Chemicals, Metals, and Pesticide Pits Waste Unit Low Induction Number Electromagnetic Survey^(U)

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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Site Geotechnical Services

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Executive Summary

An electromagnetic survey was conducted at the Chemicals, Metals, and Pesticide Waste Unit to identify any buried metallic objects that may be present in the materials used to fill and cover the pits after removal of pit debris. The survey was conducted with a Geonics EM-31 Terrain Conductivity Meter along north - south oriented traverses with 5-ft station intervals to produce a 5-ft by 5-ft square grid node pattern. Both conductivity and in-phase components were measured at each station for vertical dipole orientation with the common axis of the dipoles in the north - south and east - west orientations.

The conductivity data clearly show elevated conductivities (2.1 to 7.0 mS/m) associated with the material over the pits, as compared with the surrounding area that is characterized by lower conductivities (1 to 2 mS/m). This is probably the result of the higher clay content of the fill material relative to the surrounding area, which has a higher sand to clay ratio and the presence of a plastic cover beneath the fill that has probably trapped water.

Many metal objects are present in the survey area including manhole covers, monitoring well heads, metal signs, drain culverts, abandoned wells, and HP waste unit marker balls. All of these exhibit associated conductivity and in-phase anomalies of various magnitude. In addition to these anomalies that can be definitely associated with surface sources, conductivity and in-phase anomalies are also present with no obvious surface source. These anomalies are probably indicative of subsurface buried metallic objects. A high concentration of these objects appears to be present in the southwest corner of the survey area.

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Introduction and Scope

The Chemical, Metals, and Pesticide Pits Waste Unit is located north of L Area on SRS (Figure 1). This waste unit originally consisted of seven unlined pits used for disposal of various wastes. The pits were arranged in two rows on top of a small hill and were 10 to 15 ft wide, 10 to 15 ft deep, and 45 to 70 ft long. In 1984 the pits were excavated, backfilled, and capped with a berm underlain by plastic.

To assess the possibility of buried metallic debris in the area around the capped trenches, an electromagnetic survey was conducted in August and September 1994 by the Site Geotechnical Services Department at the request of the Environmental Restoration Department. In particular, the occurrence of fluorescent lamp ballasts were the primary concern, in that several of these objects can be found at various locations around the trench cap.

To assess the applicability of a magnetic survey, a test was conducted over one of the exposed ballasts. It was determined that the anomalies generated by these objects was insufficient to make magnetic survey techniques feasible. Due to these results and the fact that the ballasts contain a large amount of nonferrous metal, it was decided that an electromagnetic technique would be more applicable.

Electromagnetic Survey Concepts

The EM Technique

Electromagnetic geophysical survey techniques are based primarily on the sensitivity of electromagnetic fields to nearby conductors. This sensitivity is manifested by changes in the amplitude and phase of an electromagnetic signal generated in the presence of a conductor (i.e. the earth or a buried metallic object). In practice this technique is employed to determine the conductivity (or inversely the resistivity) of the earth near the signal source (transmitter), or the presence of extremely good conductors such as metallic objects. These effects are detected by a sensor or antenna (receiver) placed some distance from the transmitter. The main advantage of the electromagnetic technique is that the transmitter and receiver devices can be made extremely portable; thus electromagnetic surveys can be acquired more efficiently than with other techniques for determining earth conductivity.

In principal, an electromagnetic transmitter can be characterized by the simple circuit illustrated in Figure 2. The

components of this circuit consist of an alternating current source (ac) that produces a time varying current (I_t) in the transmitting circuit. This current is limited by the resistance of the circuit (R_t), which is constant with time, and by the fact that the alternating electric current in the circuit induces a corresponding alternating electromagnetic field in the surrounding space. The effects of producing this electromagnetic field are characterized by the self inductance of the circuit (L_t). The real effect of the inductance on the circuit can be thought of as a time-varying resistance in the circuit. The important point is that the transmitting circuit will produce an alternating electromagnetic field in surrounding space, with a specific amplitude, frequency, and phase that is determined by the characteristics of the various circuit components described above.

Since the transmitting circuit produces a time-varying magnetic field in surrounding space (primary field, H_p) it will couple to other circuits in this space. That is, the alternating magnetic field produced by the transmitting circuit will induce a current to flow in nearby circuits that are intersected by the magnetic flux lines. This induced current in nearby circuits will also cause these circuits to produce a magnetic field in nearby space by self induction (secondary field, H_s) which in turn also affects the transmitter circuit. This coupling effect between the two circuits is called mutual inductance. The circuit that has the current induced by the transmitting circuit can also be characterized by its resistance (R_a) and self inductance (L_a) as shown in Figure 3. The main difference being that the alternating current (ac) source in the nontransmitting circuit is the alternating magnetic field produced by the transmitter rather than an internal circuit component (ac). The alternating current in the nontransmitter circuit will be of the same frequency as the transmitter, but will differ in both amplitude and phase depending on the values of R_a and L_a .

Since the earth can be considered a conductor, it can also be described by a simple circuit coupled by mutual inductance to the electromagnetic field produced by the transmitter, and its resulting current flow can also be characterized by the simple circuit described above. In its most fundamental form the electromagnetic survey technique can be described by the utilization of the mutual inductance of the three circuits shown in Figure 4. A transmitter produces an electromagnetic field (primary field, H_p) that is coupled by mutual inductance to the earth, which because it is conductive, produces a secondary magnetic field (H_s) that differs in both amplitude and phase from the primary field (H_p). A third nearby circuit is coupled to both the transmitter and the earth by mutual inductance and therefore senses both the primary and secondary magnetic fields. Since the primary field is known,

the secondary field produced by the earth can be determined from analysis of the current induced in the antenna circuit.

The relationships discussed above are illustrated in Figure 5, which shows a vector representation of the primary field produced by the transmitter (H_p) and the secondary field produced by the conductor (i.e. earth or metal object, H_s), which differs from H_p in amplitude and phase ($\alpha + \pi/2$) depending on the specific properties of the conductor. The field sensed by the antenna will be the resultant of H_p and H_s , or H_r . Also, as shown in Figure 5, the components of the secondary field (H_s) are both in phase with the primary field (i.e. $H_s \sin \phi$), and the component 90 degrees out of phase with the primary field (i.e. $H_s \cos \phi$) can be resolved. These components are termed the in-phase component and out-of-phase or quadrature component, respectively.

As stated above, the angle $\alpha + \pi/2$ between the primary (H_p) and secondary field (H_s) is a function of the properties of the conductor. That is, for very good conductors α approaches $\pi/2$ and the secondary field (H_s) is 180 degrees out of phase with the primary field, resulting in a relatively small value for the quadrature component and a relatively larger magnitude for the in-phase component. For poor conductors α approaches 0 and the secondary field lags the primary field by 90 degrees, which results in a relatively small in-phase component and a relatively large value for the quadrature component. Based on this type of analysis it is apparent that the in-phase component is more sensitive to very good conductors, such as metal objects, than the quadrature phase, and that comparison of the in-phase and quadrature phase can be used to obtain information about the quality of the conductor in terms of its conductivity.

In reality the transmitter and antenna circuits are physical objects. That is, they consist of coils of wire that can be described by a vector in space aligned along the axis of the coil, whose magnitude depends on the diameter of the coil and the coil current. The coils are separated in space by some physical distance (s). Electromagnetic surveys are typically performed in either of two coil orientations (Figure 6). The axis of the coil can be oriented perpendicular to the surface of the earth (vertical dipole configuration) or parallel to the surface of the earth (horizontal dipole configuration). For a homogeneous halfspace (i.e. homogeneous earth) the expressions for the ratios of the primary (H_p) and secondary (H_s) fields are given by McNeill (1980) as:

$$\left(\frac{H_s}{H_p}\right)_V = \frac{2}{(\gamma s)^2} \left\{ 9 - \left[9 + 9\gamma s + 4(\gamma s)^2 + (\gamma s)^3 \right] e^{-\gamma s} \right\} \quad (1)$$

$$\left(\frac{H_s}{H_p}\right)_H = 2 \left\{ 1 - \frac{3}{(\gamma s)^2} + \left[3 + 3\gamma s + (\gamma s)^2 \right] \frac{e^{-\gamma s}}{(\gamma s)^2} \right\} \quad (2)$$

where $\gamma = \sqrt{i\omega\mu_0\sigma}$

$$\omega = 2\pi f$$

f = frequency of the alternating electromagnetic field (Hz)

μ_0 = permeability of free space

s = the intercoil spacing

As can be readily seen, the above expressions are complicated functions of frequency (f), conductivity (σ), and spacing between the transmitter and antenna, which makes the generalized interpretation of electromagnetic geophysical survey data complicated. However, there are some simplifying principals that may be utilized to extract useful information from electromagnetic survey data, in spite of the complicated relationship expressed in the above equations. For a halfspace of uniform conductivity (σ), the attenuation of electromagnetic energy as a function of depth is dependent on the frequency of the alternating electromagnetic field (f), given by the expression (McNeill, 1980):

$$\delta = \sqrt{\frac{2}{\omega\mu_0\sigma}} = \frac{\sqrt{2}i}{\gamma} \quad (3)$$

where δ is termed the "skin depth", and is the distance in the halfspace that results in the attenuation of the amplitude of the electromagnetic wave by a factor of $1/e$. Based on this relationship it can be seen that for a halfspace of given conductivity, that lower frequencies will penetrate deeper into the halfspace before significant attenuation occurs than can higher frequency electromagnetic fields. The utility of the skin depth effect is that the depth of investigation of an electromagnetic survey may be controlled, in part, by the frequency of the electromagnetic field selected for the survey.

The Low Induction Number Constraint

Incorporating the intercoil spacing into the skin depth equation results in the following expression:

$$\gamma s = \sqrt{2}i \frac{s}{\delta} \quad (4)$$

which highlights the quantity s/δ (ratio of intercoil spacing to skin depth), which is defined as the induction number (B). This relationship is significant because for values of B

much less than unity (i.e. $\gamma s \ll 1$) the complicated expressions for the ratios of the primary and secondary fields expressed in equations (1) and (2) are greatly simplified to:

$$\left(\frac{H_s}{H_p}\right)_V \equiv \left(\frac{H_s}{H_p}\right)_H \equiv \frac{iB^2}{2} \equiv \frac{i\omega\mu_o\sigma s^2}{4} \quad (5)$$

For small B, that is low induction number, with constant frequency and intercoil spacing, the ratio of the primary to secondary fields for both the vertical and horizontal dipole conditions is linearly proportional to the conductivity, and the phase of the secondary field leads the primary by 90 degrees. To effectively achieve the low induction number condition ($B \ll 1$) the intercoil spacing is set to be much less than the skin depth ($s \ll \delta$) and the frequency of the electromagnetic field is set so that the following condition is satisfied:

$$\omega = \frac{2}{\mu_o\sigma s^2} \quad (6)$$

(McNeill, 1980). This choice of parameters allows the apparent conductivity to be defined by:

$$\sigma_a = \frac{4}{\omega\mu_o s^2} = \left(\frac{H_s}{H_p}\right)_{\text{quadrature component}} \quad (7)$$

As the ground conductivity increases the approximations stated above become invalid, so that for a given intercoil spacing and operating frequency the linear relationship stated above breaks down.

In addition to the simplification in interpretation allowed by the low induction number condition, the fact that current flow in a uniform halfspace or horizontally stratified earth is horizontal means that for the low induction number condition the response measured at the surface of the earth for a layered model can be calculated from the sum of the response of each layer. This response will be a function of the depth of the layer and its conductivity. The relative contributions for a thin layer for both the horizontal ($\phi_H(z)$) and vertical dipole ($\phi_V(z)$) configurations are given by (McNeill, 1980):

$$\phi_V(z) = \frac{4z}{(4z^2 + 1)^{3/2}} \quad (8)$$

$$\phi_H(z) = 2 - \frac{4z}{(4z^2 + 1)^{1/2}} \quad (9)$$

where z is the normalized depth, defined as the depth divided by the intercoil spacing (s). The relative contribution for material below a certain normalized depth ($R_V(z)$ and $R_H(z)$) may also be determined by integration of the above equations as:

$$R_V(z) = \frac{1}{(4z^2 + 1)^{1/2}} \quad (10)$$

$$R_H(z) = (4z^2 + 1)^{1/2} - 2z \quad (11)$$

These relationships are illustrated in Figure 7.

Description of Survey Site

The Chemicals, Metals, and Pesticide Pits Waste Unit occurs as a grassy, cleared area surrounded by pine forest on a small hill. The fill over the waste unit is a raised rectangular berm surrounded by a shallow ditch. The berm and immediately surrounding area is a grassy field, clear of other vegetation. The remainder of the survey area contains clumps of small pines and brush interspersed with other areas that are relatively clear.

A planimetric map of the waste unit is shown in Figure 8. The corners of the berm are marked by HP orange waste unit marker balls. Several manholes penetrate the berm in the locations of the original trenches. These manholes consist of vertical concrete access holes covered by cast iron manhole covers. Also several metal signs and marker posts occur on the edge of the berm. In addition to these features, hydrologic monitoring well heads and abandoned well casings are present in several areas. In some places metal objects can be found on the ground surface, including a fallen metal sign and a culvert that runs under an access road.

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Electromagnetic Survey

Survey and Analytical Techniques

Due to the small size of lamp ballasts and the relatively large area to be covered by the survey (approximately 250 ft by 500 ft) fairly good location control was necessary so that any metallic objects located during the survey could be relocated and removed. Prior to acquiring the electromagnetic survey data, survey markers were located at 5-ft intervals along lines oriented east-west, and spaced 50 ft apart to cover the area of interest. The locations of these surveyed stations are illustrated in Figure 9 in terms of the Savannah River Site coordinate system and the coordinates given in Appendix A, along with corresponding magnetic survey grid node coordinates. During the course of the electromagnetic survey, a cord marked at 5-ft intervals was stretched between the 50-ft lines, and the electromagnetic data acquired along traverses oriented perpendicular to the surveyed lines. This technique allowed relatively good control in keeping the station marker cord straight, and was necessary in order to maintain location control due to the relatively thick vegetation in areas surrounding the berm. This produced a survey grid defined by 5-ft by 5-ft-square survey grid nodes.

The electromagnetic data were collected with a Geonics Model EM-31 Terrain Conductivity Meter equipped with an automatic data logger. This instrument employs an operating frequency of 9.8 kHz with an intercoil spacing of 12 ft (3.66 meters), which allows operation in the low-induction-number mode for halfspace conductivities typical of the earth. Both quadrature (conductivity in millisiemens per meter (mS/m)) and in-phase (in parts per thousand of the ratio of the secondary to primary magnetic fields) components were measured in the vertical-dipole mode at orientations both parallel and perpendicular to the traverse directions at each survey station. Before each measurement the instrument was allowed to settle down for 3 to 5 seconds. This set of measurements produced four data points for each station; the in-phase and quadrature components for the parallel direction, and the in-phase and quadrature components for the perpendicular direction.

The manufacturer quotes a measurement accuracy of $5\pm\%$ at 20 mS/m, and noise levels of 0.1 mS/m and 0.03 ppt. In order to evaluate the precision of the instrument ten measurements of each value, made approximately 10 seconds apart, were made at a single station (grid node 0,0) on two successive days. The results of these measurements are

tabulated in Appendix B. Standard deviations for the ten measurements of conductivity range between 0.05 and 0.12 mS/m, and for the in-phase component between 0.019 and 0.044 ppt, which is generally consistent with the values quoted from the manufacturer. However, the mean values for the conductivity show considerable drift from day to day, with consistently higher values on the second day for both orientations. Similar effects are present in the in-phase data although not as extreme. This same behavior was noted at irregular intervals during the conduct of the survey, and seemed to be correlated to temperature changes during the day. This behavior is probably a characteristic of this instrument in that the operator's manual mentions that mechanical vibration can cause zeroing errors.

To account for instrumental drift, the instrument was calibrated at a common point (grid node 0,0) at the beginning of each day and at periodic intervals during the day as the survey progressed. To constrain the effects due to the drift as much as possible, at the end of the survey the stations at the ends of each traverse line were remeasured after the instrument had been recalibrated in the early morning, when it was cool. This process took approximately 10 minutes so that no time was allowed for significant instrument drift to occur. In addition, this was accomplished as a closed survey loop so that any drift could be accounted for. Using these data the measurements along each survey line were corrected for drift by linear interpolation between the endpoints.

The data were downloaded from the data logger through a RS-232 port to an IBM PC Model 70. After downloading, the data were sorted and assigned coordinates with DAT-31 software provided by Geonics. Further data display and processing, including gridding and contouring were accomplished with software provided by GEOSOFT Inc. Gridding of the data was accomplished with BIGRID, which is specifically designed to grid line data and enhance trends.

Electromagnetic Data Set

Conductivity

The conductivity data set for both the north-south and the east-west dipole orientations are shown in Figures 10 and 11. Most of the survey area surrounding the berm and the waste unit, as defined by the HP orange waste unit marker balls, shows conductivities ranging from 1 to 2 mS/m. Conductivities measured for the berm over the waste unit are higher than the surrounding area, with values ranging from 2.1 to 7.0 mS/m. In both of these areas a north-south corrugation can be seen in the data for both the east-west

and north-south orientations. In addition to these broad conductivity trends, the data show prominent electromagnetic anomalies that exhibit negative conductivity values (physically not possible) associated with all of the metal objects seen on the surface, such as the manhole covers, the monitoring well heads, metal signs, and HP waste unit marker balls. The negative conductivities result from the highly conductive metal objects, which violate the basic assumptions of the low induction number operating condition and causes highly nonlinear behavior of the instrument response. However, the presence of these negative values can provide diagnostic help in locating metallic material. Anomalies are also present in the location of a metal drain culvert that runs under the access road to the site. Several other anomalies that exhibit negative conductivity values are evident in the conductivity data in the western and southwestern corner of the survey area.

Figure 12 shows the difference between the conductivity values for the north-south and east-west orientations. The data presented in this fashion enhances anisotropic conductivity features, or features smaller than the scale of the antenna separation. The conductivity anomaly from the berm is no longer present in the conductivity difference display, since it is several times the size of the antenna separation and of a uniform isotropic conductivity structure. However, the anomalies associated with the metal objects on the surface, in addition to those seen in the western part of the area, are highlighted.

In-Phase Component

The data for the in-phase component, for both the north-south and east-west orientations are illustrated as color contour diagrams in Figures 13 and 14. These data in general show the same features as the conductivity data, with the exception that the anomaly associated with the berm is not present. The majority of the survey area is characterized by background values ranging from -0.2 to +0.1 ppt. Both positive and negative in-phase anomalies are associated with all the large metal objects that can be seen on the surface of the survey area. In addition to these anomalies that can be easily identified, several smaller anomalies occur in the survey area. Several of these anomalies are concentrated in the southwest corner of the survey area.

Discussion and Conclusions

The electromagnetic survey data for the Chemicals, Metals, and Pesticide Waste Unit over most of the survey area surrounding the fill berm show conductivities ranging from 1 to 2 mS/m. The area over the berm reveals conductivities significantly higher than the surrounding area, with conductivities from 2.1 to 7.0 mS/m. Both areas show in-phase components ranging from -0.3 to +0.2 ppt. The conductivity differences exhibited between the berm and surrounding area is consistent with the composition of the soil types of the two areas. The fill material probably contains a high percentage of clay relative to the surrounding area, which is dominated by a higher sand/clay ratio, resulting in higher conductivities measured over the berm. This is probably compounded by the presence of trapped water above the plastic liner. The very low in-phase components exhibited by both of these areas in general indicated that there are no very broad expanses of highly conductive material. The background areas in both the conductivity and in-phase data also show north-south oriented corrugations. These corrugations are strongest in the north-south data set, and this is partially due to the anisotropy caused by the dipole orientation. However, the presence of corrugation in the east-west orientations indicates that most of this effect can be attributed to unresolved instrument drift associated with each traverse line.

The larger metal objects that can be seen at the surface of the survey site all have significant conductivity and in-phase anomalies associated with them. These include the manhole covers, metal signs, drain culvert, and monitoring well heads. Small anomalies also occur associated with the HP waste unit marker balls and abandoned wells.

The other anomalies that occur are unexplained by metallic material that can easily be identified on the surface, and probably represent buried metal objects. A large concentration of these anomalies occurs in the southwest corner of the waste unit. Outlined areas showing anomalies in the geometric mean for both orientations of in-phase data of suspected buried metallic objects are shown in Figure 15.

The electromagnetic survey identified several large conductivity and in-phase anomalies in the survey area. Most of these anomalies can be definitely associated with metal objects readily identified on the surface. However, several smaller, isolated anomalies occur that may represent buried metallic objects. Several of these anomalies are concentrated in the southwest corner of the survey area.

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Figure 1. Location of the Chemicals, Metals, and Pesticide Pits Waste Unit at SRS

Figure 2. A simple electromagnetic transmitter circuit

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Figure 3. Coupling of an electromagnetic transmitting circuit to a nearby receiver circuit by mutual inductance through an alternating magnetic field (H)

95X02274.02.AIL

Figure 4. Mutual inductive coupling between equivalent circuits representing an electromagnetic transmitter, a receiver, and conductive earth

Figure 5. Vector representation of the phase relationships between the primary (H_p) and secondary (H_s) magnetic fields for systems coupled by mutual inductance (after Telford and others, 1978)

Vertical Dipole Configuration

Horizontal Dipole Configuration

Figure 6. Orientations of transmitter (Tx) and receiver (Rx) circuits relative to uniform halfspace of constant conductivity (σ). Circuit orientations are described by a vector oriented along the circuit coil axis with magnitude dependent on the current in the circuit and circuit diameter. The circuits are separated in space by distance (s).

95X02274.03.AIL

Figure 7. Relative response for horizontal ($\phi_H(Z)$) and vertically ($\phi_V(Z)$) oriented dipoles from a thin layer at normalized depth Z (depth/dipole separation). Also shown, the cumulative response for a vertical dipole ($R_V(Z)$) for all material below the normalized depth (Z) (adapted from McNeill, 1980)

Figure 8. Planimetric map of the Chemicals, Metals, and Pesticide Pit Waste Unit

Figure 10. Color contoured electromagnetic survey vertical dipole conductivity data for dipole common axis oriented north-south

Figure 11. Color contoured electromagnetic survey vertical dipole conductivity data for dipole common axis oriented east-west

Figure 12. Color contoured conductivity difference between the north-south and east-west orientations

Figure 13. Color contoured vertical dipole in-phase component for north-south dipole common axis orientation

Figure 14. Color contoured vertical dipole in-phase component for east-west dipole common axis orientation

Figure 15. Color contoured geometric mean for both orientations of in-phase data with suspected areas of buried metallic objects outlined

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Appendix A—Surveyed Electromagnetic Survey Station Locations

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Line	SITE		GRID	
	Easting	Northing	X	Y
A-0	54055.20	51575.71	0	0
A-1	54051.24	51578.76	5	0
A-2	54047.28	51581.81	10	0
A-3	54043.32	51584.87	15	0
A-4	54039.36	51587.92	20	0
A-5	54035.40	51590.97	25	0
A-6	54031.44	51594.02	30	0
A-7	54027.48	51597.07	35	0
A-8	54023.52	51600.13	40	0
A-9	54019.56	51603.18	45	0
A-10	54015.60	51606.23	50	0
A-11	54011.64	51609.28	55	0
A-12	54007.68	51612.33	60	0
A-13	54003.72	51615.39	65	0
A-14	53999.75	51618.44	70	0
A-15	53995.79	51621.49	75	0
A-16	53991.83	51624.54	80	0
A-17	53987.87	51627.59	85	0
A-18	53983.91	51630.65	90	0
A-19	53979.95	51633.70	95	0
A-20	53975.99	51636.75	100	0
A-21	53972.03	51639.80	105	0
A-22	53968.07	51642.85	110	0
A-23	53964.11	51645.91	115	0
A-24	53960.15	51648.96	120	0
A-25	53956.19	51652.01	125	0
A-26	53952.23	51655.06	130	0
A-27	53948.27	51658.11	135	0
A-28	53944.31	51661.17	140	0
A-29	53940.35	51664.22	145	0
A-30	53936.39	51667.27	150	0
A-31	53932.43	51670.32	155	0
A-32	53928.47	51673.37	160	0
A-33	53924.51	51676.43	165	0
A-34	53920.55	51679.48	170	0
A-35	53916.59	51682.53	175	0
A-36	53912.62	51685.58	180	0
A-37	53908.66	51688.63	185	0
A-38	53904.70	51691.69	190	0
A-39	53900.74	51694.74	195	0
A-40	53896.78	51697.79	200	0
A-41	53892.82	51700.84	205	0
A-42	53888.86	51703.89	210	0
A-43	53884.90	51706.95	215	0
A-44	53880.94	51710.00	220	0
A-45	53876.98	51713.05	225	0
A-46	53873.02	51716.10	230	0

Line	SITE		GRID	
	Easting	Northing	X	Y
D-0	53963.64	51456.90	0	150
D-1	53959.68	51459.95	5	150
D-2	53955.72	51463.00	10	150
D-3	53951.76	51466.05	15	150
D-4	53947.80	51469.10	20	150
D-5	53943.84	51472.16	25	150
D-6	53939.88	51475.21	30	150
D-7	53935.92	51478.26	35	150
D-8	53931.96	51481.31	40	150
D-9	53928.00	51484.36	45	150
D-10	53924.04	51487.42	50	150
D-11	53920.08	51490.47	55	150
D-12	53916.12	51493.52	60	150
D-13	53912.16	51496.57	65	150
D-14	53908.19	51499.62	70	150
D-15	53904.23	51502.68	75	150
D-16	53900.27	51505.73	80	150
D-17	53896.31	51508.78	85	150
D-18	53892.35	51511.83	90	150
D-19	53888.39	51514.88	95	150
D-20	53884.43	51517.94	100	150
D-21	53880.47	51520.99	105	150
D-22	53876.51	51524.04	110	150
D-23	53872.55	51527.09	115	150
D-24	53868.59	51530.14	120	150
D-25	53864.63	51533.20	125	150
D-26	53860.67	51536.25	130	150
D-27	53856.71	51539.30	135	150
D-28	53852.75	51542.35	140	150
D-29	53848.79	51545.40	145	150
D-30	53844.83	51548.46	150	150
D-31	53840.87	51551.51	155	150
D-32	53836.91	51554.56	160	150
D-33	53832.95	51557.61	165	150
D-34	53828.99	51560.66	170	150
D-35	53825.02	51563.72	175	150
D-36	53821.06	51566.77	180	150
D-37	53817.10	51569.82	185	150
D-38	53813.14	51572.87	190	150
D-39	53809.18	51575.92	195	150
D-40	53805.22	51578.98	200	150
D-41	53801.26	51582.03	205	150
D-42	53797.30	51585.08	210	150
D-43	53793.34	51588.13	215	150
D-44	53789.38	51591.18	220	150
D-45	53785.42	51594.24	225	150
D-46	53781.46	51597.29	230	150

Line	SITE		GRID	
	Easting	Northing	X	Y
A-47	53869.06	51719.15	235	0
A-48	53865.10	51722.21	240	0
A-49	53861.14	51725.26	245	0
A-50	53857.18	51728.31	250	0
A-51	53853.22	51731.36	255	0
A-52	53849.26	51734.41	260	0
A-53	53845.30	51737.47	265	0
A-54	53841.34	51740.52	270	0
A-55	53837.38	51743.57	275	0
A-56	53833.42	51746.62	280	0
A-57	53829.45	51749.67	285	0
A-58	53825.49	51752.73	290	0
A-59	53821.53	51755.78	295	0
A-60	53817.57	51758.83	300	0
A-61	53813.61	51761.88	305	0
A-62	53809.65	51764.93	310	0
A-63	53805.69	51767.99	315	0
A-64	53801.73	51771.04	320	0
A-65	53797.77	51774.09	325	0
A-66	53793.81	51777.14	330	0
A-67	53789.85	51780.19	335	0
A-68	53785.89	51783.25	340	0
A-69	53781.93	51786.30	345	0
A-70	53777.97	51789.35	350	0
A-71	53774.01	51792.40	355	0
A-72	53770.05	51795.45	360	0
A-73	53766.09	51798.51	365	0
A-74	53762.13	51801.56	370	0
A-75	53758.17	51804.61	375	0
A-76	53754.21	51807.66	380	0
A-77	53750.25	51810.71	385	0
A-78	53746.29	51813.77	390	0
A-79	53742.32	51816.82	395	0
A-80	53738.36	51819.87	400	0
A-81	53734.40	51822.92	405	0
A-82	53730.44	51825.97	410	0
A-83	53726.48	51829.03	415	0
A-84	53722.52	51832.08	420	0
A-85	53718.56	51835.13	425	0
A-86	53714.60	51838.18	430	0
A-87	53710.64	51841.23	435	0
A-88	53706.68	51844.29	440	0
A-89	53702.72	51847.34	445	0
A-90	53698.76	51850.39	450	0
B-0	54024.68	51536.10	0	50
B-1	54020.72	51539.16	5	50
B-2	54016.76	51542.21	10	50
B-3	54012.80	51545.26	15	50
B-4	54008.84	51548.31	20	50

Line	SITE		GRID	
	Easting	Northing	X	Y
D-47	53777.50	51600.34	235	150
D-48	53773.54	51603.39	240	150
D-49	53769.58	51606.44	245	150
D-50	53765.62	51609.50	250	150
D-51	53761.66	51612.55	255	150
D-52	53757.70	51615.60	260	150
D-53	53753.74	51618.65	265	150
D-54	53749.78	51621.70	270	150
D-55	53745.82	51624.76	275	150
D-56	53741.86	51627.81	280	150
D-57	53737.89	51630.86	285	150
D-58	53733.93	51633.91	290	150
D-59	53729.97	51636.96	295	150
D-60	53726.01	51640.02	300	150
D-61	53722.05	51643.07	305	150
D-62	53718.09	51646.12	310	150
D-63	53714.13	51649.17	315	150
D-64	53710.17	51652.22	320	150
D-65	53706.21	51655.28	325	150
D-66	53702.25	51658.33	330	150
D-67	53698.29	51661.38	335	150
D-68	53694.33	51664.43	340	150
D-69	53690.37	51667.48	345	150
D-70	53686.41	51670.54	350	150
D-71	53682.45	51673.59	355	150
D-72	53678.49	51676.64	360	150
D-73	53674.53	51679.69	365	150
D-74	53670.57	51682.74	370	150
D-75	53666.61	51685.80	375	150
D-76	53662.65	51688.85	380	150
D-77	53658.69	51691.90	385	150
D-78	53654.73	51694.95	390	150
D-79	53650.76	51698.00	395	150
D-80	53646.80	51701.06	400	150
D-81	53642.84	51704.11	405	150
D-82	53638.88	51707.16	410	150
D-83	53634.92	51710.21	415	150
D-84	53630.96	51713.26	420	150
D-85	53627.00	51716.32	425	150
D-86	53623.04	51719.37	430	150
D-87	53619.08	51722.42	435	150
D-88	53615.12	51725.47	440	150
D-89	53611.16	51728.52	445	150
D-90	53607.20	51731.58	450	150
D-91	53603.24	51734.63	455	150
D-92	53599.28	51737.68	460	150
D-93	53595.32	51740.73	465	150
D-94	53591.36	51743.78	470	150
D-95	53587.40	51746.84	475	150

Line	SITE		GRID	
	Easting	Northing	X	Y
B-5	54004.88	51551.36	25	50
B-6	54000.92	51554.42	30	50
B-7	53996.96	51557.47	35	50
B-8	53993.00	51560.52	40	50
B-9	53989.04	51563.57	45	50
B-10	53985.08	51566.62	50	50
B-11	53981.12	51569.68	55	50
B-12	53977.16	51572.73	60	50
B-13	53973.20	51575.78	65	50
B-14	53969.23	51578.83	70	50
B-15	53965.27	51581.89	75	50
B-16	53961.31	51584.94	80	50
B-17	53957.35	51587.99	85	50
B-18	53953.39	51591.04	90	50
B-19	53949.43	51594.09	95	50
B-20	53945.47	51597.15	100	50
B-21	53941.51	51600.20	105	50
B-22	53937.55	51603.25	110	50
B-23	53933.59	51606.30	115	50
B-24	53929.63	51609.35	120	50
B-25	53925.67	51612.41	125	50
B-26	53921.71	51615.46	130	50
B-27	53917.75	51618.51	135	50
B-28	53913.79	51621.56	140	50
B-29	53909.83	51624.61	145	50
B-30	53905.87	51627.67	150	50
B-31	53901.91	51630.72	155	50
B-32	53897.95	51633.77	160	50
B-33	53893.99	51636.82	165	50
B-34	53890.03	51639.87	170	50
B-35	53886.07	51642.93	175	50
B-36	53882.10	51645.98	180	50
B-37	53878.14	51649.03	185	50
B-38	53874.18	51652.08	190	50
B-39	53870.22	51655.13	195	50
B-40	53866.26	51658.19	200	50
B-41	53862.30	51661.24	205	50
B-42	53858.34	51664.29	210	50
B-43	53854.38	51667.34	215	50
B-44	53850.42	51670.39	220	50
B-45	53846.46	51673.45	225	50
B-46	53842.50	51676.50	230	50
B-47	53838.54	51679.55	235	50
B-48	53834.58	51682.60	240	50
B-49	53830.62	51685.65	245	50
B-50	53826.66	51688.71	250	50
B-51	53822.70	51691.76	255	50
B-52	53818.74	51694.81	260	50
B-53	53814.78	51697.86	265	50

Line	SITE		GRID	
	Easting	Northing	X	Y
D-96	53583.44	51749.89	480	150
D-97	53579.48	51752.94	485	150
D-98	53575.52	51755.99	490	150
D-99	53571.56	51759.04	495	150
D-100	53567.59	51762.10	500	150
E-0	53933.12	51417.29	0	200
E-1	53929.16	51420.34	5	200
E-2	53925.20	51423.40	10	200
E-3	53921.24	51426.45	15	200
E-4	53917.28	51429.50	20	200
E-5	53913.32	51432.55	25	200
E-6	53909.36	51435.60	30	200
E-7	53905.40	51438.66	35	200
E-8	53901.44	51441.71	40	200
E-9	53897.48	51444.76	45	200
E-10	53893.52	51447.81	50	200
E-11	53889.56	51450.86	55	200
E-12	53885.60	51453.92	60	200
E-13	53881.64	51456.97	65	200
E-14	53877.67	51460.02	70	200
E-15	53873.71	51463.07	75	200
E-16	53869.75	51466.12	80	200
E-17	53865.79	51469.18	85	200
E-18	53861.83	51472.23	90	200
E-19	53857.87	51475.28	95	200
E-20	53853.91	51478.33	100	200
E-21	53849.95	51481.38	105	200
E-22	53845.99	51484.44	110	200
E-23	53842.03	51487.49	115	200
E-24	53838.07	51490.54	120	200
E-25	53834.11	51493.59	125	200
E-26	53830.15	51496.64	130	200
E-27	53826.19	51499.70	135	200
E-28	53822.23	51502.75	140	200
E-29	53818.27	51505.80	145	200
E-30	53814.31	51508.85	150	200
E-31	53810.35	51511.90	155	200
E-32	53806.39	51514.96	160	200
E-33	53802.43	51518.01	165	200
E-34	53798.47	51521.06	170	200
E-35	53794.50	51524.11	175	200
E-36	53790.54	51527.16	180	200
E-37	53786.58	51530.22	185	200
E-38	53782.62	51533.27	190	200
E-39	53778.66	51536.32	195	200
E-40	53774.70	51539.37	200	200
E-41	53770.74	51542.42	205	200
E-42	53766.78	51545.48	210	200
E-43	53762.82	51548.53	215	200

Line	SITE		GRID	
	Easting	Northing	X	Y
B-54	53810.82	51700.91	270	50
B-55	53806.86	51703.97	275	50
B-56	53802.90	51707.02	280	50
B-57	53798.93	51710.07	285	50
B-58	53794.97	51713.12	290	50
B-59	53791.01	51716.17	295	50
B-60	53787.05	51719.23	300	50
B-61	53783.09	51722.28	305	50
B-62	53779.13	51725.33	310	50
B-63	53775.17	51728.38	315	50
B-64	53771.21	51731.43	320	50
B-65	53767.25	51734.49	325	50
B-66	53763.29	51737.54	330	50
B-67	53759.33	51740.59	335	50
B-68	53755.37	51743.64	340	50
B-69	53751.41	51746.69	345	50
B-70	53747.45	51749.75	350	50
B-71	53743.49	51752.80	355	50
B-72	53739.53	51755.85	360	50
B-73	53735.57	51758.90	365	50
B-74	53731.61	51761.95	370	50
B-75	53727.65	51765.01	375	50
B-76	53723.69	51768.06	380	50
B-77	53719.73	51771.11	385	50
B-78	53715.77	51774.16	390	50
B-79	53711.80	51777.21	395	50
B-80	53707.84	51780.27	400	50
B-81	53703.88	51783.32	405	50
B-82	53699.92	51786.37	410	50
B-83	53695.96	51789.42	415	50
B-84	53692.00	51792.47	420	50
B-85	53688.04	51795.53	425	50
B-86	53684.08	51798.58	430	50
B-87	53680.12	51801.63	435	50
B-88	53676.16	51804.68	440	50
B-89	53672.20	51807.73	445	50
B-90	53668.24	51810.79	450	50
B-91	53664.28	51813.84	455	50
B-92	53660.32	51816.89	460	50
B-93	53656.36	51819.94	465	50
B-94	53652.40	51822.99	470	50
B-95	53648.44	51826.05	475	50
B-96	53644.48	51829.10	480	50
B-97	53640.52	51832.15	485	50
B-98	53636.56	51835.20	490	50
B-99	53632.60	51838.25	495	50
B-100	53628.64	51841.31	500	50
B-101	53624.67	51844.36	505	50
B-102	53620.71	51847.41	510	50

Line	SITE		GRID	
	Easting	Northing	X	Y
E-44	53758.86	51551.58	220	200
E-45	53754.90	51554.63	225	200
E-46	53750.94	51557.68	230	200
E-47	53746.98	51560.74	235	200
E-48	53743.02	51563.79	240	200
E-49	53739.06	51566.84	245	200
E-50	53735.10	51569.89	250	200
E-51	53731.14	51572.94	255	200
E-52	53727.18	51576.00	260	200
E-53	53723.22	51579.05	265	200
E-54	53719.26	51582.10	270	200
E-55	53715.30	51585.15	275	200
E-56	53711.34	51588.20	280	200
E-57	53707.37	51591.26	285	200
E-58	53703.41	51594.31	290	200
E-59	53699.45	51597.36	295	200
E-60	53695.49	51600.41	300	200
E-61	53691.53	51603.46	305	200
E-62	53687.57	51606.52	310	200
E-63	53683.61	51609.57	315	200
E-64	53679.65	51612.62	320	200
E-65	53675.69	51615.67	325	200
E-66	53671.73	51618.72	330	200
E-67	53667.77	51621.78	335	200
E-68	53663.81	51624.83	340	200
E-69	53659.85	51627.88	345	200
E-70	53655.89	51630.93	350	200
E-71	53651.93	51633.98	355	200
E-72	53647.97	51637.04	360	200
E-73	53644.01	51640.09	365	200
E-74	53640.05	51643.14	370	200
E-75	53636.09	51646.19	375	200
E-76	53632.13	51649.24	380	200
E-77	53628.17	51652.30	385	200
E-78	53624.21	51655.35	390	200
E-79	53620.24	51658.40	395	200
E-80	53616.28	51661.45	400	200
E-81	53612.32	51664.50	405	200
E-82	53608.36	51667.56	410	200
E-83	53604.40	51670.61	415	200
E-84	53600.44	51673.66	420	200
E-85	53596.48	51676.71	425	200
E-86	53592.52	51679.76	430	200
E-87	53588.56	51682.82	435	200
E-88	53584.60	51685.87	440	200
E-89	53580.64	51688.92	445	200
E-90	53576.68	51691.97	450	200
E-91	53572.72	51695.02	455	200
E-92	53568.76	51698.08	460	200

Line	SITE		GRID	
	Easting	Northing	X	Y
C-0	53994.16	51496.50	0	100
C-1	53990.20	51499.55	5	100
C-2	53986.24	51502.60	10	100
C-3	53982.28	51505.66	15	100
C-4	53978.32	51508.71	20	100
C-5	53974.36	51511.76	25	100
C-6	53970.40	51514.81	30	100
C-7	53966.44	51517.86	35	100
C-8	53962.48	51520.92	40	100
C-9	53958.52	51523.97	45	100
C-10	53954.56	51527.02	50	100
C-11	53950.60	51530.07	55	100
C-12	53946.64	51533.12	60	100
C-13	53942.68	51536.18	65	100
C-14	53938.71	51539.23	70	100
C-15	53934.75	51542.28	75	100
C-16	53930.79	51545.33	80	100
C-17	53926.83	51548.38	85	100
C-18	53922.87	51551.44	90	100
C-19	53918.91	51554.49	95	100
C-20	53914.95	51557.54	100	100
C-20	53910.99	51560.59	105	100
C-22	53907.03	51563.64	110	100
C-23	53903.07	51566.70	115	100
C-24	53899.11	51569.75	120	100
C-25	53895.15	51572.80	125	100
C-26	53891.19	51575.85	130	100
C-27	53887.23	51578.90	135	100
C-28	53883.27	51581.96	140	100
C-29	53879.31	51585.01	145	100
C-30	53875.35	51588.06	150	100
C-31	53871.39	51591.11	155	100
C-32	53867.43	51594.16	160	100
C-33	53863.47	51597.22	165	100
C-34	53859.51	51600.27	170	100
C-35	53855.55	51603.32	175	100
C-36	53851.58	51606.37	180	100
C-37	53847.62	51609.42	185	100
C-38	53843.66	51612.48	190	100
C-39	53839.70	51615.53	195	100
C-40	53835.74	51618.58	200	100
C-41	53831.78	51621.63	205	100
C-42	53827.82	51624.68	210	100
C-43	53823.86	51627.74	215	100
C-44	53819.90	51630.79	220	100
C-45	53815.94	51633.84	225	100
C-46	53811.98	51636.89	230	100
C-47	53808.02	51639.94	235	100
C-48	53804.06	51643.00	240	100

Line	SITE		GRID	
	Easting	Northing	X	Y
E-93	53564.80	51701.13	465	200
E-94	53560.84	51704.18	470	200
E-95	53556.88	51707.23	475	200
E-96	53552.92	51710.28	480	200
E-97	53548.96	51713.34	485	200
E-98	53545.00	51716.39	490	200
E-99	53541.04	51719.44	495	200
E-100	53537.07	51722.49	500	200
E-101	53533.11	51725.54	505	200
E-102	53529.15	51728.60	510	200
E-103	53525.19	51731.65	515	200
E-104	53521.23	51734.70	520	200
E-105	53517.27	51737.75	525	200
E-106	53513.31	51740.80	530	200
E-107	53509.35	51743.86	535	200
E-108	53505.39	51746.91	540	200
E-109	53501.43	51749.96	545	200
E-110	53497.47	51753.01	550	200
E-111	53493.51	51756.06	555	200
E-112	53489.55	51759.12	560	200
E-113	53485.59	51762.17	565	200
E-114	53481.63	51765.22	570	200
E-115	53477.67	51768.27	575	200
F-0	53902.60	51377.69	0	250
F-1	53898.64	51380.74	5	250
F-2	53894.68	51383.79	10	250
F-3	53890.72	51386.84	15	250
F-4	53886.76	51389.89	20	250
F-5	53882.80	51392.95	25	250
F-6	53878.84	51396.00	30	250
F-7	53874.88	51399.05	35	250
F-8	53870.92	51402.10	40	250
F-9	53866.96	51405.15	45	250
F-10	53863.00	51408.21	50	250
F-11	53859.04	51411.26	55	250
F-12	53855.08	51414.31	60	250
F-13	53851.11	51417.36	65	250
F-14	53847.15	51420.41	70	250
F-15	53843.19	51423.47	75	250
F-16	53839.23	51426.52	80	250
F-17	53835.27	51429.57	85	250
F-18	53831.31	51432.62	90	250
F-19	53827.35	51435.67	95	250
F-20	53823.39	51438.73	100	250
F-21	53819.43	51441.78	105	250
F-22	53815.47	51444.83	110	250
F-23	53811.51	51447.88	115	250
F-24	53807.55	51450.93	120	250
F-25	53803.59	51453.99	125	250

Line	SITE		GRID	
	Easting	Northing	X	Y
C-49	53800.10	51646.05	245	100
C-50	53796.14	51649.10	250	100
C-51	53792.18	51652.15	255	100
C-52	53788.22	51655.20	260	100
C-53	53784.26	51658.26	265	100
C-54	53780.30	51661.31	270	100
C-55	53776.34	51664.36	275	100
C-56	53772.38	51667.41	280	100
C-57	53768.41	51670.46	285	100
C-58	53764.45	51673.52	290	100
C-59	53760.49	51676.57	295	100
C-60	53756.53	51679.62	300	100
C-61	53752.57	51682.67	305	100
C-62	53748.61	51685.72	310	100
C-63	53744.65	51688.78	315	100
C-64	53740.69	51691.83	320	100
C-65	53736.73	51694.88	325	100
C-66	53732.77	51697.93	330	100
C-67	53728.81	51700.98	335	100
C-68	53724.85	51704.04	340	100
C-69	53720.89	51707.09	345	100
C-70	53716.93	51710.14	350	100
C-71	53712.97	51713.19	355	100
C-72	53709.01	51716.24	360	100
C-73	53705.05	51719.30	365	100
C-74	53701.09	51722.35	370	100
C-75	53697.13	51725.40	375	100
C-76	53693.17	51728.45	380	100
C-77	53689.21	51731.50	385	100
C-78	53685.25	51734.56	390	100
C-79	53681.28	51737.61	395	100
C-80	53677.32	51740.66	400	100
C-81	53673.36	51743.71	405	100
C-82	53669.40	51746.76	410	100
C-83	53665.44	51749.82	415	100
C-84	53661.48	51752.87	420	100
C-85	53657.52	51755.92	425	100
C-86	53653.56	51758.97	430	100
C-87	53649.60	51762.02	435	100
C-88	53645.64	51765.08	440	100
C-89	53641.68	51768.13	445	100
C-90	53637.72	51771.18	450	100
C-91	53633.76	51774.23	455	100
C-92	53629.80	51777.28	460	100
C-93	53625.84	51780.34	465	100
C-94	53621.88	51783.39	470	100
C-95	53617.92	51786.44	475	100
C-96	53613.96	51789.49	480	100
C-97	53610.00	51792.54	485	100

Line	SITE		GRID	
	Easting	Northing	X	Y
F-26	53799.63	51457.04	130	250
F-27	53795.67	51460.09	135	250
F-28	53791.71	51463.14	140	250
F-29	53787.75	51466.19	145	250
F-30	53783.79	51469.25	150	250
F-31	53779.83	51472.30	155	250
F-32	53775.87	51475.35	160	250
F-33	53771.91	51478.40	165	250
F-34	53767.95	51481.45	170	250
F-35	53763.98	51484.51	175	250
F-36	53760.02	51487.56	180	250
F-37	53756.06	51490.61	185	250
F-38	53752.10	51493.66	190	250
F-39	53748.14	51496.71	195	250
F-40	53744.18	51499.77	200	250
F-41	53740.22	51502.82	205	250
F-42	53736.26	51505.87	210	250
F-43	53732.30	51508.92	215	250
F-44	53728.34	51511.97	220	250
F-45	53724.38	51515.03	225	250
F-46	53720.42	51518.08	230	250
F-47	53716.46	51521.13	235	250
F-48	53712.50	51524.18	240	250
F-49	53708.54	51527.23	245	250
F-50	53704.58	51530.29	250	250
F-51	53700.62	51533.34	255	250
F-52	53696.66	51536.39	260	250
F-53	53692.70	51539.44	265	250
F-54	53688.74	51542.49	270	250
F-55	53684.78	51545.55	275	250
F-56	53680.82	51548.60	280	250
F-57	53676.85	51551.65	285	250
F-58	53672.89	51554.70	290	250
F-59	53668.93	51557.75	295	250
F-60	53664.97	51560.81	300	250
F-61	53661.01	51563.86	305	250
F-62	53657.05	51566.91	310	250
F-63	53653.09	51569.96	315	250
F-64	53649.13	51573.01	320	250
F-65	53645.17	51576.07	325	250
F-66	53641.21	51579.12	330	250
F-67	53637.25	51582.17	335	250
F-68	53633.29	51585.22	340	250
F-69	53629.33	51588.27	345	250
F-70	53625.37	51591.33	350	250
F-71	53621.41	51594.38	355	250
F-72	53617.45	51597.43	360	250
F-73	53613.49	51600.48	365	250
F-74	53609.53	51603.53	370	250

Line	SITE		GRID	
	Easting	Northing	X	Y
C-98	53606.04	51795.60	490	100
C-99	53602.08	51798.65	495	100
C-100	53598.12	51801.70	500	100
C-101	53594.15	51804.75	505	100
C-102	53590.19	51807.80	510	100

Line	SITE		GRID	
	Easting	Northing	X	Y
F-75	53605.57	51606.59	375	250
F-76	53601.61	51609.64	380	250
F-77	53597.65	51612.69	385	250
F-78	53593.68	51615.74	390	250
F-79	53589.72	51618.79	395	250
F-80	53585.76	51621.85	400	250
F-81	53581.80	51624.90	405	250
F-82	53577.84	51627.95	410	250
F-83	53573.88	51631.00	415	250
F-84	53569.92	51634.05	420	250
F-85	53565.96	51637.11	425	250
F-86	53562.00	51640.16	430	250
F-87	53558.04	51643.21	435	250
F-88	53554.08	51646.26	440	250
F-89	53550.12	51649.32	445	250
F-90	53546.16	51652.37	450	250
F-91	53542.20	51655.42	455	250
F-92	53538.24	51658.47	460	250
F-93	53534.28	51661.52	465	250
F-94	53530.32	51664.58	470	250
F-95	53526.36	51667.63	475	250
F-96	53522.40	51670.68	480	250
F-97	53518.44	51673.73	485	250
F-98	53514.48	51676.78	490	250
F-99	53510.52	51679.84	495	250
F-100	53506.55	51682.89	500	250
F-101	53502.59	51685.94	505	250
F-102	53498.63	51688.99	510	250
F-103	53494.67	51692.04	515	250
F-104	53490.71	51695.10	520	250
F-105	53486.75	51698.15	525	250

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Appendix B—Instrument QA

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DAY 1					
meas. #	conductivity \\\n mS/m	in-phase \\\n ppt.		conductivity +\n mS/m	in-phase +\n ppt.
0	1.07	0.233		1.13	0.222
1	1.16	0.193		1.43	0.226
2	1.10	0.222		1.07	0.254
3	0.98	0.198		1.19	0.220
4	1.04	0.217		1.07	0.243
5	1.04	0.226		1.25	0.233
6	1.16	0.226		1.22	0.222
7	1.01	0.220		1.13	0.244
8	1.07	0.233		1.07	0.250
9	0.95	0.259		1.04	0.246
mean:	1.06	0.223		1.16	0.236
sd:	0.07	0.019		0.12	0.013

DAY 2					
meas.#	conductivity \\\n mS/m	in-phase \\\n ppt.		conductivity +\n mS/m	in-phase +\n ppt.
0	1.97	0.285		1.86	0.230
1	1.90	0.252		1.79	0.257
2	1.80	0.281		1.82	0.246
3	1.89	0.263		1.84	0.333
4	1.86	0.259		1.92	0.265
5	1.94	0.270		1.87	0.263
6	2.03	0.362		1.88	0.309
7	1.86	0.265		1.97	0.261
8	1.96	0.391		1.89	0.298
9	1.87	0.292		1.91	0.311
10	1.94	0.289		1.94	0.263
mean:	1.91	0.292		1.88	0.276
sd:	0.07	0.044		0.05	0.032

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