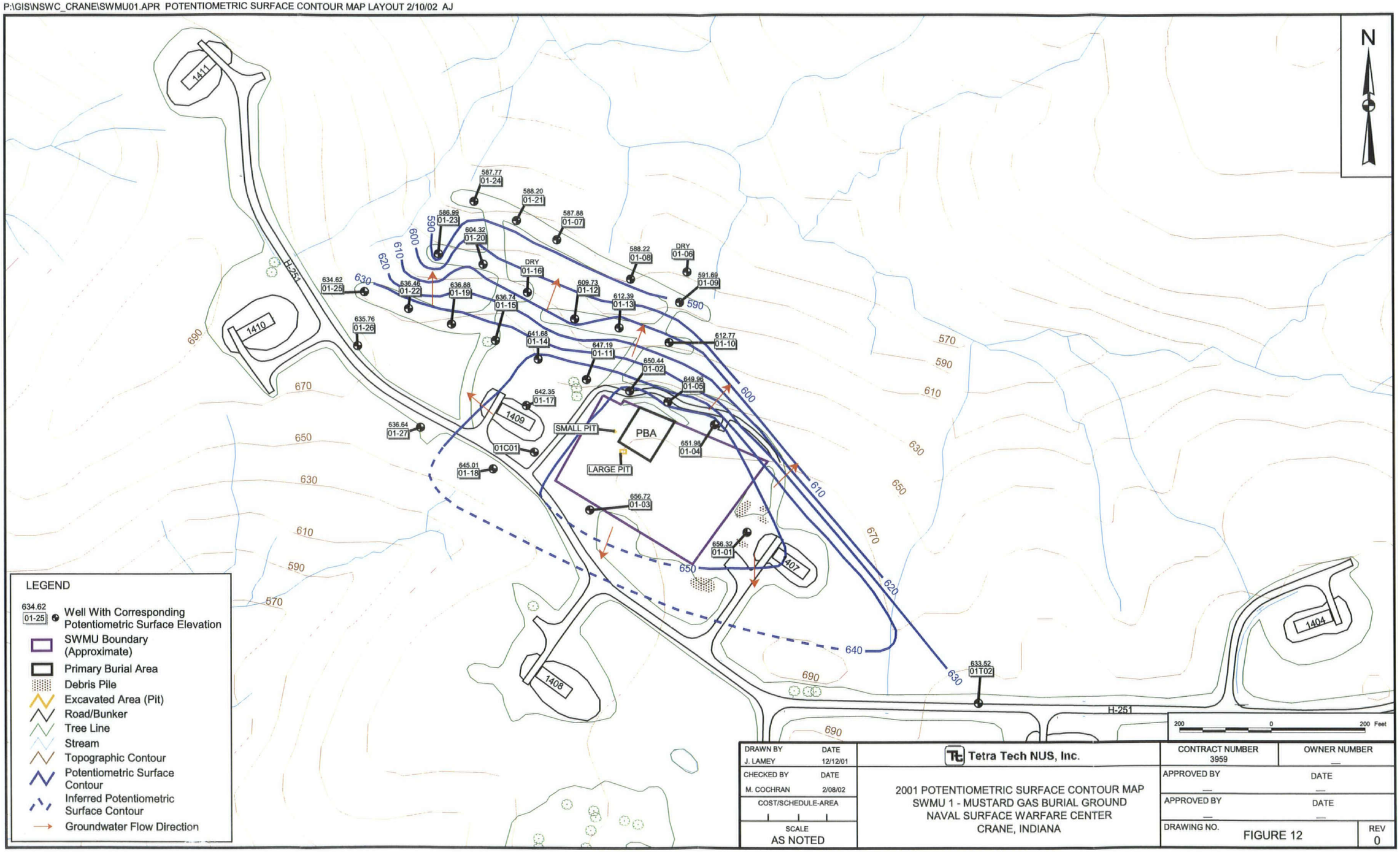
GW INORGANICS AND ORGANICS
MCL = U.S. EPA Maximum Contaminant Level.
R9TAP = EPA Region 9 Tap Water Goal.
IDEM = Indiana Dept. of Env. Mgmt. Default Closure Level.

DRAWN BY	DATE
A. JANOCHA	1/22/02
CHECKED BY	DATE
T. JOHNSTON	2/11/02
COST/SCHEDULE-AREA	
SCALE	AS NOTED

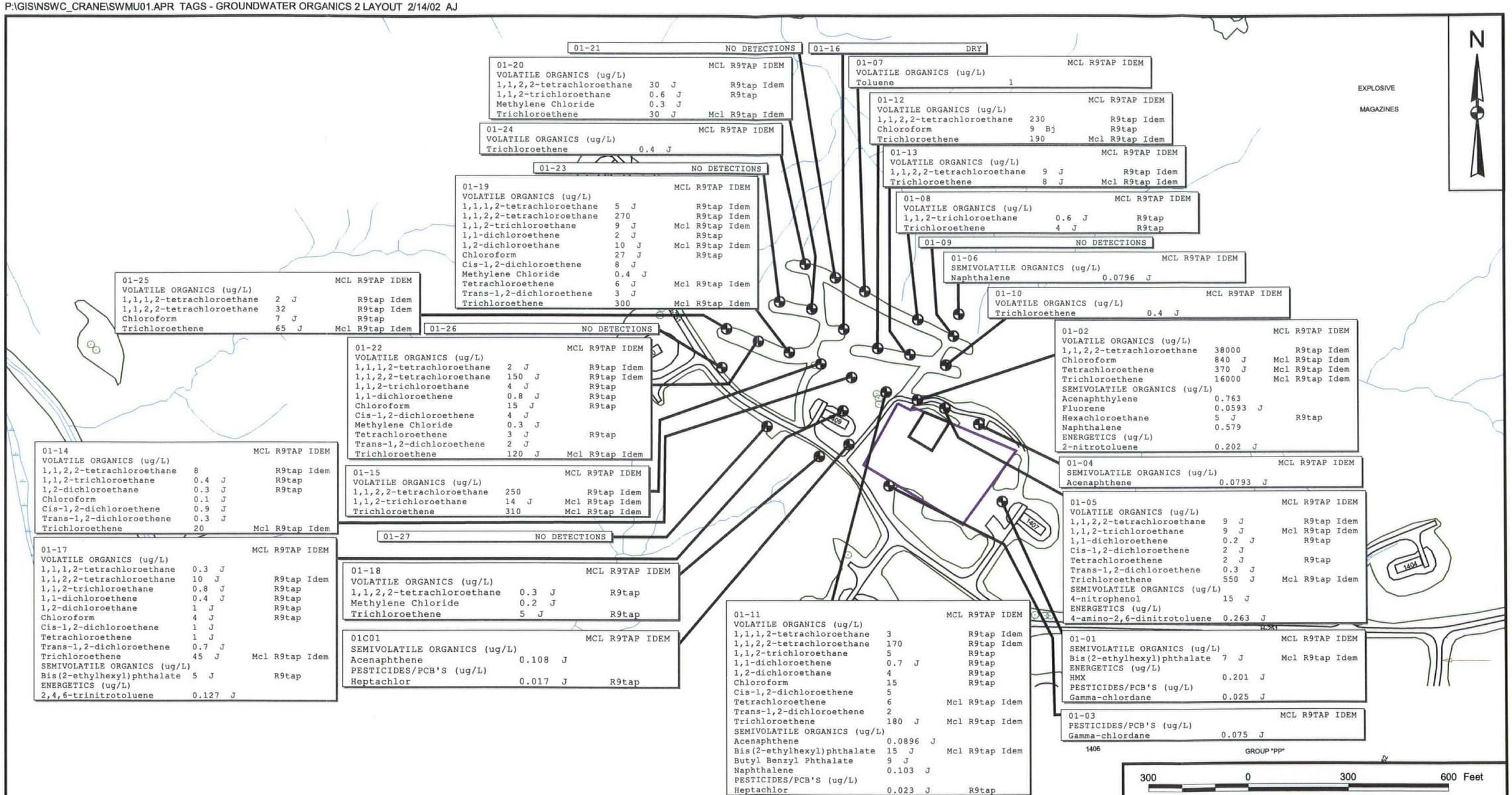
Tetra Tech NUS, Inc.

GROUNDWATER INORGANICS
AND RADIOLOGICALS
SWMU 1 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

CONTRACT NUMBER	OWNER NUMBER
3959	—
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO. FIGURE 11	REV 1



DRAWN BY J. LAMEY	DATE 12/12/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959 / OWNER NUMBER —
CHECKED BY M. COCHRAN	DATE 2/08/02	2001 POTENTIOMETRIC SURFACE CONTOUR MAP SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 12 / REV 0



01-21 NO DETECTIONS

01-16 DRY

01-20 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	30	J	R9tap Idem
1,1,2-trichloroethane	0.6	J	R9tap
Methylene Chloride	0.3	J	
Trichloroethene	30	J	Mcl R9tap Idem

01-24 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

Trichloroethene	0.4	J	

01-23 NO DETECTIONS

01-19 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,1,2-tetrachloroethane	5	J	R9tap Idem
1,1,2,2-tetrachloroethane	270		R9tap Idem
1,1,2-trichloroethane	9	J	Mcl R9tap Idem
1,1-dichloroethene	2	J	R9tap
1,2-dichloroethane	10	J	Mcl R9tap Idem
Chloroform	27	J	R9tap
Cis-1,2-dichloroethene	8	J	
Methylene Chloride	0.4	J	
Tetrachloroethene	6	J	Mcl R9tap Idem
Trans-1,2-dichloroethene	3	J	
Trichloroethene	300		Mcl R9tap Idem

01-07 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

Toluene	1		

01-12 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	230		R9tap Idem
Chloroform	9	Bj	R9tap
Trichloroethene	190		Mcl R9tap Idem

01-13 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	9	J	R9tap Idem
Trichloroethene	8	J	Mcl R9tap Idem

01-08 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2-trichloroethane	0.6	J	R9tap
Trichloroethene	4	J	R9tap

01-09 NO DETECTIONS

01-06 MCL R9TAP IDEM
SEMIVOLATILE ORGANICS (ug/L)

Naphthalene	0.0796	J	

01-10 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

Trichloroethene	0.4	J	

01-25 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,1,2-tetrachloroethane	2	J	R9tap Idem
1,1,2,2-tetrachloroethane	32		R9tap Idem
Chloroform	7	J	R9tap
Trichloroethene	65	J	Mcl R9tap Idem

01-26 NO DETECTIONS

01-22 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,1,2-tetrachloroethane	2	J	R9tap Idem
1,1,2,2-tetrachloroethane	150	J	R9tap Idem
1,1,2-trichloroethane	4	J	R9tap
1,1-dichloroethene	0.8	J	R9tap
Chloroform	15	J	R9tap
Cis-1,2-dichloroethene	4	J	
Methylene Chloride	0.3	J	
Tetrachloroethene	3	J	R9tap
Trans-1,2-dichloroethene	2	J	
Trichloroethene	120	J	Mcl R9tap Idem

01-15 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	250		R9tap Idem
1,1,2-trichloroethane	14	J	Mcl R9tap Idem
Trichloroethene	310		Mcl R9tap Idem

01-02 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	38000		R9tap Idem
Chloroform	840	J	Mcl R9tap Idem
Tetrachloroethene	370	J	Mcl R9tap Idem
Trichloroethene	16000		Mcl R9tap Idem
SEMIVOLATILE ORGANICS (ug/L)			
Acenaphthylene	0.763		
Fluorene	0.0593	J	
Hexachloroethane	5	J	R9tap
Naphthalene	0.579		
ENERGETICS (ug/L)			
2-nitrotoluene	0.202	J	

01-04 MCL R9TAP IDEM
SEMIVOLATILE ORGANICS (ug/L)

Acenaphthene	0.0793	J	

01-05 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	9	J	R9tap Idem
1,1,2-trichloroethane	9	J	Mcl R9tap Idem
1,1-dichloroethene	0.2	J	R9tap
Cis-1,2-dichloroethene	2	J	
Tetrachloroethene	2	J	R9tap
Trans-1,2-dichloroethene	0.3	J	
Trichloroethene	550	J	Mcl R9tap Idem
SEMIVOLATILE ORGANICS (ug/L)			
4-nitrophenol	15	J	
ENERGETICS (ug/L)			
4-amino-2,6-dinitrotoluene	0.263	J	

01-14 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	8		R9tap Idem
1,1,2-trichloroethane	0.4	J	R9tap
1,2-dichloroethane	0.3	J	R9tap
Chloroform	0.1	J	
Cis-1,2-dichloroethene	0.9	J	
Trans-1,2-dichloroethene	0.3	J	
Trichloroethene	20		Mcl R9tap Idem

01-17 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,1,2-tetrachloroethane	0.3	J	
1,1,2,2-tetrachloroethane	10	J	R9tap Idem
1,1,2-trichloroethane	0.8	J	R9tap
1,1-dichloroethene	0.4	J	R9tap
1,2-dichloroethane	1	J	R9tap
Chloroform	4	J	R9tap
Cis-1,2-dichloroethene	1	J	
Tetrachloroethene	1	J	
Trans-1,2-dichloroethene	0.7	J	
Trichloroethene	45	J	Mcl R9tap Idem
SEMIVOLATILE ORGANICS (ug/L)			
Bis(2-ethylhexyl)phthalate	5	J	R9tap
ENERGETICS (ug/L)			
2,4,6-trinitrotoluene	0.127	J	

01-27 NO DETECTIONS

01-18 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,2,2-tetrachloroethane	0.3	J	R9tap
Methylene Chloride	0.2	J	
Trichloroethene	5	J	R9tap

01C01 MCL R9TAP IDEM
SEMIVOLATILE ORGANICS (ug/L)

Acenaphthene	0.108	J	
PESTICIDES/PCB'S (ug/L)			
Heptachlor	0.017	J	R9tap

01-11 MCL R9TAP IDEM
VOLATILE ORGANICS (ug/L)

1,1,1,2-tetrachloroethane	3		R9tap Idem
1,1,2,2-tetrachloroethane	170		R9tap Idem
1,1,2-trichloroethane	5		R9tap
1,1-dichloroethene	0.7	J	R9tap
1,2-dichloroethane	4		R9tap
Chloroform	15		R9tap
Cis-1,2-dichloroethene	5		
Tetrachloroethene	6		Mcl R9tap Idem
Trans-1,2-dichloroethene	2		
Trichloroethene	180	J	Mcl R9tap Idem
SEMIVOLATILE ORGANICS (ug/L)			
Acenaphthene	0.0896	J	
Bis(2-ethylhexyl)phthalate	15	J	Mcl R9tap Idem
Butyl Benzyl Phthalate	9	J	
Naphthalene	0.103	J	
PESTICIDES/PCB'S (ug/L)			
Heptachlor	0.023	J	R9tap

01-01 MCL R9TAP IDEM
SEMIVOLATILE ORGANICS (ug/L)

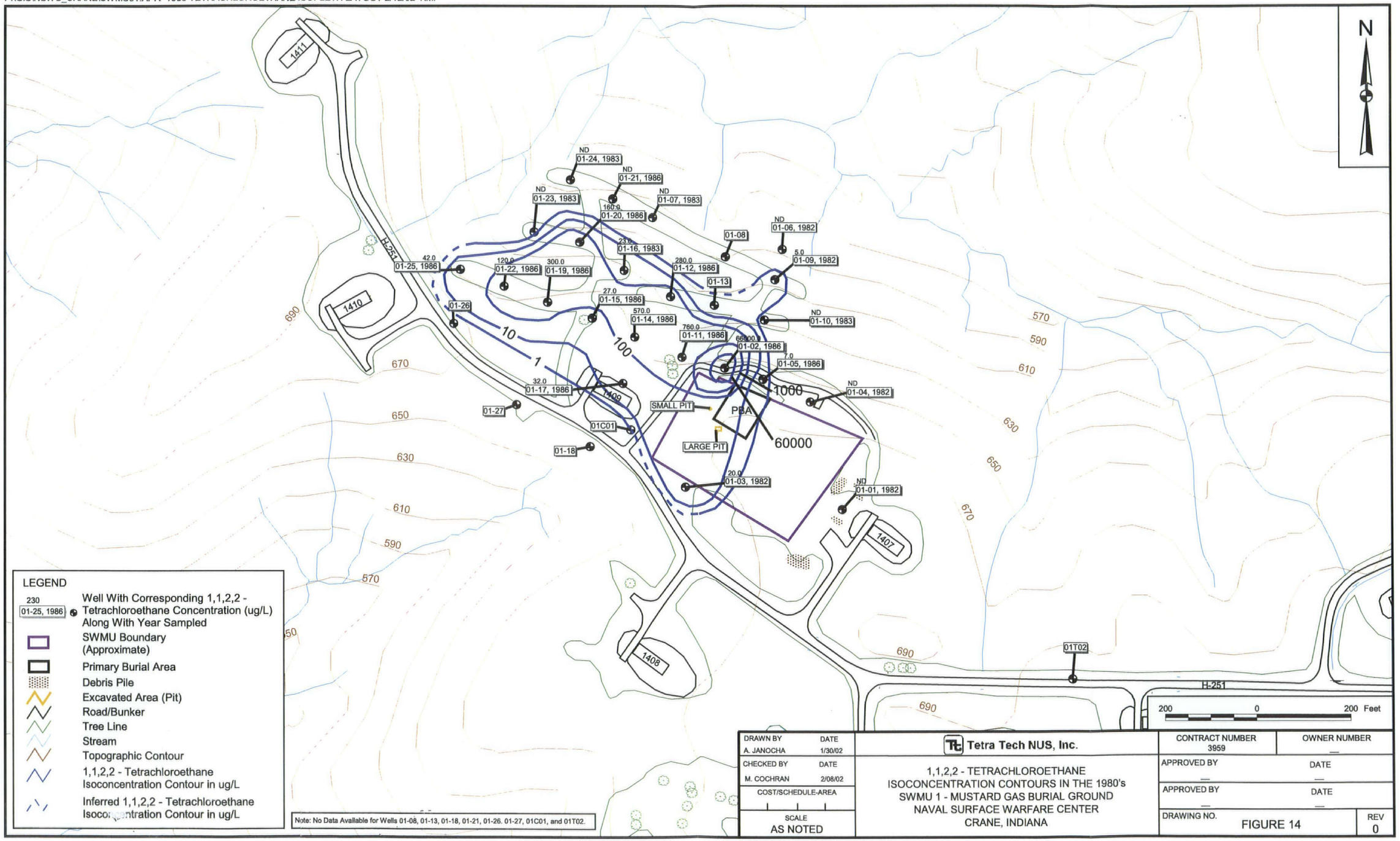
Bis(2-ethylhexyl)phthalate	7	J	Mcl R9tap Idem
ENERGETICS (ug/L)			
HMX	0.201	J	
PESTICIDES/PCB'S (ug/L)			
Gamma-chlordane	0.025	J	

01-03 MCL R9TAP IDEM
PESTICIDES/PCB'S (ug/L)

Gamma-chlordane	0.075	J	

GW INORGANICS AND ORGANICS
MCL = U.S. EPA Maximum Contaminant Level.
R9TAP = EPA Region 9 Tap Water Goal.
IDEM = Indiana Dept. of Env. Mgmt. Default Closure Level.

DRAWN BY A. JANOCHA	DATE 1/22/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959 / OWNER NUMBER —
CHECKED BY T. JOHNSTON	DATE 2/11/02	GROUNDWATER ORGANICS SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 13 / REV 1

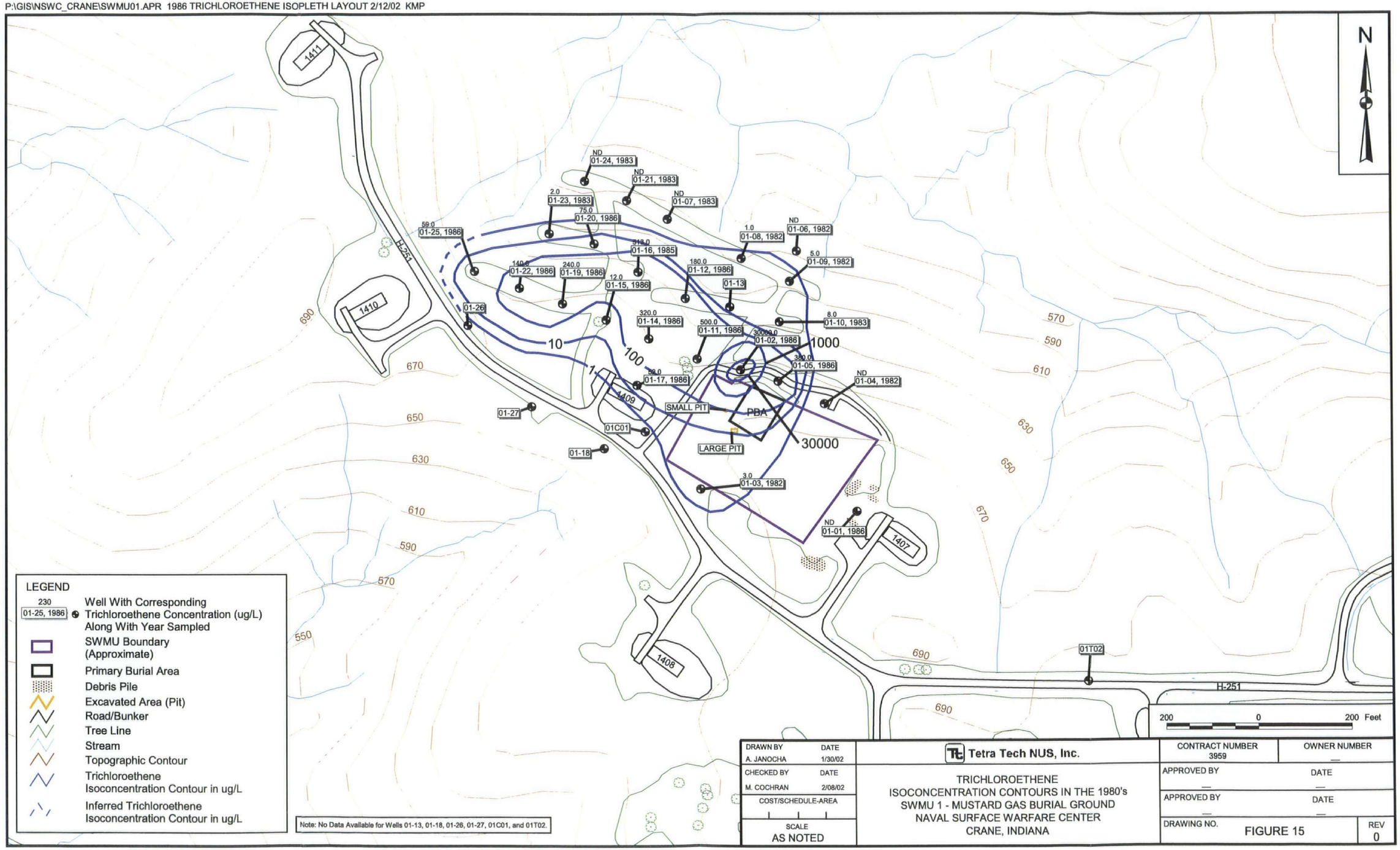


LEGEND

- 230 / 01-25, 1986 — Well With Corresponding 1,1,2,2 - Tetrachloroethane Concentration (ug/L) Along With Year Sampled
- SWMU Boundary (Approximate)
- Primary Burial Area
- Debris Pile
- Excavated Area (Pit)
- Road/Bunker
- Tree Line
- Stream
- Topographic Contour
- 1,1,2,2 - Tetrachloroethane Isoconcentration Contour in ug/L
- Inferred 1,1,2,2 - Tetrachloroethane Isoconcentration Contour in ug/L

Note: No Data Available for Wells 01-08, 01-13, 01-18, 01-21, 01-26. 01-27, 01C01, and 01T02.

DRAWN BY A. JANOCHA	DATE 1/30/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959 / OWNER NUMBER —
CHECKED BY M. COCHRAN	DATE 2/08/02	1,1,2,2 - TETRACHLOROETHANE ISOCONCENTRATION CONTOURS IN THE 1980's SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 14 / REV 0

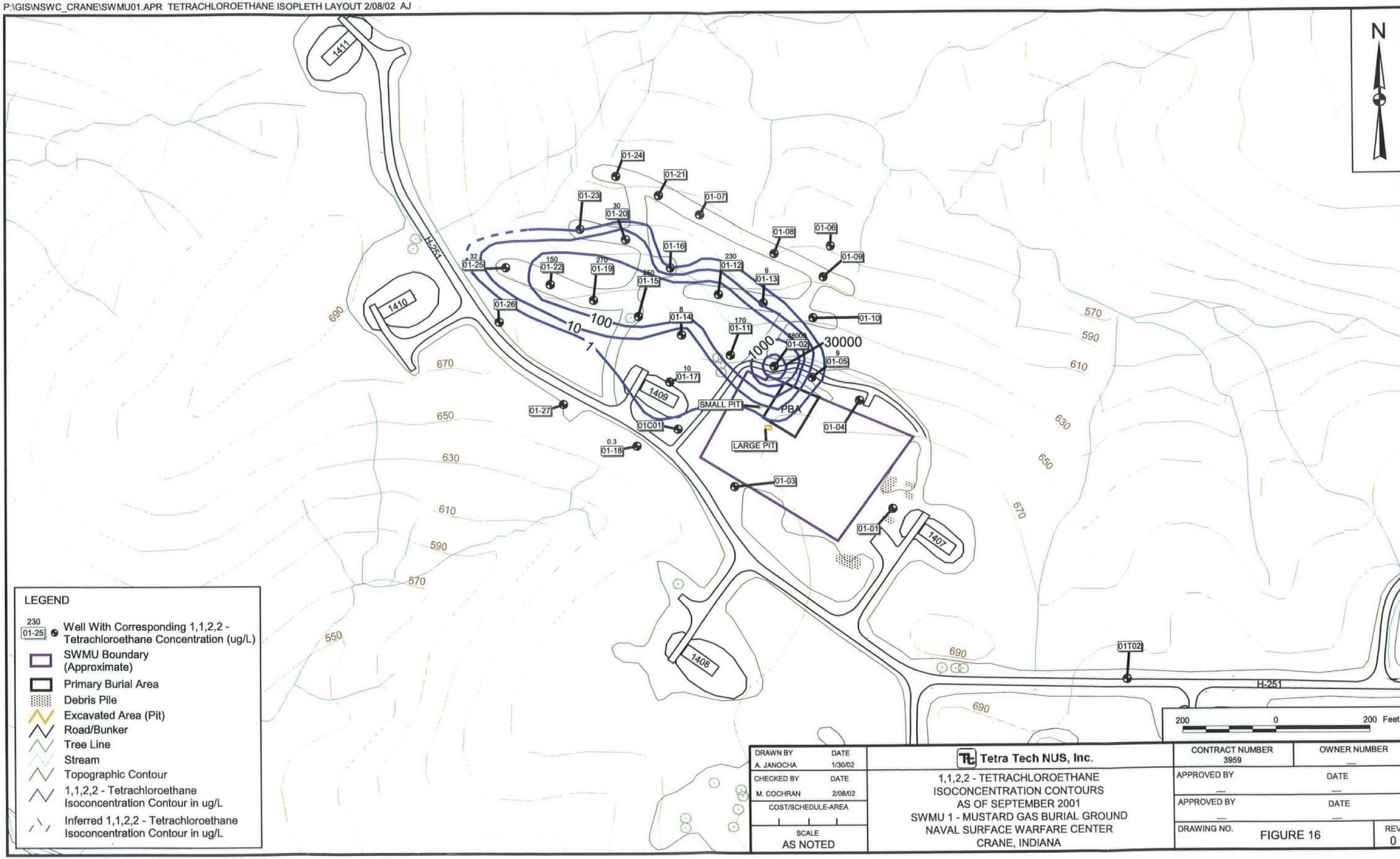


LEGEND

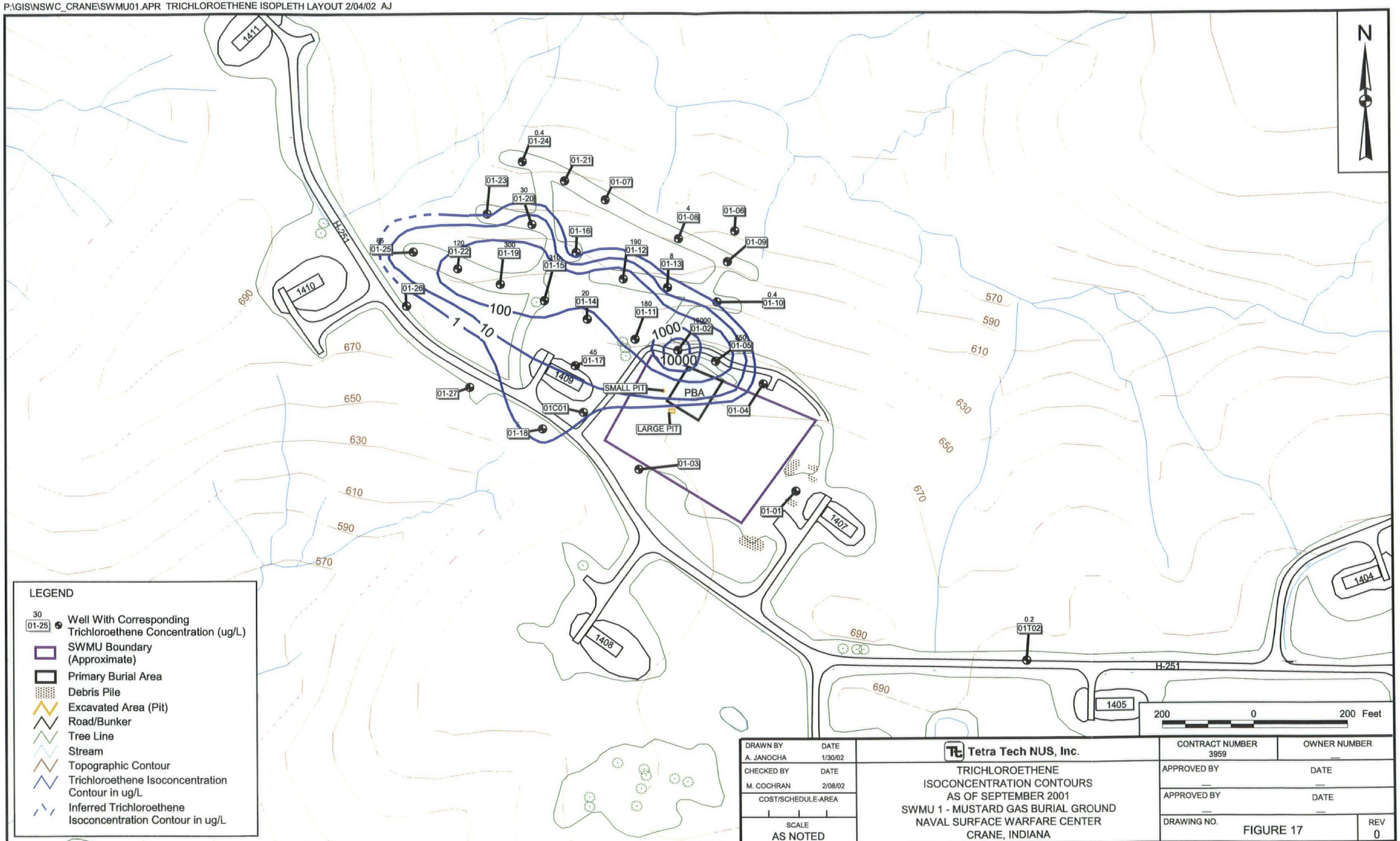
- 230 / 01-25, 1986 — Well With Corresponding Trichloroethene Concentration (ug/L) Along With Year Sampled
- SWMU Boundary (Approximate)
- Primary Burial Area
- Debris Pile
- Excavated Area (Pit)
- Road/Bunker
- Tree Line
- Stream
- Topographic Contour
- Trichloroethene Isoconcentration Contour in ug/L
- Inferred Trichloroethene Isoconcentration Contour in ug/L

Note: No Data Available for Wells 01-13, 01-18, 01-26, 01-27, 01C01, and 01T02.

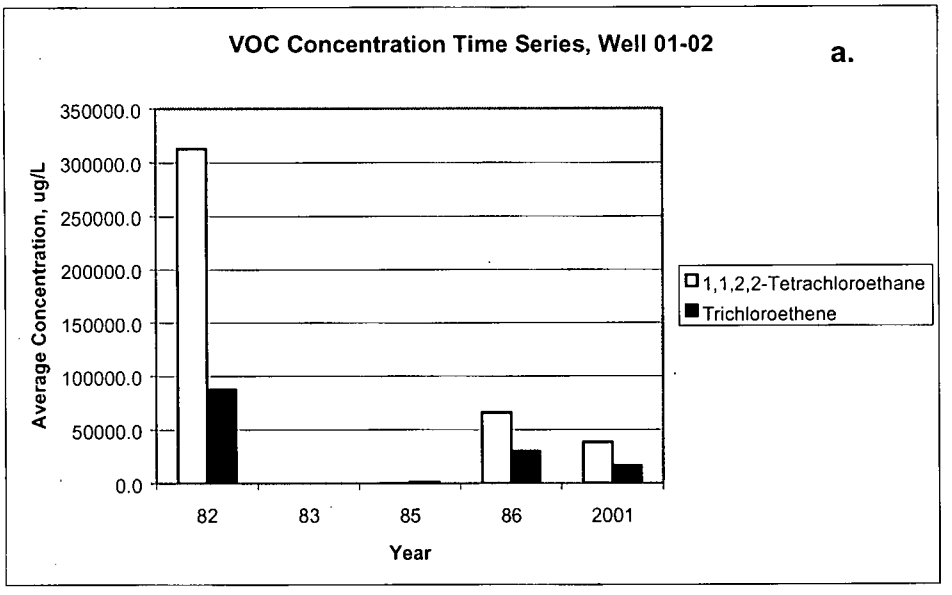
DRAWN BY A. JANOCHA	DATE 1/30/02	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959 / OWNER NUMBER —
CHECKED BY M. COCHRAN	DATE 2/08/02	TRICHLOROETHENE ISOCONCENTRATION CONTOURS IN THE 1980's SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 15 / REV 0



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959	OWNER NUMBER —
A. JANOCHA	1/30/02	1,1,2,2 - TETRACHLOROETHANE ISOCONCENTRATION CONTOURS AS OF SEPTEMBER 2001 SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
CHECKED BY	DATE		APPROVED BY —	DATE —
M. COCHRAN	2/08/02		DRAWING NO. FIGURE 16	REV 0
COST/SCHEDULE-AREA				
SCALE AS NOTED				



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959	OWNER NUMBER
A. JANOCHA	1/30/02	TRICHLOROETHENE ISOCONCENTRATION CONTOURS AS OF SEPTEMBER 2001 SWMU 1 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY —	DATE —
CHECKED BY	DATE		APPROVED BY —	DATE —
M. COCHRAN	2/08/02		DRAWING NO. FIGURE 17	REV 0
COST/SCHEDULE-AREA				
SCALE AS NOTED				



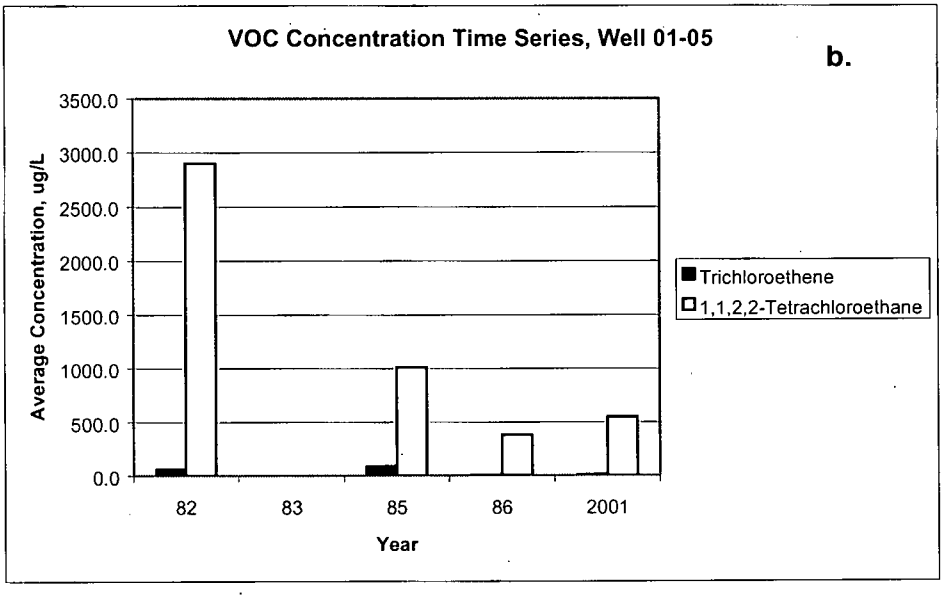


Figure 18. Time series of select VOC concentrations in the two most contaminated wells: a. Well 01-02; b. Well 01-05. Plotted concentrations are averages over all sampling rounds within each year.

Attachment 1. Evaluation of Arsenic Soil Data

Soil sample data were segregated into three of the nine basewide background soil groups according to the NSWC Crane Basewide Soil Background Report (TtNUS, 2000b). Metal concentrations in each of the three soil groups were compared to metal concentrations from the corresponding background soil group. Based on these comparisons each metal at the MGBG was classified as being statistically elevated or not elevated relative to background concentrations. For any metal that was determined to exceed its background concentration, all concentrations were plotted on tag maps for soil samples belonging to the soil group that exceed background concentrations. The resulting plots include a range of concentrations for each such metal, some of which would clearly exceed the upper end of the background soil concentrations and some that would not. If a metal concentration exceeds the 95/95 UTL of the background data set, the tag for that sample indicates "UTL".

Arsenic was detected in all 24 surface soil samples at concentrations ranging from 6 mg/kg to 10.9 mg/kg (Figure 7 of memorandum text). Concentrations of arsenic were in excess of the USEPA Region IX Preliminary Remediation Goal (PRG) for residential land use, IDEM Tier I Default Residential and Commercial/Industrial Soil Closure Levels, and USEPA SSL for migration to groundwater (DAF 1), and the Basewide background concentrations. There are a couple of features related to the MGBG arsenic concentrations that warrant discussion. First, the arsenic concentrations are rather uniform across the MGBG. This kind of spatial distribution is inconsistent with most forms of liquid or solid waste releases, which would typically exhibit an area of high concentration surrounded by increasingly lower concentrations as the distance from the point of release increases. Second, Figure A-1 shows a comparison of NSWC Crane background soil arsenic concentrations to MGBG surface soil arsenic concentrations. The MGBG arsenic concentrations are compressed into a distribution that is approximately half the range of concentrations observed across all of NSWC Crane, yet the upper end of the MGBG distribution is comparable to the upper end of the NSWC Crane background concentrations. This suggests that the MGBG arsenic concentrations are a subset of NSWC Crane background concentrations and are probably not an indication of site-related contamination. This is even more significant when considering that there are more concentration values in the MGBG data set (20 samples) than in the NSWC Crane background data set (15 samples). Such a situation favors the probability of obtaining a concentration in the MGBG data set that is greater than the maximum value observed across all of NSWC Crane. Finally, a comparison to background concentrations presumes that site contamination is added to background concentrations. To obtain the observed arsenic concentration distribution for MGBG samples, virtually all contamination would have to have been selectively deposited at the areas having the least arsenic concentrations, thus raising only those concentrations to the observed concentrations, and yielding a "compressed" but very slightly elevated concentration distribution. Such a contamination scenario is extremely implausible. In summary, although MGBG arsenic soil concentrations were determined to be statistically greater than NSWC Crane background concentrations, the MGBG is not viewed to be contaminated with arsenic. Instead, the very slightly elevated arsenic concentrations at the MGBG are viewed to represent a subset of the NSWC Crane background.

Figure 7 of the memorandum text shows that arsenic was detected in 26 of 35 subsurface soil samples at concentrations ranging from 0.48 mg/kg to 20.2 mg/kg. All but one of those values is less than the background subsurface soil 95/95 UTL of 8.2 mg/kg. Similar to the situation for arsenic in surface soils (see Surface Soil, above), it is not believed that the observed arsenic concentrations represent site contamination.

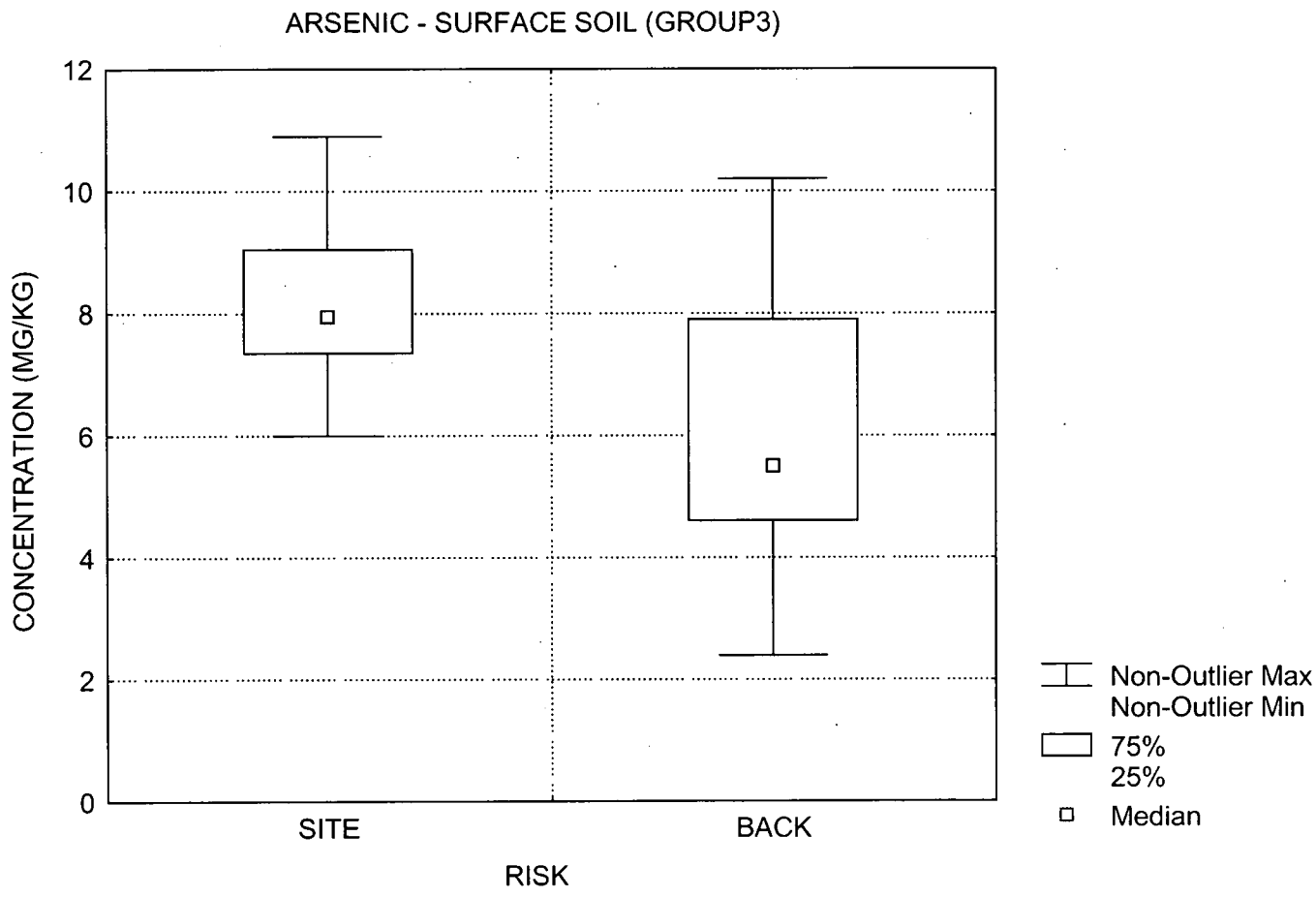


Figure A-1. Comparison of Arsenic Site Data with NSWC Crane Basewide Background Data.