United States Department of Agriculture

Natural Resources Conservation Service

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Subject: SOI -- Geophysical Assistance -- **Date:** 27 July 2001

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PURPOSE:
Ground-penetrating radar (GPR) was used in an attempt to locate Abenaki graves near the town of Alburg. It was also used to determine the depths to bedrock within selected soil map units in Orleans and Caledonia counties. Data will be used to document the composition of several soil map units.

PARTICIPANTS:
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ACTIVITIES:
All field activities were completed during the period of 19 to 21 June 2001. The archaeological investigation was conducted in a gravel pit near the town of Alburg on 18 June. The remainder of the week was spent conducting GPR surveys in representative areas of select map units in Caledonia and Orleans Counties.

EQUIPMENT:
The radar unit is the Subsurface Interface Radar (SIR) System-2000, manufactured by Geophysical Survey Systems, Inc.[1] Morey (1974), Doolittle (1987), and Daniels (1996) have discussed the use and operation of GPR. The SIR System-2000 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. This unit is backpack portable and, with an antenna, requires two people to operate. A 400 MHz antenna was used in this study. The scanning time was of 50 nanoseconds (ns). Hard copies of the radar data were printed in the field on a model P-608 printer.

ARCHAEOLOGICAL INVESTIGATION AT ALBURG GRAVEL PIT:
Bones had been unearthed in a sidewall of a gravel pit. A GPR survey was proposed to help identify the locations of additional burials within the area surrounding the gravel pit. The site was located in an area of Nellis soil (Flynn and Joslin, 1979). The very deep, well drained Nellis soil formed in calcareous till. Nellis is a member of the

[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

coarse-loamy, mixed, superactive, mesic Typic Eutrudepts Family. Random traverses were conducted across the site using a 400 MHz antenna. Several traverses crossed over or close to known burial sites along the face of the gravel pit.

Even with fairly favorable site conditions (i.e. coarse-loamy soils) the detection of buried cultural features with the GPR cannot be guaranteed. The detection of buried cultural features is affected by (i) the electromagnetic gradient existing between a cultural feature and the soil, (ii) the size, shape, and orientation of the buried cultural feature, and (iii) the presence of scattering bodies within the soil (Vickers et al., 1976).

The amount of energy reflected back to an antenna by an interface is a function of the dielectric gradient existing between the two mediums. The greater or more abrupt the difference in dielectric properties, the greater the amount of energy reflected back to the antenna, and the more intense will be the amplitude of the image recorded on the radar record. Buried cultural features with dielectric properties similar to the surrounding soil matrix are poor reflectors of electromagnetic energy and are difficult to discern on radar profiles.

The size, orientation, and depth to a buried cultural feature affect detection. Large objects reflect more energy and are easier to detect than small objects. Small, shallowly buried features will be missed, unless located directly beneath the aperture of the radar antenna. Killam (1990) believes that most bones are too small and not directly detectable with GPR. This author noted that the disruption of soil horizons makes some graves and cultural features detectable. However, in soils that lack contrasting horizons or geologic strata, the detection of a grave shaft is more improbable. In addition, with the passage of time, natural soil-forming processes erase the signs of disturbances. Bones and cultural features would be difficult to distinguish in areas of Nellis soils because of the large number of rock fragments in the till. These scattering bodies produce undesired subsurface reflections that complicate radar imagery and can mask the presence of buried cultural features.

At the Alburg site, burials appear to lack sufficient size and contrast with the surrounding soil matrix to be detected with GPR. Ground-penetrating radar provided no information concerning the presence and distribution of additional graves within the Alburg site.

SOIL/BEDROCK INVESTIGATIONS:
SSURGO requires an exact join between counties. Differences in the composition of several map units with the same named components in Orleans and Caledonia counties presently preclude an exact join. The units in question are map units 3 (Vershire-Glover Complex, rocky), and 6 (Vershire- Glover complex, very stony) in Orleans County; and map units 14 (Vershire-Dummerston complex, rocky), and 214 – (Vershire-Dummerston complex, very stony) in Caledonia and Essex counties. These soils formed in loamy till on uplands. The moderately deep, well-drained Vershire soil is a member of the coarse-loamy, mixed, active, frigid Humic Dystrudepts family. The shallow, somewhat excessively drained Glover soil is a member of the loamy, mixed, active, frigid Humic Lithic Dystrudepts family. The very deep, well-drained Dummerston is a member of the coarse-loamy, mixed, active, frigid Typic Dystrudepts family.

Field procedures:
Radar surveys were completed by pulling the 400 MHz antenna by hand across areas of soil map units 3B, 3C, 3D, 6C, 14B, 14C AND 14D. Soil delineations were selected to cover a large geographic area in Orleans and Caledonia counties. At the request of the soil survey project leaders, transect were of varying lengths and cross the breadth of most map units.

Although, GPR provides a continuous profile of subsurface conditions, interpretations were restricted to observation points. For each transect, observation points were spaced at distances of about 25 feet. At each observation point, the radar operator impressed a dashed, vertical line on the radar profile. This line identified an observation point on the radar record. A total of 1002 observation points were recorded during this field assignment.

Each radar traverse was stored as a separate file on a hard disc. Radar files were printed, reviewed and the bedrock surface was identified. The radar profiles that were printed on the P-608 printer lacked sufficient contrast to

accurately identify and chart the depths to the weathered and unweathered bedrock surfaces. Radar profiles were more interpretable on the SIR-2000's VGA video screen. All interpretations were made from color-enhanced images visible on this computer screen. Different color transforms were use to interpret the depths to Cr materials and to lithic/paralithic contacts. The Cr horizon appeared as a low amplitude reflector. The lithic and paralithic contact appeared as a higher amplitude reflector. Both interfaces were highly irregular. Laterally, these interfaces were interspersed with both high and low amplitude reflectors. At each observation point, the presence and depth to the Cr horizon and the depth to bedrock (either lithic or paralithic contact) were interpreted from the radar profile.

Discussion:

Calibration of GPR:

Ground-penetrating radar is a time scaled system. This system measures the time that it takes electromagnetic energy to travel from the antenna to an interface (e.g., bedrock, soil horizon, stratigraphic layer) and back. To convert the travel time into a depth scale, either the velocity of pulse propagation or the depth to a reflector must be known. The relationships among depth (D), two-way pulse travel time (T), and velocity of propagation (V) are described in the following equation (Morey, 1974):

$$V = 2D/T \qquad [1]$$

The velocity of propagation is principally affected by the dielectric permittivity (E) of the profiled material(s) according to the equation:

$$E = (C/V)^2 \qquad [2]$$

Where C is the velocity of propagation in a vacuum (0.3 m/nanosecond). Velocity is expressed in meters per nanosecond (ns). A nanosecond is one billionth of a second. The amount and physical state of water (temperature dependent) have the greatest effect on the dielectric permittivity of a material.

The velocity of propagation and the depth scale were determined by comparing the interpreted depth to known reflectors (buried metallic reflector) on the radar profile with the measured depths. Based on the measured depth and the two-way travel time to this interface, and equation [1], the velocity of propagation was estimated to be about 0.1088 m/ns. The dielectric permittivity was 7.6. A scanning time of 50 ns was used in this investigation. Using equation [1], scanning time of 50 ns, and a propagation velocity of 0.1088 m/ns, the maximum depth of observation was estimated to be about 2.7 m.

On radar profiles, reflections from interfaces spaced closer than one half wavelength apart are indistinguishable due to constructive and destructive interference (Daniels, 1996). Daniels (1996) used the following equation to show the relationship between velocity of propagation (v), antenna center frequency (f), and wavelength (λ):

$$\lambda = v/f \qquad [3]$$

Equation [3] shows that the propagated wavelength will decrease with decreasing propagation velocity and increasing antenna frequency. Using equation [2] and an average velocity of 0.11 m/ns resulted in wavelengths of about 25 cm (9 inches) at a frequency of 400 MHz. Interfaces (Cr and R) spaced closer than 9 inches were difficult to identify on radar profiles.

Calibration trials were completed with the 200 and 400 MHz antennas. As the 400 MHz antenna provided the best balance of resolution and depth of observation, it was used in all subsequent fieldwork. The depth to Cr and lithic or paralithic materials were measured at several observation points during survey work. This was done to verify interpretations and to confirm the accuracy of the depth scale. Interfaces were correctly identified and the difference between interpreted and measured depths to these interfaces ranged from 0 to 8 inches.

Interpretation of radar profiles:

The soil/bedrock interface was identifiable and traceable on all radar profiles. However, this interface did not consist of smooth, continuous, high amplitude reflections that are indicative of an abrupt and highly contrasting

boundary. The soil/bedrock interface did contain numerous segmented reflectors of varying amplitudes that suggest a boundary consisting of both Cr and R materials. Though the soil/bedrock interface was identifiable, because of its varying expression, depth estimates were considered less precise than those commonly made in areas of more uniform and contrasting materials.

Because of the abundance of similar rock-type fragments in the overlying soil, the highly irregular and often highly fractured bedrock surface, and the varying degree of hardness exhibited by both the Cr horizon and the underlying bedrock, the soil/bedrock interface was unaccustomedly vague on radar profiles.

RESULTS:

The results of this investigation are summarized in Table 1 and Appendix 1. Table 1 summarizes interpreted depths to lithic or paralithic materials by soil depth classes. For each transect the map unit symbol and county name have been provided. In addition, for each transect, the number of observations as well as the frequency observations for each depth class are given. Depth classes are shallow (0 to 20 inches), moderately deep (20 to 40 inches), deep (40 to 60 inches) and very deep (>60 inches). Where bedrock was exposed at the surface the observation depth was 0 and the depth class was shallow.

Table 1. Summary of Transect Data
Frequency Distribution of Depths to Lithic or Paralithic Contacts by Soil Depth Classes

			------- Soil Depth Classes (inches) -------			
Map Unit	**County**	**Observations**	**0 to 20**	**20 to 40**	**40 to 60**	**>60**
3C	Orleans	32	0.03	0.38	0.47	0.12
3C	Orleans	28	0.00	0.57	0.43	0.00
3C	Orleans	31	0.07	0.77	0.16	0.00
3C	Orleans	36	0.11	0.64	0.22	0.03
3B	Orleans	35	0.06	0.54	0.23	0.17
3B	Orleans	35	0.08	0.40	0.46	0.06
3D	Orleans	70	0.03	0.36	0.44	0.17
6C	Orleans	47	0.00	0.79	0.21	0.00
6C	Orleans	37	0.05	0.68	0.27	0.00
3D	Orleans	20	0.10	0.55	0.30	0.05
3D	Orleans	14	0.07	0.43	0.50	0.00
3C	Orleans	48	0.02	0.35	0.46	0.17
3C	Orleans	37	0.00	0.19	0.57	0.24
3C	Orleans	24	0.00	0.08	0.67	0.25
3C	Orleans	38	0.08	0.47	0.39	0.05
3C	Orleans	36	0.00	0.53	0.44	0.03
6C	Orleans	31	0.06	0.68	0.26	0.00
6C	Orleans	38	0.00	0.66	0.34	0.00
14C	Caledonia	43	0.05	0.40	0.46	0.09
14C	Caledonia	46	0.00	0.13	0.74	0.13
14B	Caledonia	18	0.06	0.06	0.88	0.00
14B	Caledonia	46	0.09	0.43	0.46	0.02
14D	Caledonia	14	0.00	0.29	0.64	0.07
14D	Caledonia	27	0.11	0.33	0.48	0.08
14D	Caledonia	14	0.06	0.35	0.53	0.06
14C	Caledonia	21	0.05	0.43	0.52	0.00
14C	Caledonia	15	0.07	0.33	0.60	0.00
14C	Caledonia	44	0.12	0.36	0.52	0.00
14D	Caledonia	33	0.06	0.52	0.42	0.00
14D	Caledonia	44	0.07	0.75	0.18	0.00

Appendix 1 summarizes the interpreted depths to Cr material and the bedrock surface for each transect. Depths are expressed in inches. For each transect, the file number and map unit symbol have been provided. Many observation points lack a depth to the Cr horizon. At these observation points, the Cr material was either not present, too thin or lacked sufficient contrast to be resolved with the 400 MHz antenna.

The selected units are composed predominantly of moderately deep and deep soils over paralithic or lithic materials. Based on the results of this GPR survey, the shallow Glover soil should be treated as an included soil rather than a named component. No deep soils are presently recognized. Map units surveyed in Orleans County have a slightly higher incidence of moderately deep than deep soils. Map units surveyed in Caledonia County have a slightly higher incidence of deep than moderately deep soils. Many soils have a layer of highly weathered rock (Cr) overlying paralithic or lithic materials. The bedrock surface is highly irregular and grades both laterally and vertically into materials of different resistance to weathering.

Recommendations:
The Soil Survey Project Leaders should review the tabulated data from the GPR survey. Hopefully this data will provide insight into the composition and designation of soil map units.

As always, it was my pleasure to work in Vermont and with members of your fine staff.

With kind regards,

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File 3 MU-3C	Cr inches	lithic/paralithic inches
	31.5	39.0
	-----	35.4
	-----	37.8
	38.5	75.6
	-----	48.4
	-----	42.9
	-----	45.7
	36.9	61.8
	-----	57.1
	-----	44.5
	31.5	48.4
	31.5	42.5
	-----	35.0
	-----	37.4
	55.4	63.8
	44.6	50.0
	-----	48.0
	-----	44.1
	-----	48.8
	-----	30.3
	-----	35.0
	61.5	82.7
	-----	32.7
	-----	44.1
	36.2	42.9
	-----	19.7
	-----	33.1
	37.7	46.1
	26.2	32.7
	------	32.7
	26.2	35.0
	30.8	47.2

File 4 MU-3C	Cr inches	lithic/paralithic inches
	25.4	53.2
	-----	28.0
	-----	31.1
	-----	31.1
	31.5	39.0
	-----	42.1
	-----	29.1
	-----	37.8
	-----	39.0
	-----	35.0
	-----	31.9
	-----	25.2
	-----	53.5
	-----	42.9
	28.5	37.4
	-----	43.3
	-----	42.1
	-----	51.2
	-----	38.2
	-----	33.1
	-----	34.2

File 4 MU-3C	Cr inches	lithic/paralithic inches
	-----	42.1
	-----	42.1
	-----	29.9
	-----	58.7
	-----	46.8
	-----	35.4
	-----	52.4

File 5 MU-3C	Cr inches	lithic/paralithic inches
	-----	43.7
	-----	44.9
	23.8	35.4
	30.8	37.0
	-----	37.0
	-----	36.2
	-----	37.8
	-----	26.4
	-----	35.0
	-----	17.7
	-----	38.2
	-----	30.3
	-----	31.1
	-----	43.3
	-----	31.9
	37.7	54.3
	26.9	35.4
	-----	31.5
	-----	51.2
	-----	33.5
	-----	27.6
	-----	16.9
	-----	37.4
	-----	29.9
	-----	31.5
	-----	24.8
	-----	30.7
	-----	27.2
	-----	26.8
	-----	23.2
	-----	35.4

File 6 MU-3C	Cr inches	lithic/paralithic inches
	------	40.6
	-----	33.1
	-----	12.2
	-----	26.0
	-----	46.8
	-----	25.9
	-----	19.3
	-----	34.2
	-----	44.5
	-----	25.6

File 6 MU-3C	Cr inches	lithic/paralithic inches
	-----	19.3
	-----	63.4
	-----	37.0
	-----	29.9
	-----	27.6
	-----	37.0
	-----	22.4
	-----	33.8
	-----	28.4
	-----	33.1
	-----	21.6
	49.2	52.8
	------	35.4
	------	35.4
	-----	29.5
	-----	29.9
	-----	26.0
	-----	48.8
	-----	44.9
	40.0	50.0
	16.9	41.7
	20.0	29.1
	23.1	35.0
	-----	18.1
	18.5	28.4
	19.2	25.6

File 7 MU-3B	Cr inches	lithic/paralithic inches
	-----	31.1
	16.9	55.5
	21.5	106.7
	28.5	106.7
	29.2	106.7
	33.1	106.7
	-----	11.4
	28.5	94.9
	24.6	42.1
	-----	40.9
	40.0	89.0
	46.2	52.8
	46.2	55.1
	38.5	47.6
	-----	29.1
	-----	24.8
	-----	28.4
	-----	22.0
	-----	27.6
	-----	35.4
	26.9	31.5
	-----	26.0
	31.5	38.6
	37.7	44.1
	-----	32.3
	24.6	38.2
	18.5	28.4

File 7 MU-3B	Cr inches	lithic/paralithic inches
	-----	38.6
	-----	41.7
	21.5	38.2
	-----	31.5
	17.7	27.2
	16.9	30.7
	-----	28.4
	-----	14.6

File 8 MU-3B	Cr inches	lithic/paralithic inches
	16.5	35.4
	19.3	42.9
	-----	26.0
	27.6	35.4
	17.3	29.5
	24.4	43.3
	26.4	34.3
	26.0	40.6
	24.8	33.1
	26.4	42.1
	31.1	95.7
	37.0	48.8
	-----	43.7
	-----	42.1
	-----	24.8
	29.1	35.0
	-----	40.6
	-----	26.0
	25.2	33.1
	23.2	51.2
	-----	16.9
	-----	17.7
	22.0	42.1
	23.6	33.9
	24.0	41.7
	18.1	27.6
	------	17.3
	29.5	64.6
	27.2	42.5
	39.8	53.5
	-----	51.2
	-----	55.5
	17.7	42.5
	-----	26.0
	-----	23.2

File 9 MU-3D	Cr inches	lithic/paralithic inches
	-----	18.9
	22.8	45.3
	32.7	38.2
	22.0	36.2
	39.0	46.1
	35.0	48.8
	30.7	44.5
	31.5	42.5
	33.9	56.7
	21.7	33.1
	28.0	38.6
	-----	50.4
	26.4	67.3
	39.8	52.0
	18.5	60.2
	25.6	54.7
	21.3	45.7
	29.1	47.2
	48.4	93.3
	26.0	93.3
	26.4	92.1
	20.9	71.7
	-----	33.1
	50.0	58.7
	-----	31.9
	24.8	59.8
	-----	48.8
	-----	28.7
	-----	18.9
	29.9	37.0
	-----	35.8
	35.0	48.8
	27.6	70.5
	-----	28.7
	-----	31.1
	27.6	40.6
	27.6	44.9
	-----	49.6
	31.1	48.8
	20.9	81.1
	28.0	79.5
	-----	40.6
	26.4	46.9
	-----	27.6
	-----	26.0
	-----	31.5
	24.0	30.3
	37.0	46.5
	27.2	33.1
	18.5	25.6
	-----	42.1
	27.6	43.3
	26.8	32.3
	35.8	44.5
	-----	35.0
	-----	37.8
	-----	37.8
	40.6	48.0

File 9 MU-3D	Cr inches	lithic/paralithic inches
	24.8	69.3
	27.2	40.9
	-----	32.7
	-----	26.0
	28.3	40.6
	20.5	59.4
	17.7	52.8
	25.2	40.6
	22.8	66.9
	17.7	64.6
	-----	33.1
	-----	23.2

File 10 MU-6C	Cr inches	lithic/paralithic inches
	20.9	30.7
	-----	25.2
	-----	29.5
	26.4	39.4
	-----	35.8
	21.7	38.2
	15.7	36.6
	31.1	44.9
	26.4	48.0
	17.3	37.8
	20.9	37.0
	25.2	42.5
	27.6	42.1
	-----	20.9
	33.1	39.4
	-----	37.0
	-----	35.0
	30.7	40.9
	-----	37.8
	-----	49.2
	20.5	31.1
	-----	27.2
	26.0	39.8
	-----	33.1
	-----	30.3
	-----	27.2
	-----	33.1
	17.3	31.9
	-----	29.9
	28.3	53.1
	23.6	39.8
	----	42.1
	20.5	31.1
	22.0	41.7
	35.4	43.3
	19.3	38.2
	-----	26.8
	-----	28.3
	-----	31.1
	-----	33.5
	-----	35.4
	-----	29.1

File 10 MU-6C	Cr inches	lithic/paralithic inches
	-----	26.8
	-----	24.8
	-----	29.1
	-----	25.6
	-----	20.9

File 11 MU-6C	Cr inches	lithic/paralithic inches
	-----	19.3
	-----	24.4
	25.2	37.8
	-----	29.9
	-----	31.1
	-----	49.2
	33.1	39.0
	16.9	33.1
	-----	20.1
	28.3	48.0
	24.8	43.3
	20.5	39.8
	20.5	31.5
	29.1	38.6
	24.4	47.6
	-----	22.0
	-----	13.0
	----	34.6
	23.6	32.3
	25.6	44.5
	31.5	38.2
	-----	31.9
	-----	44.5
	40.2	54.3
	-----	43.7
	-----	30.7
	16.5	32.3
	26.4	42.9
	-----	29.1
	20.5	53.1
	-----	27.6
	25.6	34.6
	-----	31.9
	19.7	36.6
	-----	26.4
	23.2	39.0
	-----	26.0

File 12 MU-3D	Cr inches	lithic/paralithic inches
	18.5	44.5
	26.4	35.4
	16.5	61.0
	-----	0.0
	-----	24.0
	-----	22.4
	-----	35.0
	24.4	36.6
	25.2	32.3

File 12 MU-3D	Cr inches	lithic/paralithic inches
	-----	31.1
	-----	40.6
	-----	43.7
	-----	42.1
	-----	31.9
	34.3	47.6
	-----	28.3
	-----	28.3
	-----	0.0
	-----	41.7
	27.6	38.6

File 13 MU-3D	Cr inches	lithic/paralithic inches
	28.7	42.5
	25.2	55.1
	36.2	45.7
	-----	29.9
	37.4	50.0
	28.7	41.7
	25.6	38.2
	-----	37.4
	-----	39.8
	-----	44.5
	-----	37.8
	-----	46.5
	30.7	39.0
	-----	18.5

File 14 MU-3C	Cr inches	lithic/paralithic inches
	31.9	48.8
	28.3	87.0
	46.5	77.6
	62.6	106.7
	52.8	89.4
	42.5	77.6
	26.4	31.1
	-----	27.6
	-----	28.3
	-----	44.5
	40.6	52.8
	28.7	44.9
	----	37.0
	-----	28.0
	-----	18.5
	-----	35.4
	-----	46.5
	48.0	53.9
	40.6	55.5
	-----	47.6
	29.1	42.9
	-----	28.3
	29.1	44.9
	-----	36.6
	-----	42.9

File 14 MU-3C	Cr inches	lithic/paralithic inches
	-----	35.4
	25.2	31.9
	28.0	44.1
	33.1	63.8
	31.9	42.5
	29.1	45.7
	-----	34.6
	-----	49.2
	-----	23.2
	20.5	36.2
	-----	23.2
	-----	35.0
	23.6	65.0
	33.9	50.4
	-----	34.3
	35.8	42.5
	32.7	52.4
	35.4	67.3
	-----	53.1
	-----	47.6
	25.2	48.8
	-----	41.7
	-----	28.7

File 15 FARM	Cr inches	lithic/paralithic inches
	24.8	54.7
	-----	29.5
	59.1	68.5
	-----	45.7
	48.0	106.7
	50.8	101.6
	46.5	55.5
	50.0	71.7
	44.5	51.2
	31.5	42.5
	35.0	59.1
	24.0	37.8
	26.8	47.2
	35.4	42.5
	39.4	57.5
	41.3	65.7
	40.2	57.1
	26.4	50.8
	33.9	52.8
	50.4	106.7
	-----	51.6
	34.3	81.9
	-----	47.6
	37.8	62.6
	31.5	47.6
	30.7	54.7
	68.5	91.7
	-----	37.8
	-----	41.7
	28.7	52.8
	-----	48.8

File 15 FARM	Cr inches	lithic/paralithic inches
	31.5	37.0
	-----	45.3
	-----	31.1
	-----	39.0
	25.6	33.5
	-----	42.5

File 16 MU-3C	Cr inches	lithic/paralithic inches
	----	44.9
	39.4	52.4
	-----	48.8
	46.5	60.6
	37.4	68.5
	-----	41.7
	29.1	66.5
	-----	47.6
	46.5	103.5
	-----	51.6
	63.4	70.1
	-----	42.5
	66.5	70.5
	-----	50.4
	-----	52.8
	-----	42.1
	-----	47.6
	29.9	44.5
	-----	35.4
	-----	39.0

File 17 MU-3C	Cr inches	lithic/paralithic inches
	----	42.9
	-----	40.9
	-----	31.5
	59.1	80.7
	36.6	45.3
	-----	39.4
	26.0	48.8
	29.9	50.0
	39.4	51.6
	-----	38.6
	40.6	48.4
	51.6	60.6
	28.7	40.9
	-----	28.7
	-----	39.8
	----	46.1
	-----	45.7
	-----	35.8
	29.9	57.9
	35.4	53.9
	-----	43.3
	31.1	39.4
	-----	39.0
	-----	24.0
	18.1	37.8

File 17 MU-3C	Cr inches	lithic/paralithic inches
	27.2	35.4
	-----	37.4
	-----	28.7
	-----	0.0
	-----	33.9
	-----	40.9
	-----	22.4
	25.2	37.0
	31.9	53.1
	-----	26.4
	-----	15.0
	-----	0.0
	-----	23.6

File 18 MU-3C	Cr inches	lithic/paralithic inches
	29.9	53.5
	----	33.1
	20.9	53.5
	----	24.4
	42.1	50.0
	31.9	37.8
	27.2	45.3
	22.0	31.9
	----	31.9
	26.8	37.0
	34.3	39.0
	----	33.5
	28.3	37.4
	----	40.6
	26.4	32.7
	----	29.9
	49.6	87.8
	----	46.1
	40.6	48.4
	33.9	42.9
	----	44.9
	----	41.3
	----	33.1
	33.1	37.0
	----	29.5
	21.7	37.0
	----	43.3
	----	46.5
	----	26.4
	----	34.3
	----	32.3
	40.9	53.5
	46.9	52.8
	31.5	40.2
	----	30.3
	30.3	40.6

File 19 MU-6C	Cr inches	lithic/paralithic inches
	-----	19.3
	22.8	30.7
	-----	28.7
	31.9	52.4
	----	33.1
	-----	18.5
	24.4	47.2
	30.3	37.0
	22.8	35.0
	26.8	41.3
	-----	28.7
	-----	40.6
	24.8	39.4
	23.6	31.9
	-----	28.3
	26.4	41.7
	-----	26.4
	18.5	35.8
	-----	24.4
	28.7	47.2
	-----	29.1
	18.1	25.2
	-----	42.5
	-----	38.2
	-----	33.9
	22.0	31.9
	16.5	25.6
	----	39.0
	-----	25.2
	-----	20.9
	19.7	43.3

File 20 MU-6C	Cr inches	lithic/paralithic inches
	----	39.4
	-----	51.2
	-----	32.7
	-----	38.2
	-----	41.3
	-----	46.1
	-----	32.7
	-----	37.8
	26.0	35.0
	-----	27.6
	24.4	35.4
	37.8	40.9
	-----	33.1
	24.8	47.6
	31.9	37.4
	-----	23.6
	-----	33.9
	-----	42.5
	-----	26.4
	-----	44.1
	-----	25.6
	-----	37.0
	-----	28.3

File 20 MU-6C	Cr inches	lithic/paralithic inches
	-----	24.8
	-----	38.2
	-----	29.9
	-----	34.3
	-----	31.9
	-----	38.2
	-----	42.1
	-----	35.4
	-----	46.5
	28.3	52.4
	-----	28.7
	-----	31.9
	40.6	48.8
	45.7	55.1
	32.3	46.9

File 21 MU-14C	Cr	lithic/paralithic inches inches
	-----	26.4
	-----	0.0
	-----	52.0
	44.9	60.2
	-----	53.1
	34.6	40.9
	-----	35.4
	43.3	66.1
	39.8	51.6
	36.6	45.3
	-----	37.8
	-----	38.6
	37.0	46.5
	-----	38.6
	-----	37.8
	-----	44.9
	-----	47.6
	-----	50.4
	-----	55.5
	-----	41.7
	-----	44.1
	-----	34.3
	-----	36.6
	-----	44.5
	-----	37.0
	-----	60.2
	-----	33.1
	----	28.7
	-----	26.4
	-----	16.9
	31.5	38.6
	-----	33.1
	35.0	41.7
	37.0	46.1
	-----	32.3
	37.0	57.9
	32.7	40.2
	-----	39.4
	37.0	62.6

File 21 MU-14C	Cr	lithic/paralithic inches inches
	-----	43.3
	-----	46.1
	----	44.9
	30.7	39.8

File 22 MU-14C	Cr	lithic/paralithic inches inches
	37.4	49.2
	-----	42.5
	-----	35.8
	47.2	66.9
	----	49.6
	-----	42.9
	33.5	52.0
	-----	27.6
	-----	36.6
	37.4	42.5
	39.0	48.0
	----	46.5
	----	55.1
	----	45.7
	43.7	51.2
	----	43.7
	32.7	68.1
	36.6	50.4
	48.8	58.3
	40.9	55.9
	43.7	62.2
	-----	53.1
	-----	35.0
	-----	37.0
	54.3	65.0
	35.8	56.7
	44.1	49.2
	-----	44.5
	48.8	55.9
	43.3	52.4
	-----	41.7
	-----	50.8
	-----	52.8
	-----	43.3
	-----	53.1
	-----	52.0
	-----	43.3
	-----	35.0
	-----	50.4
	26.4	55.9
	44.9	55.5
	-----	44.9
	27.2	55.5
	39.4	64.6
	42.1	62.2
	26.8	53.9

File 23 MU-14B	Cr inches	lithic/paralithic inches
	37.8	55.5
	44.5	51.6
	-----	50.0
	-----	49.2
	26.0	47.6
	38.2	44.1
	30.7	40.6
	28.0	50.0
	40.9	52.0
	29.5	42.1
	----	48.4
	28.3	43.7
	----	0.0
	----	31.5
	26.8	51.6
	35.4	42.5
	27.2	54.3
	28.3	46.5

File 24 MU-14B	Cr	lithic/paralithic inches inches
	24.8	41.3
	30.3	37.0
	36.2	45.3
	32.7	48.4
	-----	35.0
	28.3	75.2
	27.6	59.1
	29.5	52.8
	-----	0.0
	26.8	55.9
	25.2	53.5
	25.6	37.8
	-----	44.1
	-----	41.3
	30.3	35.8
	28.3	32.7
	-----	47.6
	-----	26.8
	31.5	37.8
	-----	40.6
	-----	38.2
	-----	37.4
	-----	44.5
	25.2	43.3
	22.8	43.7
	----	24.8
	23.2	34.3
	-----	18.9
	20.9	59.8
	-----	17.3
	28.0	42.1
	-----	39.0
	-----	37.8
	33.5	48.0
	26.8	42.5
	26.4	39.4
	22.0	40.9

File 24 Cr MU-14B	lithic/paralithic
inches	inches
22.4	42.5
30.3	37.0
-----	34.3
24.4	43.3
-----	37.8
-----	22.4
-----	18.5
24.4	32.7
16.5	26.4

File 25 Cr MU-14D	lithic/paralithic
inches	inches
29.1	55.5
26.4	39.8
-----	31.9
23.6	40.2
24.4	50.4
33.1	44.9
30.7	40.6
23.6	51.6
29.9	64.6
24.8	51.2
26.0	31.1
22.4	42.1
32.7	47.6
27.2	35.0

File 26 Cr MU-14D	lithic/paralithic
inches	inches
33.5	40.2
-----	26.4
26.4	39.8
26.8	42.5
22.4	33.1
27.6	51.6
-----	0.0
20.9	53.9
15.0	40.6
20.9	33.9
-----	0.0
25.6	47.2
26.4	48.8
21.7	45.7
21.7	56.7
21.3	46.1
-----	0.0
17.7	33.5
20.9	60.6
28.3	56.7
26.0	60.6
27.2	48.4
-----	22.4
-----	24.8
21.7	29.1
26.4	43.7
20.9	39.4

File 27 Cr MU-14D	lithic/paralithic
inches	inches
21.7	39.4
16.5	40.9
-----	28.0
19.7	49.2
-----	31.5
21.3	79.9
-----	17.7
21.7	30.7
28.3	40.6
22.4	37.8
20.9	46.9
26.4	45.3
27.2	37.4
27.6	46.9
24.8	40.9
25.6	53.5
28.3	52.0

File 28 Cr MU-14C	lithic/paralithic
inches	inches
23.6	36.6
26.4	37.0
36.2	48.8
-----	17.7
24.0	35.8
36.6	45.3
-----	28.7
-----	33.1
31.9	42.1
29.9	44.1
25.6	36.6
25.6	44.5
24.8	36.6
40.6	46.5
26.0	49.6
24.0	51.2
-----	31.5
18.9	46.1
31.1	40.2
-----	26.8
24.0	45.3

File 29 Cr MU-14C	lithic/paralithic
inches	inches
19.3	32.7
25.2	43.7
26.4	36.2
28.0	46.1
34.3	52.4
26.8	40.2
31.5	39.4
-----	26.0
22.0	40.9
18.1	27.2
16.9	53.9
17.7	44.9

File 29 Cr MU-14C	lithic/paralithic
inches	inches
18.9	43.3
28.3	43.3
-----	12.2

File 30 Cr MU-14C	lithic/paralithic
inches	inches
25.6	51.6
28.7	59.1
31.9	51.2
35.4	55.9
36.6	49.2
39.8	49.2
29.5	48.8
-----	39.8
23.6	37.0
-----	11.8
-----	19.7
33.5	49.2
-----	22.4
26.0	40.2
26.4	42.9
-----	18.1
26.0	36.2
-----	27.2
-----	16.1
32.7	48.8
31.1	51.6
28.7	46.5
-----	26.0
26.8	52.8
36.6	47.6
24.4	31.9
28.3	33.9
----	29.9
37.8	47.2
-----	29.1
35.4	49.6
21.3	46.5
40.9	44.1
27.2	44.9
-----	27.6
-----	35.4
-----	33.1
32.3	41.7
-----	39.8
-----	30.3
27.6	39.8
29.1	47.6
29.1	44.5
-----	18.5

File 31 MU-14D	Cr	lithic/paralithic inches	inches
	-----	18.1	
	-----	23.2	
	-----	46.5	
	-----	42.5	
	-----	29.1	
	-----	37.0	
	-----	43.3	
	-----	35.4	
	-----	23.2	
	-----	50.0	
	-----	26.0	
	-----	39.4	
	-----	27.2	
	33.1	41.3	
	-----	44.1	
	-----	44.1	
	-----	29.5	
	-----	42.1	
	-----	39.8	
	-----	26.4	
	-----	41.3	
	-----	33.1	
	-----	40.9	
	-----	31.5	
	-----	25.2	
	-----	33.1	
	-----	43.3	
	-----	49.6	
	-----	36.6	
	-----	42.5	
	-----	57.8	
	-----	35.0	
	-----	0.0	

File 32 MU-14D	Cr	lithic/paralithic inches	inches
	-----	37.8	
	-----	28.7	
	-----	44.9	
	-----	34.6	
	-----	41.7	
	-----	45.7	
	-----	49.2	
	-----	46.1	
	-----	24.4	
	-----	28.7	
	-----	27.2	
	-----	32.3	
	-----	55.5	
	-----	33.1	
	-----	34.3	
	-----	42.9	
	-----	39.4	
	-----	29.9	
	-----	42.1	
	-----	46.5	
	-----	27.2	
	-----	35.0	
	-----	47.2	
	-----	38.2	
	-----	39.0	
	-----	24.4	
	-----	38.6	
	-----	37.0	
	-----	52.0	
	-----	51.6	
	-----	29.9	
	-----	33.1	
	-----	32.3	
	-----	0.0	
	-----	15.7	
	-----	16.5	