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LAW ENVIRONMENTAL

FINAL

MONITORING WELL INSTALLATION PLAN
OFF-BASE GROUND WATER INVESTIGATION

FOR

GRIFFISS AIR FORCE BASE
NEW YORK

PREPARED FOR

416 th
C. S. G.



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B. W. (SAC)

U.S. ARMY CORPS OF ENGINEERS
KANSAS CITY DISTRICT

MARCH 1991

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GRIFFISS AIR FORCE BASE

ROME, NEW YORK

Prepared for:

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1.0 INTRODUCTION AND BACKGROUND

This Monitoring Well Installation Plan will document procedures that Law Environmental, Inc.- Government Services Division (LAW) will use for the installation of off-base monitoring wells and related field activities in the vicinity of Griffiss Air Force Base (GAFB), NY. The purpose of the Off-Base Ground Water Investigation is to expedite the assessment of the presence or absence of contamination resulting from operations at GAFB. The monitoring wells and selected data obtained may additionally be later used in the Remedial Investigation (RI) at GAFB.

1.1 SITE-SPECIFIC HISTORY AND BACKGROUND

GAFB is located in the lowlands of the Mohawk River Valley in Oneida County, approximately 2 miles northeast of Rome, New York (Figure 1-1). Approximately 4,500 permanent military personnel, are assigned to the base and 3,000 civilians are employed at GAFB. The base consists of approximately 3,900 contiguous acres at an average elevation of 504 feet, NGVD (National Geodetic Vertical Datum) which border small towns and rural areas.

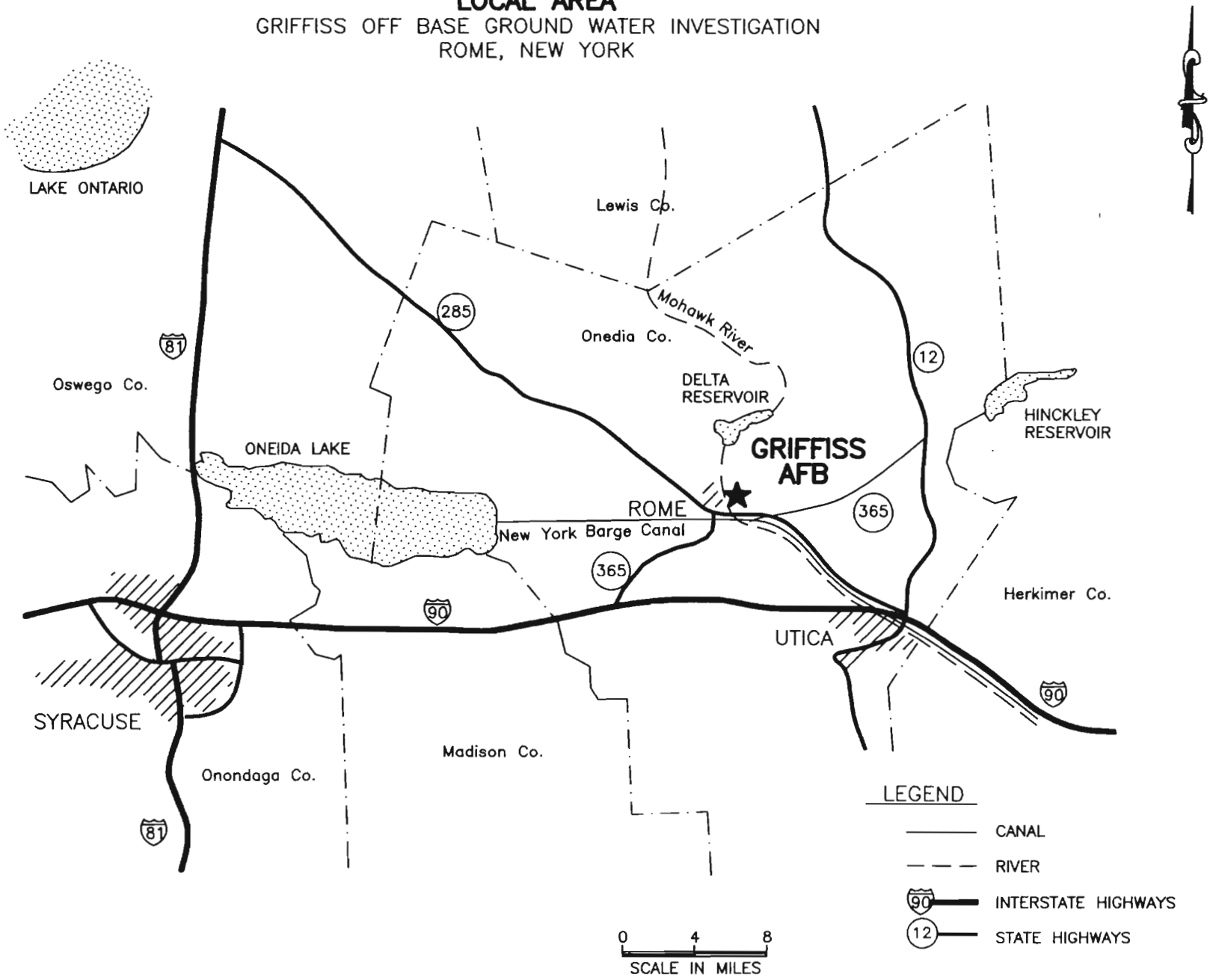
GAFB is organized with the 416th Bombardment Wing as the host unit under the supervision of Strategic Air Command (SAC). The primary mission of the Wing is the maintenance and implementation of effective aerial refueling operations, while providing bombardment capabilities on a global scale.

For over 40 years, GAFB has played a vital role in national defense. Construction of GAFB, previously named Rome Air Depot, began on August 2, 1941, with the base becoming operational by February 1, 1942. On September 20, 1948, the depot was renamed in

FIGURE 1-1

LOCAL AREA

GRIFFISS OFF BASE GROUND WATER INVESTIGATION
ROME, NEW YORK



honor of Lieutenant Colonel Townsend E. Griffiss, an Army Air Force pilot who lost his life in the European Theater of Operations during World War II.

The mission of the base has changed many times over the years. The base became an electronic center in 1950 when the Watson Laboratory Complex was transferred there. In June, 1951, the Rome Air Development Center (RADC) was established at GAFB to accomplish applied research development and testing of electronic air-ground systems. On July 1, 1970, the 416th Bombardment Wing of SAC was activated at GAFB. The U.S. Air Force (USAF), in performing its primary mission of national defense, has frequently engaged in operations that deal with toxic and hazardous materials which have been placed or come to be located in various places at GAFB.

1.1.1 Site Characteristics

The GAFB Off-Base Ground Water Investigation is located in central New York State, near the city of Rome, in Oneida County (Figure 1-2).

This area is bounded to the north by Wilson Road and Canterbury Hill Road, on the east by Phillips, Rabbit and Old Floyd Roads, on the south by River Road (A.K.A. Highway 88), and to the west by the GAFB boundary (Figure 1-2).

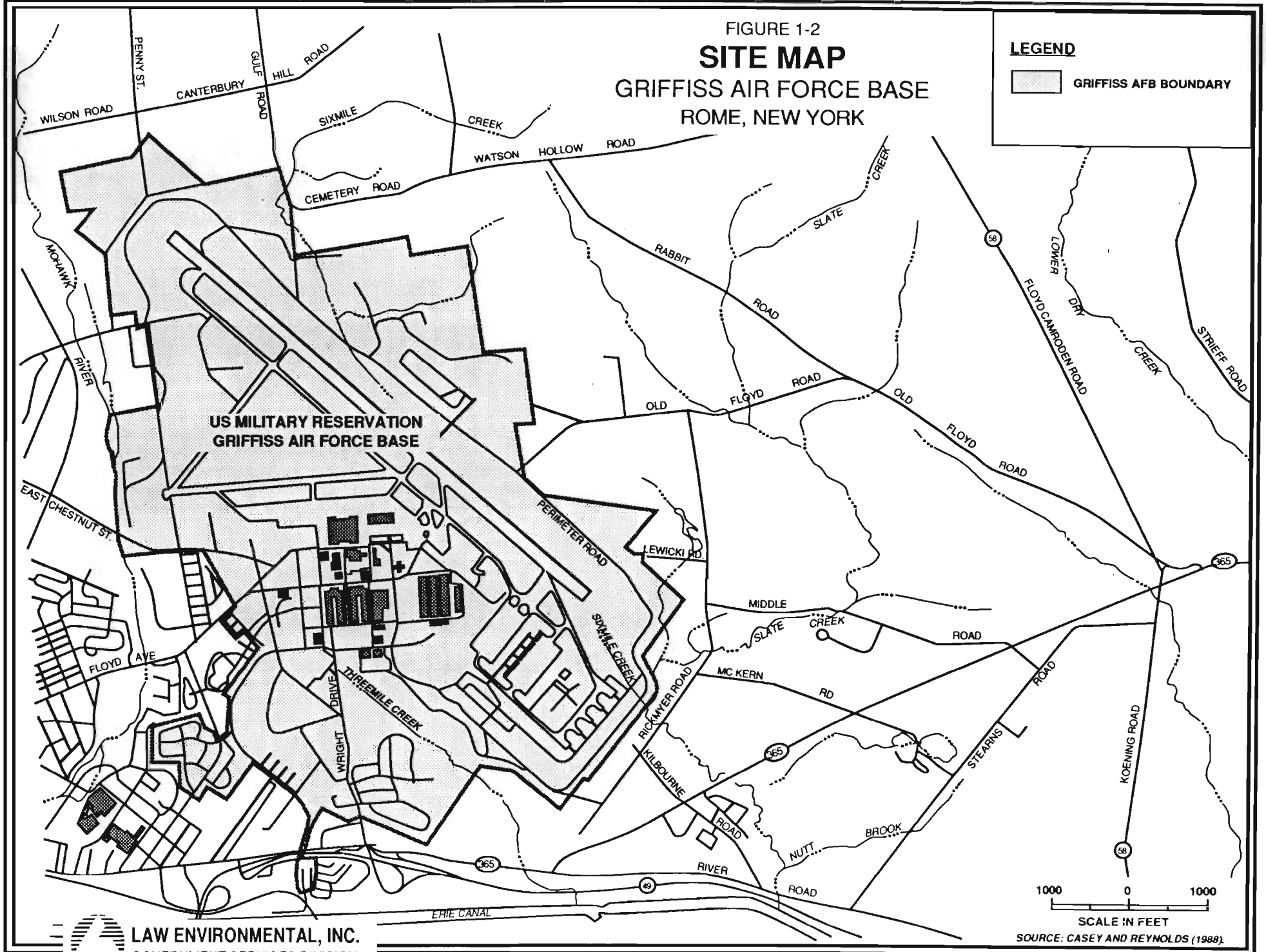
Present land usage of the study area is primarily agricultural and forested with residential communities concentrated in the south. Located among these residential areas are some sand and gravel mining activities (Figure 1-3).

FIGURE 1-2

SITE MAP

GRIFFISS AIR FORCE BASE

ROME, NEW YORK



SOURCE: CASEY AND REYNOLDS (1988).

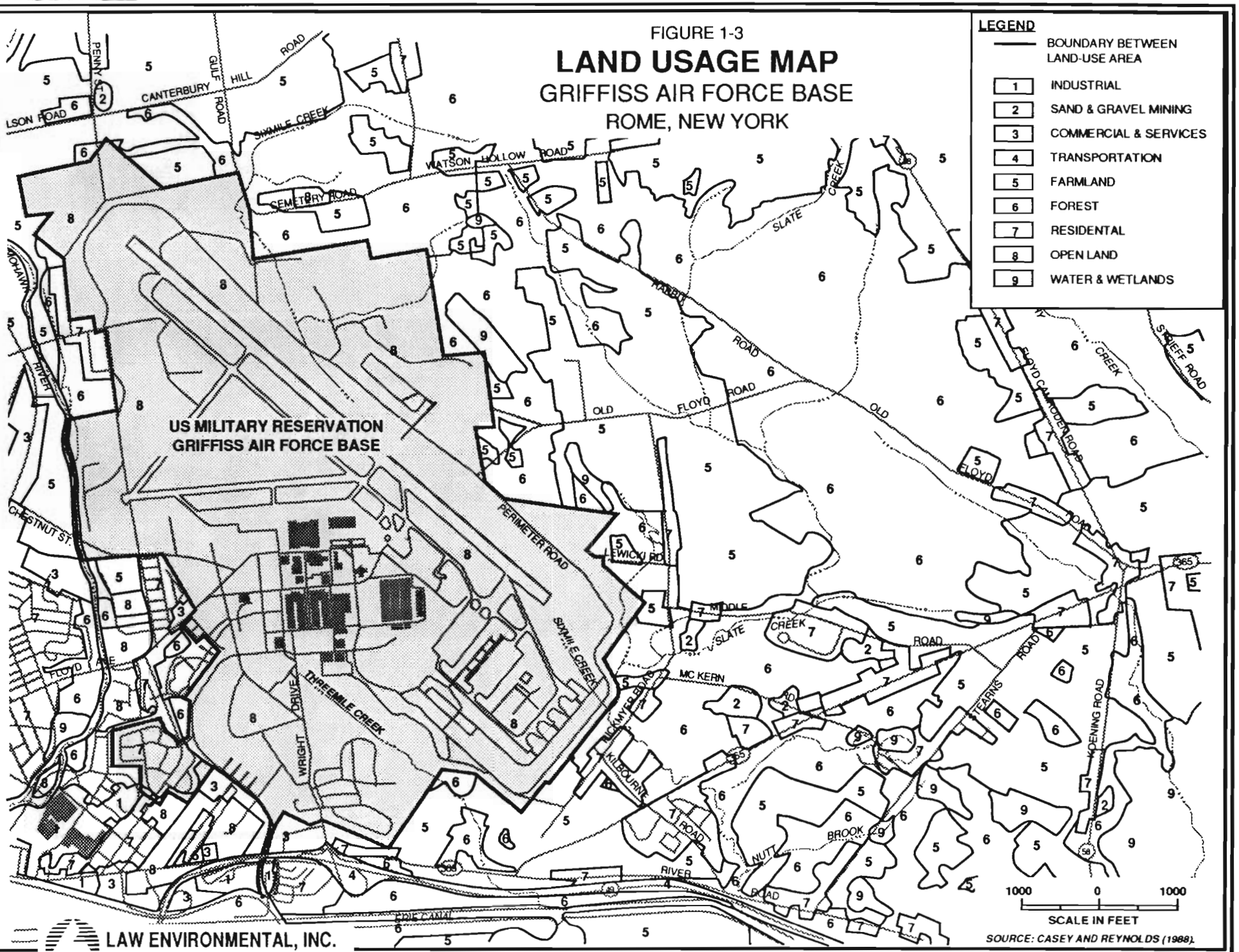
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FIGURE 1-3

LAND USAGE MAP

GRIFFISS AIR FORCE BASE

ROME, NEW YORK



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1.1.2 Previous Investigation

There are no previous environmental investigations at the GAFB Off-Base Ground Water Investigation site. However, analysis of water from wells indicates various levels of chemical contaminants, especially glycols.

1.2 ENVIRONMENTAL SETTING

This section generally describes the physiography, hydrogeology, water resources, and climatology of GAFB. Most of the following environmental data has been abstracted from the IRP Phase I report by Engineering Science dated July 1, 1988, unless otherwise indicated.

1.2.1 Physiography and Surface Water

The present day topography of the Mohawk Valley is the result of deposition and subsequent erosion of glacial and alluvial sediments (from the now extinct Glacial Lake Iroquois) resting upon bedrock. With elevations averaging 500 feet above sea level the generally flat topography is typical of the region.

Remaining glacial features include eskers and a few isolated kames near Oriska, New York, southeast of the installation. An esker is a winding ridge of stratified sediments deposited by a stream that flowed on, within or beneath a glacier. Kames are rounded, domed hills of stratified glacial drift deposited by melt water running off glacier margins or into melt depressions.

The Mohawk River Basin, which GAFB lies within, has a drainage area of 3,456 square miles. The three notable streams draining the immediate area of the installation include the Mohawk River, Six

Mile Creek, and Slate Creek. The Mohawk River flows southward along the west boundary of the installation, changing to an eastward course at a point southwest of the base. Six Mile Creek flows westward then south along the eastern boundary of the installation where it then joins the New York Barge Canal to the south. Slate Creek drains the area to the east of the installation then joins the New York Barge Canal to the southeast of the installation. Runoff from the GAFB area flows into these streams via natural and man-made drainage features.

Some 25 percent of total precipitation for the central New York State area infiltrates into the ground water system. A portion of this ground water will eventually be discharged as base flow to feed area streams. The remaining 75 percent of precipitation is accounted for as either runoff or evaporation-transpiration.

1.2.2 Climate

Precipitation and snowfall data for GAFB are summarized in Table 1-1. Mean annual precipitation is 45.6 inches, and mean annual snowfall is 107 inches. Winter months generally occur between Mid-December and Mid-March with temperatures averaging 20°F. The spring, summer and fall seasons are relatively mild with average temperatures ranging from 31°F to 81°F. Wind speeds average 5 knots primarily from the southwest.

1.2.3 Soils and Surface Geology

Figures 1-4 and 1-5 illustrate the surficial geology east of the installation. This area is described as having two distinct soil units, both of glacial origin. These are Pleistocene alluvial deposits that are typically confined to lowland areas as existing or former stream channels (Casey and Reynolds, 1989). The first unit of Pleistocene age glacio-fluvial deposits composed of

TABLE 1-1

PRECIPITATION AND SNOWFALL DATA
GRIFFISS AFB
ROME, NEW YORK

Month	Precipitation (In) Monthly				Snowfall (In) Monthly		
	Mean	Max	Min	Max 24 Hrs	Mean	Max	Max 24 Hrs
JAN	4.0	7.6	1.5	2.9	27	63	25
FEB	3.7	8.0	1.8	2.1	25	46	24
MAR	3.3	6.4	0.8	2.3	17	41	13
APR	3.8	6.0	1.7	2.1	2	11	5
MAY	3.9	7.1	0.8	2.7	*	6	3
JUN	3.8	9.9	0.9	3.1	0	0	0
JUL	3.9	7.5	1.4	3.9	0	0	0
AUG	3.5	7.9	1.4	2.6	0	0	0
SEP	3.8	9.3	0.8	2.5	0	0	0
OCT	3.4	8.7	0.3	3.0	*	1	1
NOV	4.3	8.7	1.0	3.1	9	21	7
DEC	4.2	7.2	0.9	3.0	27	54	15
ANNUAL	45.6	9.9	0.3	3.9	107	63	25

Note: Indicated period of record is 35 years.
* Data not available.

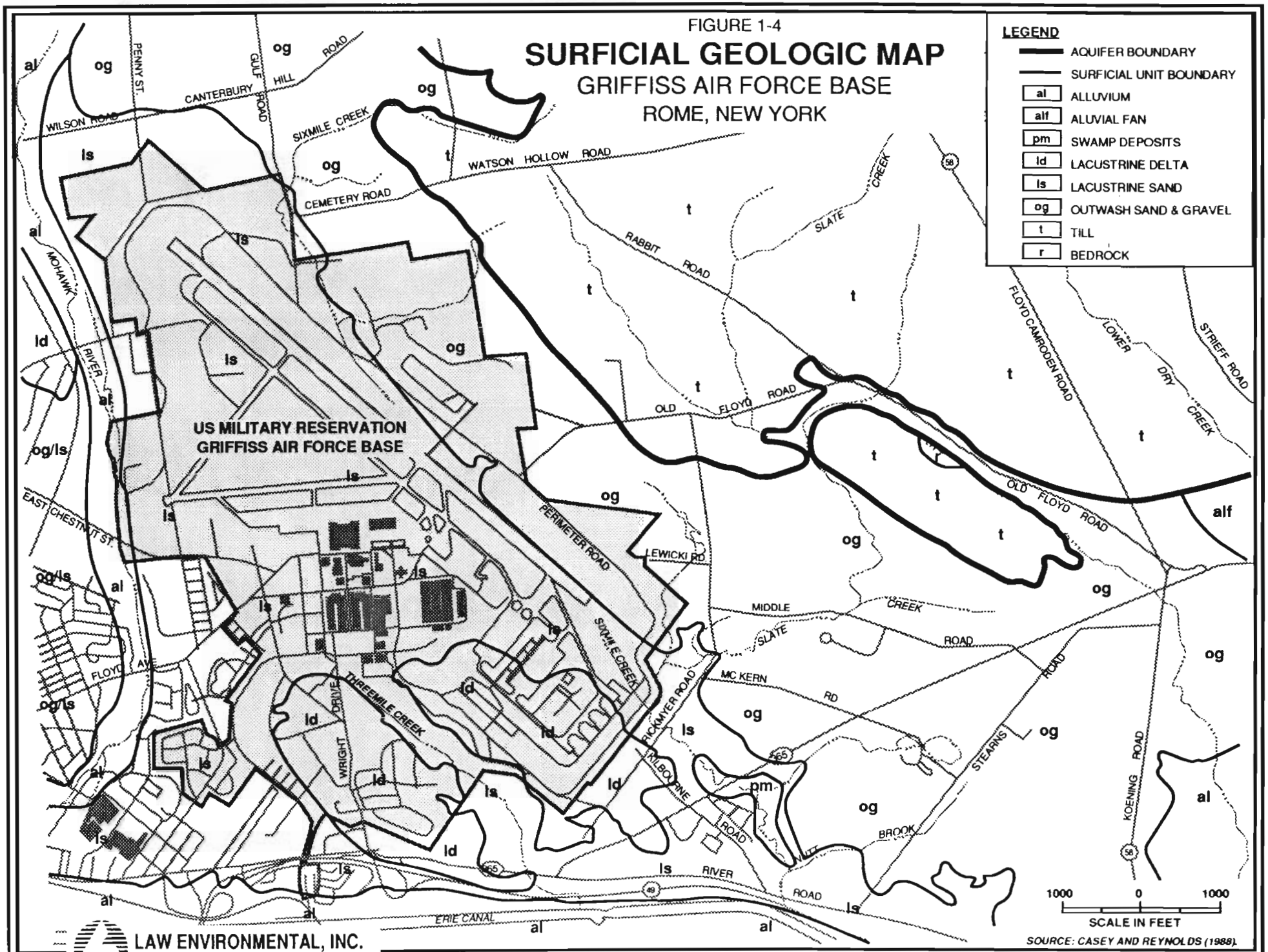
(After Engineering-Science, 1981)

FIGURE 1-4

SURFICIAL GEOLOGIC MAP

GRIFFISS AIR FORCE BASE

ROME, NEW YORK

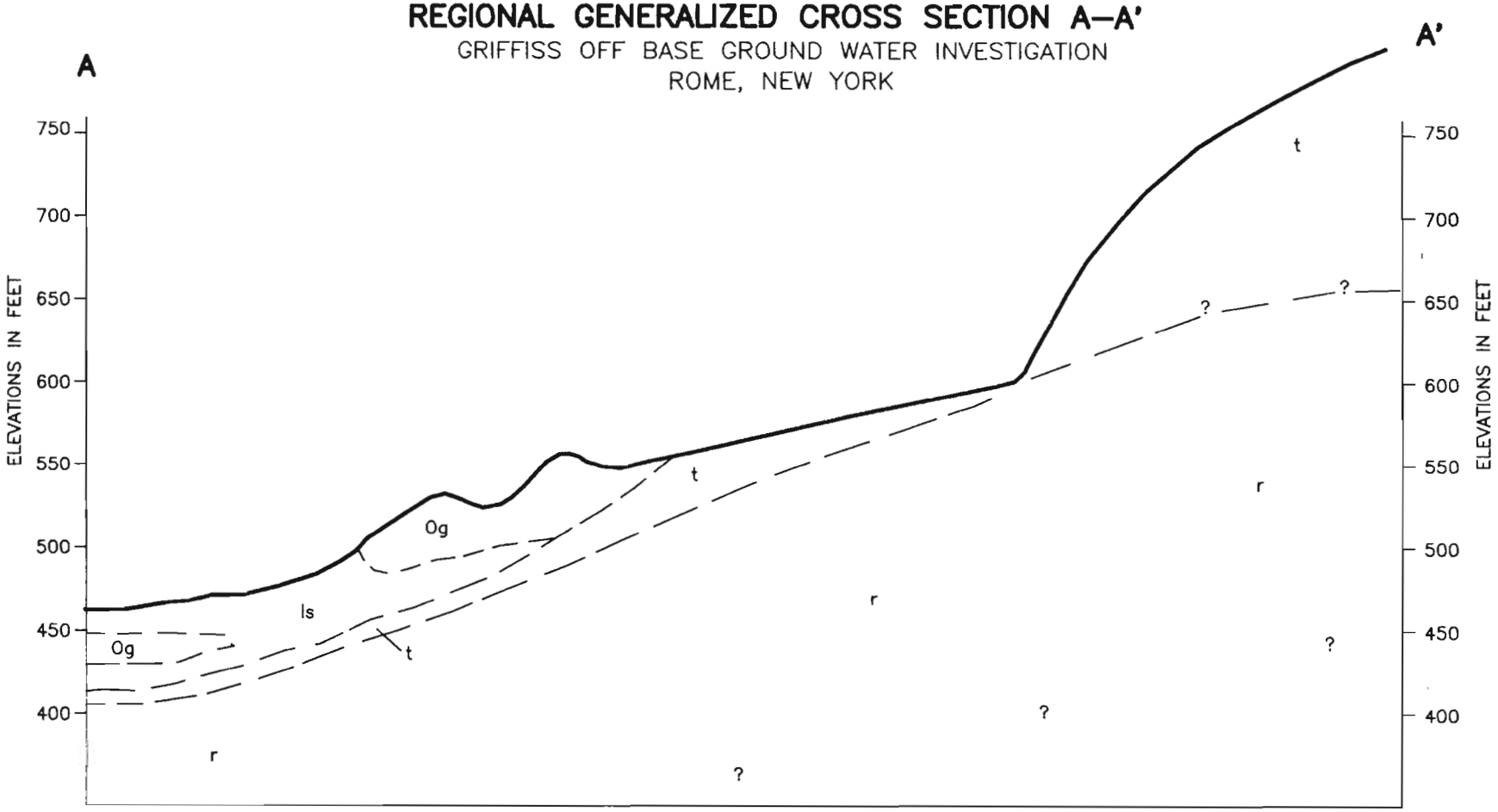


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FIGURE 1–5

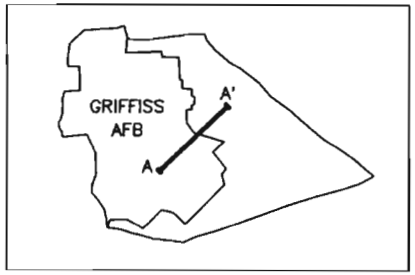
REGIONAL GENERALIZED CROSS SECTION A–A'

GRIFFISS OFF BASE GROUND WATER INVESTIGATION
ROME, NEW YORK



*DATUM IS SEA LEVEL

VERTICAL EXAGGERATION 20x



Og – GLACIOFLUVIAL DELTAIC OUTWASH–SAND AND GRAVEL
ls – LUCUSTRINE FLUVIAL SAND
t – TILL
r – BEDROCK–ORDORVICIAN FRANK, & UTICA SHALES

0 1 MILE

SOURCE: CASEY AND REYNOLDS (1988)

meltwater outwash (deltaic) sands and gravels (southwest area). These deposits are highly permeable, well sorted coarse to fine gravel with sand. Deposits become finer grained with increasing distance from glacial borders. The second soil unit consists of glacial tills which are ice-contact deposits of unstratified, unsorted mixtures of clay, silt, gravel, cobbles and boulders. These are relatively impermeable with moderate to high clay contents (Casey and Reynolds, 1989).

Other units located to the south of the study area include lacustrine delta deposits, and swamp deposits. Lacustrine delta deposits, composed of stratified coarse to fine gravel and sand, are fluvially deposited by melt water streams extending into a proglacial lake.

The lacustrine sand is a well sorted, stratified, fluvial sand deposited into a proglacial or postglacial lake. Swamp deposits found along the eastern border of the installation are postglacial to recent deposits of peat, organics, organic silt, and sand accumulated in poorly drained areas and localized depressions.

1.2.4 Geologic Setting

Underlying the unconsolidated deposits are the Upper Ordovician Utica and Frankfort shales and Middle Silurian shale and sandstones with a few beds of dolomite (Figure 1-4 and 1-5). The Utica is a relatively soft black and gray carbonaceous shale containing calcareous argillites. The Utica varies in thickness from 300 to 400 feet and dips (as measured at the City of Utica) four to five degrees southwest. The elevation of the bedrock surface is shown in Figure 1-6.

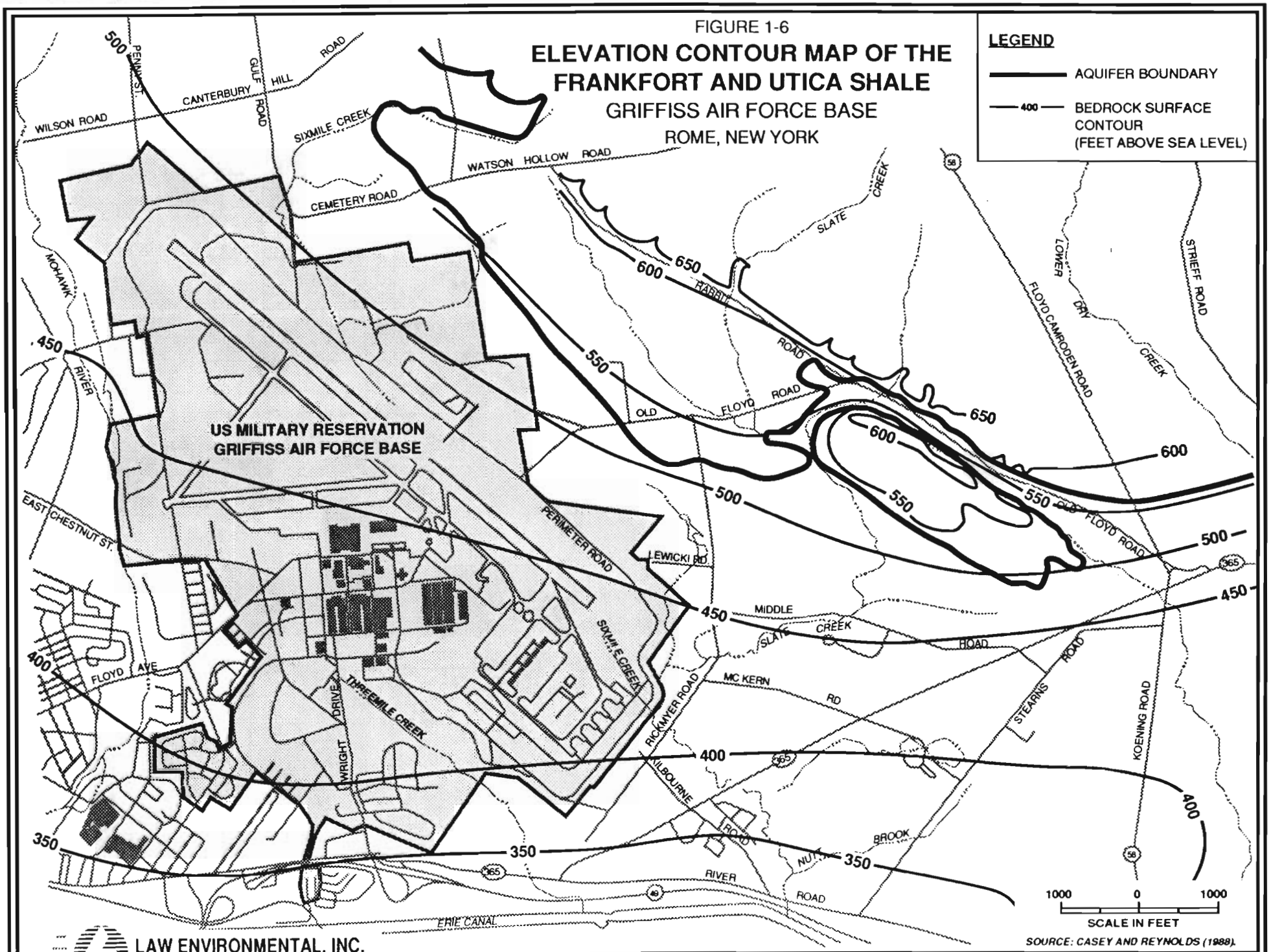
Faulting of the Utica is not directly observable as considerable overburden deposits conceal discontinuities. Several faults in the GAFB area, including one approximately four miles east of the base

FIGURE 1-6

ELEVATION CONTOUR MAP OF THE FRANKFORT AND UTICA SHALE

GRIFFISS AIR FORCE BASE

ROME, NEW YORK



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near the town of Stittville, have been mapped. Also mapped is a lineament extending north-south from the Lake Delta Reservoir along the approximate course of the Mohawk River terminating at a point at or near the western boundary of the installation. This feature, observable on topographic maps and by satellite imagery, may represent a buried fault or simply a change in bedrock conditions. Numerous non-damaging earthquakes have occurred in central New York. These are possibly due to areas that were depressed by glacial weight. The rebound of such a zone may cause small tremors in isolated zones.

Sedimentary strata of the Rome area are known to be jointed. Joint planes of this area are oriented north, west and southwest, with Figure 1-6 the predominant direction being east or southeast along the Mohawk Valley. Joint plane orientations tend to be vertical or nearly vertical.

1.2.5 Ground Water

Upstate New York derives 36 percent of its water supply from ground water sources. Most of the aquifers that supply this water are unconsolidated glacial and alluvial deposits that partly fill major bedrock valleys and their tributaries. Ground water in these aquifers may be found under both unconfined or confined conditions (Casey and Reynolds, 1988).

Local ground water resources are primarily utilized by individuals in areas not served by regional or community systems such as the sparsely populated town of Floyd, or by farmers for agricultural purposes. Most of the GAFB area appears to lie within a ground water recharge area. Recharge occurs where unconsolidated deposits exposed at ground surface capture precipitation. During dry periods, recharge occurs along stream beds traversing these deposits.

Hydrogeologic units of the GAFB area correspond directly to the geologic units previously reported and are shown in Figures 1-4 and 1-5. The saturated thickness of the deposits are shown in Figure 1-7. A brief summary of each aquifer unit is described as follows:

- Quaternary lacustrine and alluvial deposits comprise an unconsolidated, unconfined aquifer made up of primarily fine-grained sediments. It varies in thickness from 70 to 150 feet. Wells screened into this unit average 68 feet in depth. The well yield ranges from 2 to 40 gallons per minute, averaging 11 gpm. Water derived from this unit is of variable quality, and is usually hard.

- Quaternary glacial deposits make up an unconsolidated unconfined aquifer comprised of primarily coarse-grained sediments. It varies in thickness from 10 to 140 feet. Wells screened into this unit average 67 feet in depth. This is the most productive aquifer of the region, with typical yields varying from 10 to 290 gallons per minute, averaging 80 gpm. The water is reported to be of good quality.

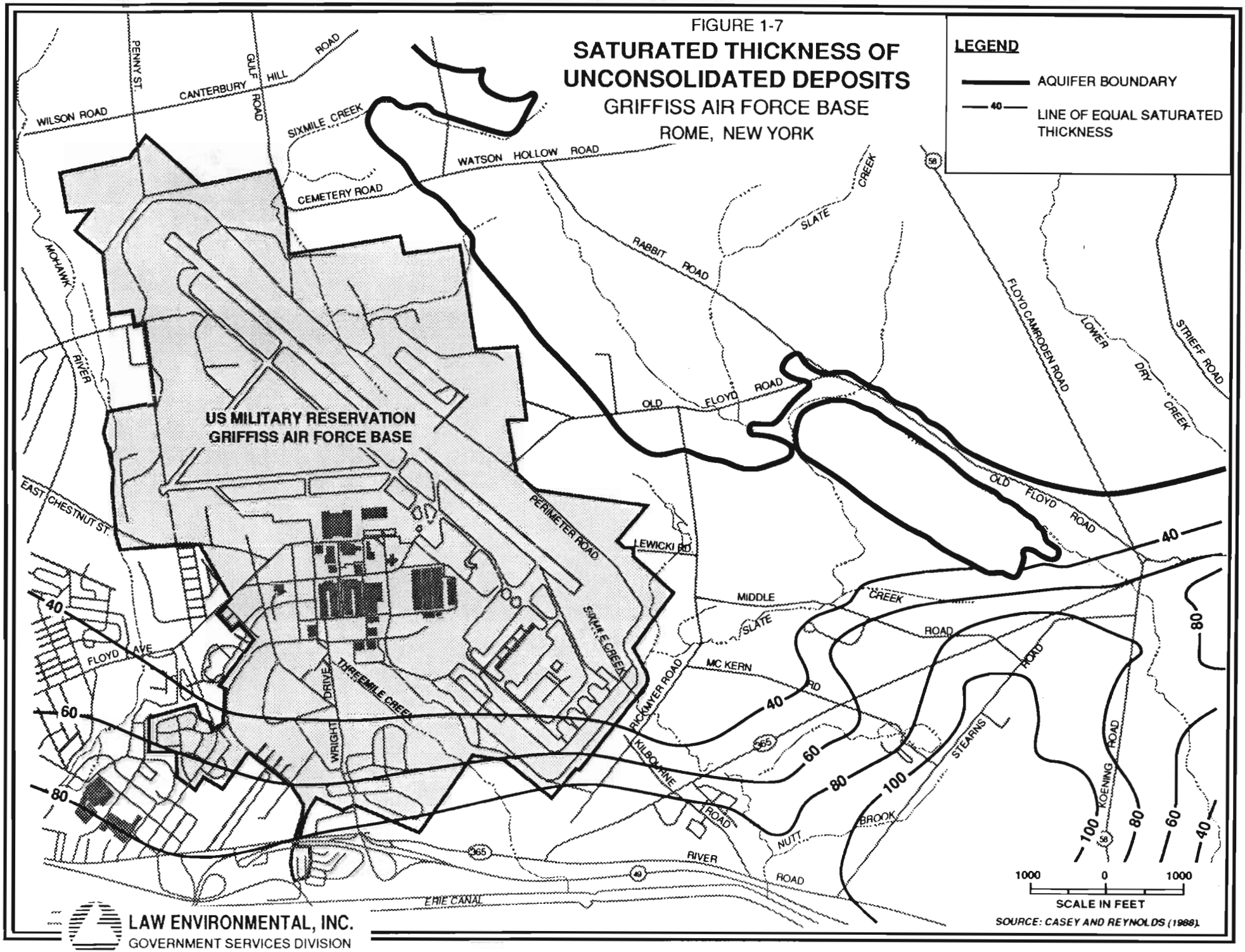
- Utica shale comprises a consolidated, usually unconfined aquifer containing water in weathered upper zones, in joints, bedding planes and in secondary fissures. This unit may function under confined (artisian) conditions locally. The unit ranges in thickness from 300 to 400 feet and typical yields from 0.5 to 48 gallons per minute, averaging 7.5 gpm. Water supplies are normally drawn from upper reaches of this unit as unit production declines with depth. Lower elevations may be naturally contaminated by salts, hydrogen sulfide or methane.

FIGURE 1-7

SATURATED THICKNESS OF UNCONSOLIDATED DEPOSITS

GRIFFISS AIR FORCE BASE

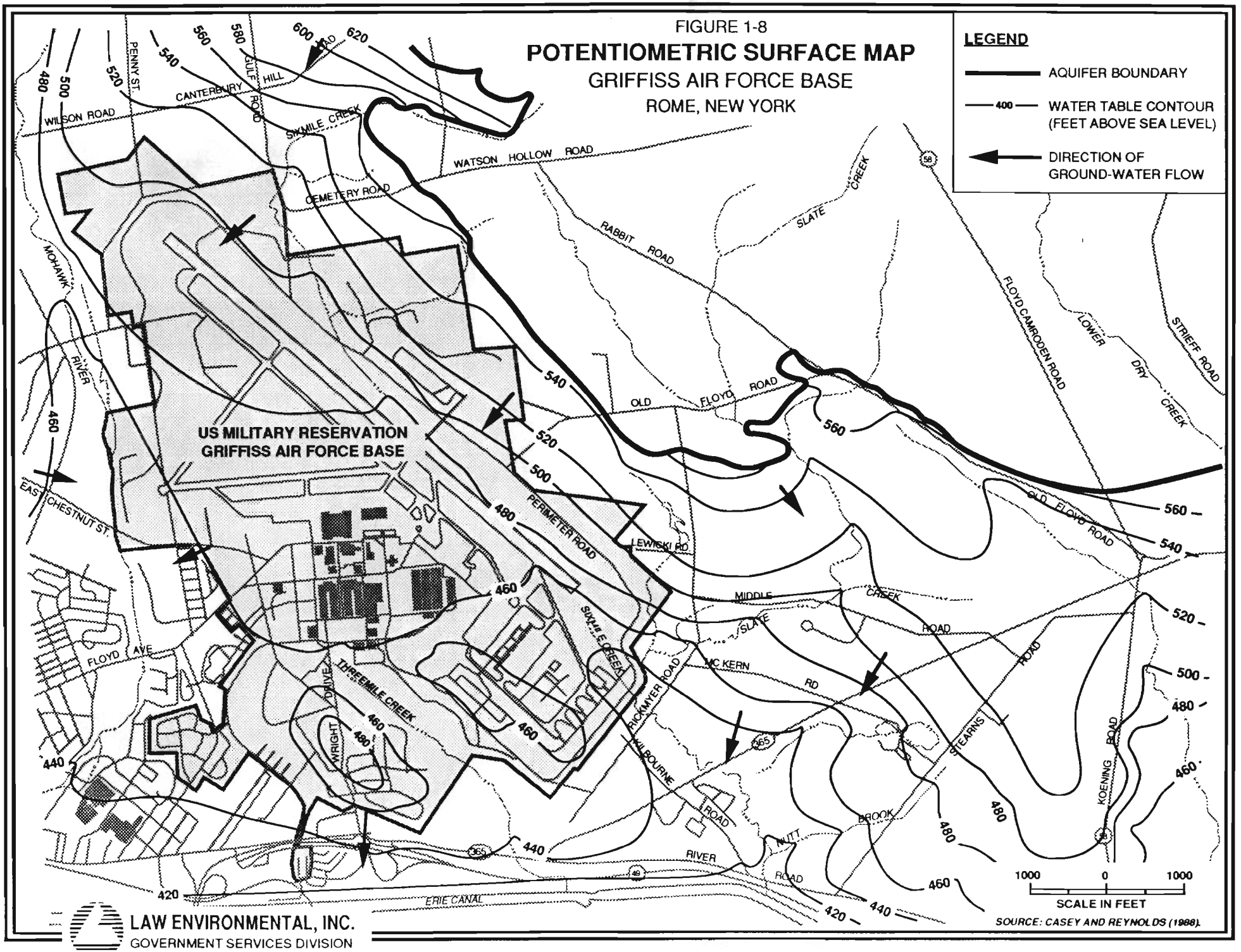
ROME, NEW YORK



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Ground water levels in the Rome-Utica area are reported to fluctuate seasonally from 3 to 15 feet per year. Ground water levels in similar hydrogeologic units are reported to vary from 5 to 25 feet in the adjacent Eastern Oswego Basin.

The water table of this region typically mirrors the topographic surface. Ground water flow directions under unconfined conditions are typically down-gradient from a high potentiometric level to a lower potentiometric level. Ground water discharge zones are typically springs, streams or surface water bodies. Figure 1-8 shows the potentiometric surface of the surficial aquifer in the unconsolidated deposits.



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2.0 WELL INSTALLATION PROGRAM

The purpose of this program is to plan, design, install, develop and test monitoring wells at the off-base site. This plan discusses the proposed field activities at the site, including the drilling and installation of monitoring wells, well development, in-situ hydraulic conductivity testing, and location surveying. The chemical sampling and analytical programs are discussed in the Chemical Data Acquisition Plan (CDAP).

2.1 SITE-SPECIFIC FIELD INVESTIGATION

The rationale for site specific drilling and sampling locations are defined in the following sections. The proposed field investigation program was developed based on background information, primarily from the Griffiss Installation Restoration Program Report of the Domestic Water Well Sampling Program (UNC Geotech, 1989) and the USGS (Casey and Reynolds, 1989).

2.1.1 Monitoring Well Locations

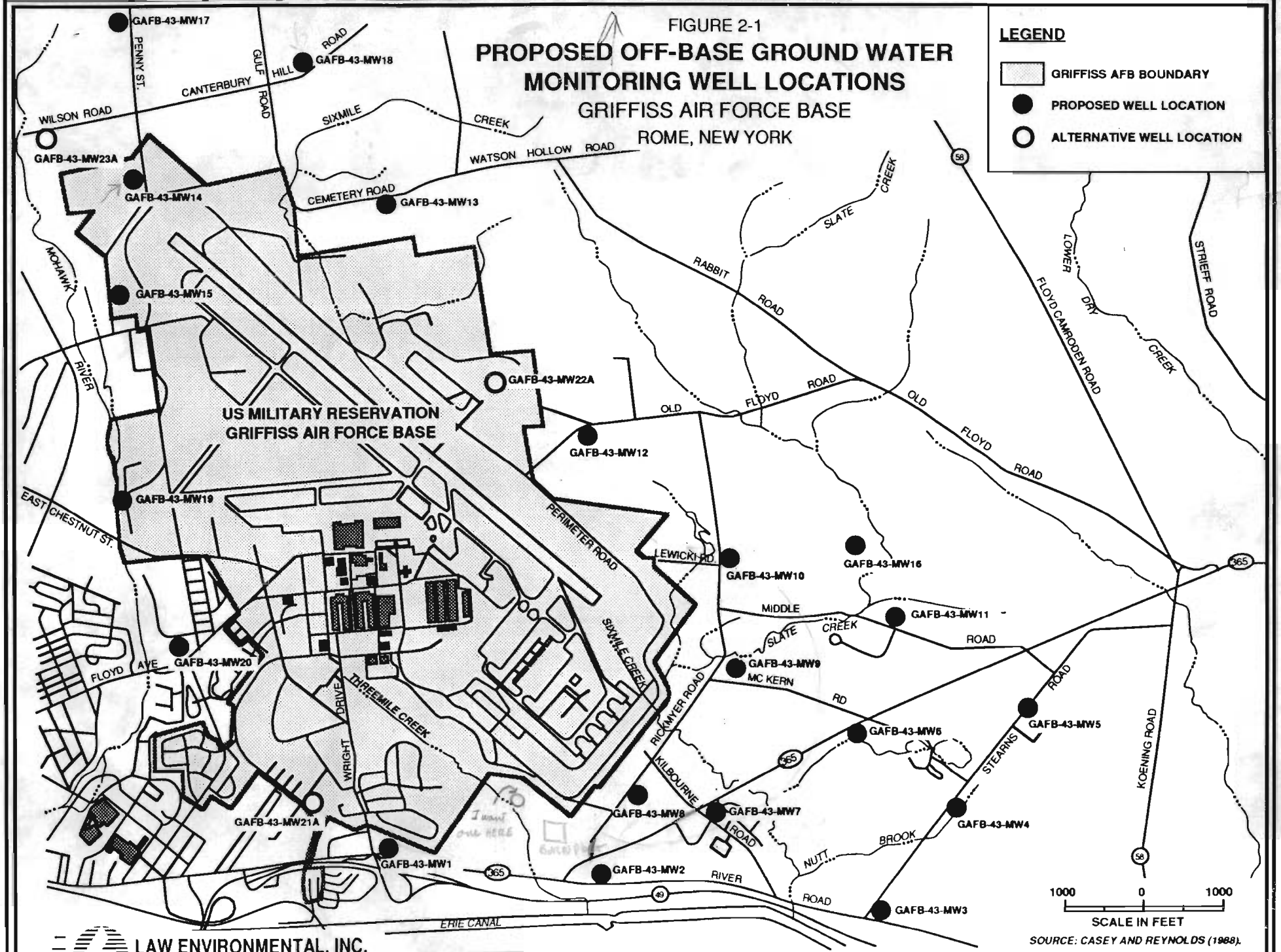
A total of 20 Type II (as shown in Figure 5-1) monitoring wells will be installed in the off-site area identified by Corps of Engineers, Missouri River - Kansas City District (CEMRK). The proposed monitoring well locations are shown in Figure 2-1. Of the 20 locations proposed, two have been selected as potential upgradient sites. The remaining eighteen locations have been selected based on previous data from domestic water wells in the area, from published topographic and from hydrogeologic elevations of the study area.

FIGURE 2-1

PROPOSED OFF-BASE GROUND WATER MONITORING WELL LOCATIONS

GRIFFISS AIR FORCE BASE

ROME, NEW YORK



SOURCE: CASEY AND REYNOLDS (1988).

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2.1.2 Monitoring Well Installation Activities

Each monitoring well boring will be drilled using hollow-stem augers with soil sampling to boring termination. The monitoring wells are estimated to be approximately 45 feet deep. The borings will be large enough to allow the required two-inch annular space around the well riser. Type II monitoring wells (as shown in Figure 5-1) will be installed within each boring to monitor potential constituents in the uppermost aquifer. It is expected that the top of the well screens will be at a depth of 30 to 35 feet; however, actual screen locations and placement may be modified in the field based upon borehole data. Monitoring wells will be installed to screen the uppermost aquifer. Following installation, each well will be developed, as described in Section 6.0, sampled and surveyed (location and elevation). In addition, in-situ hydraulic conductivity tests will be performed. These tests, as described in Section 7.0, will provide information regarding the hydraulic conductivity of the screened intervals in each well tested.

The monitoring wells will consist of schedule 40, polyvinyl chloride (PVC) pipe. Selection of this PVC for the monitoring wells is based on the primary purpose of this phase of the project, which is the detection of potential contaminants. PVC has demonstrated very good chemical resistance except to high concentrations of low molecular-weight ketones, aldehydes and chlorinated solvents. Low concentrations of these same chemicals with long term exposure has as yet had undocumented effects (Barcelona et. al., 1983 and NWWA, 1989). Permanent monitoring wells to be used for long term monitoring (20-30 years) may be constructed of either Teflon or stainless steel. Results of the detection monitoring program may warrant the use of a more chemical resistant well material.

2.2 GEOTECHNICAL SAMPLE TESTING

Soil samples for geotechnical analysis will be collected during drilling. Soil samples will be taken every 2.5 feet for the first ten feet then at five foot intervals or changes in stratigraphy for the remainder of the boring.

Sampling will be performed using a split-spoon sampler or thin wall sampler using standard sampling techniques (ASTM D 1586-84) (ASTM D 1587-83). Samples will be stored in plastic or glass jars. All samples will be visually classified according to the Unified Soil Classification System.

Two soil samples from each monitoring well boring will be submitted for geotechnical analyses. Samples will be chosen based on stratigraphic location, hydrogeological significance and location relative to the screened interval of a monitoring well.

Tests to be performed on the samples include:

Test	Tests/Boring
Grain-Size Distribution (ASTM D 421 & 422)	2
Atterburg Limits (ASTM D 4318)	2
Moisture Content (ASTM D 2216)	2

2.3 SITE SURVEY

Following monitoring well installation, coordinates and elevations will be established for each monitoring well. The horizontal coordinates will be the closest 1.0-foot and referenced to the State Plane Coordinate System. If the State Plan Coordinate System is not readily available, an existing local grid system will be used. A ground elevation to the closest 0.01-foot and an elevation

for the top of the polyvinyl chloride (PVC) casing to the closest 0.01-foot will be obtained at each well. The elevations will be referenced to the National Geodetic Vertical Datum of 1929. If the 1929 Datum is not readily available, the existing local vertical Datum will be used. Two permanent control monuments will be placed in accessible locations within the limits of the work. The monuments will be set no closer than 500-feet to each other. Coordinates and elevations will be plotted to the closest 0.01-foot for each monument. The location, identification, coordinates and elevations of the wells and monuments will be plotted on maps with a scale large enough to show their location with reference to other structures at the individual sites. A tabulated list of the monitoring wells and monuments, copies of all field books, and all computation sheets will be prepared and submitted to CEMRK. The tabulation will consist of the designated number of the well or monument, the X and Y coordinates, and all the required elevations.

3.0 DRILLING PROCEDURES

3.1 INITIAL ACTIVITIES

Prior to mobilizing on a boring location, the site will be checked with appropriate authorities for underground utility locations. Drilling will not proceed where above ground or overhead utilities are within 30 feet of the drill rig. Should utility locations require new locations for borings, they will be chosen as close as possible to the originally proposed location and utilities cleared by proper authorities.

3.2 DRILLING PROTOCOL

The monitoring well borings will be advanced using a drill rig equipped with hollow-stem augers. The rig will be capable of drilling a borehole of sufficient diameter to allow at least two inches of annular space between the boring wall and all sides of the well riser and screen. The drill rig will also have the capability to collect split-spoon samples in accordance with ASTM D 1586-84 procedures. At a minimum, the rig will be equipped with a cathead operated, 140-pound hammer with a 30-inch draw. The 30-inch draw distance will be marked on the hammer rod. The use of grease or oil on drill rod joints will not be permitted; however Teflon tape or vegetable oil will be used if necessary.

3.2.1 Type II Monitoring Wells

Twenty Type II monitoring wells will be drilled at the GAFB Off-base Ground Water Investigation site. These twenty wells will be screened at a depth of approximately 30 to 45 feet. This will vary based on site conditions. Following the site utility clearance, the drill rig will be steam-cleaned prior to being set up on a pre-selected location. Decontamination procedures are discussed in section 4.0.

Well installation procedures are discussed in section 5.0. The following protocol will be followed for completing each well:

- Advance boring using hollow stem augers to the desired depth following the sampling procedures outlined in Section 2.3.

- Monitor and record on Figure 3-1 the breathing zone continuously for organic vapors using an organic vapor analyzer (OVA).

- Record soil classifications, using the Unified Soil Classification (USC) system, on the HTW Drilling Log shown in Figure 3-1.

- Collect two soil samples for geotechnical analysis from each well. One sample will be chosen from the proposed screened interval of each well.

- Determine and record the depth to ground water following drilling for well screen placement.

FIGURE 3-1

HTW DRILLING LOG

HOLE No.		
1. COMPANY NAME	2. DRILLING SUBCONTRACTOR	SHEET 1 OF SHEETS
3. PROJECT	4. LOCATION	
5. NAME OF DRILLER	6. MANUFACTURER'S DESIGNATION OF DRILL	
7. SIZE AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8. HOLE LOCATION	
	9. SURFACE ELEVATION	
	10. DATE STARTED	11. DATE COMPLETED
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED	
13. DEPTH DRILLED INTO ROCK	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14. TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX No. e	ANALYTICAL SAMPLE No. f	BLOW COUNTS g	REMARKS h

FIGURE 3-1 CONT'D.

HTW DRILLING LOG

PROJECT	INSPECTOR	HOLE No.
		SHEET 1 OF SHEETS

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX No. e	ANALYTICAL SAMPLE No. f	BLOW COUNTS g	REMARKS h

4.0 DECONTAMINATION PROCEDURES

4.1 DRILL RIG AND EQUIPMENT

The drill rig and equipment will be steam cleaned to remove oil, grease and other contamination prior to drilling each boring. Additional drill rig decontamination will be conducted as needed and prior to demobilization from the site. The downhole drilling equipment (augers, rods, etc.) will also be steam cleaned prior to drilling each boring.

4.2 DRILLING WATER SOURCE

If it is necessary to use water during the drilling program, clean non-chlorinated water will be used, where possible. Clean, potable water will be used if a non-chlorinated source is not readily available. One sample of the water to be used during the drilling program will be collected from each transport vehicle after delivery to the site, just prior to its use. Each water transportation vehicle will be sampled once during the drilling program. (These samples will be analyzed for the same parameters specified for ground water samples and chlorine). Results of any other tests performed on the source of water by the base in the past year will be requested. Information regarding the source of water used and any impact on analytical results will be included in the draft and final report (i.e., Fire hydrant location and base well number).

4.3 EQUIPMENT DECONTAMINATION

Prior to use, sampling equipment (bailers, split-spoons, and pumps) will be decontaminated using the specified parameters as outlined in Section 1.8 of the CDAP. At a minimum, sample equipment should

be scrubbed with a non-phosphate detergent, followed by a tap water rinse, a reagent grade rinse of methanol and a final double rinse using deionized water. The quality of deionized water will be of Type II as defined by ASTM 1193-77 and shall be demonstrated to be free of organic analytes.

5.0 MONITORING WELL INSTALLATION

Monitoring wells will be installed in a manner to accomplish the following objectives: to collect representative ground water samples; to prevent contamination of the aquifer by the drilling equipment; and to prevent vertical seepage of surface water into the monitoring well water-intake zone. The well design and installation procedures used to accomplish these objectives are discussed in the following sections.

Drilling permits, if required, by state or local authorities will be obtained for all drill sites prior to the start of drilling activities. Monitoring wells will be constructed and installed in accordance with the general specifications of the state, if required. Any conflicts between the specifications of this contract and the state will be brought to the attention of the CEMRK and U.S. Air Force for clarification prior to the start of drilling.

Well dimensions, amount, type and manufacturer of materials used to construct each well will be recorded on a Type II Monitoring Well Installation Diagram illustrated in Figure 5-1.

5.1 MONITORING WELL INSTALLATION

5.1.1 Well Riser and Screen Materials

All monitoring well riser material will consist of new, threaded, flush joint, 2-inch Polyvinyl Chloride (PVC) pipe. The riser pipe will conform to ASTM F 480-81 standards for Schedule 40 pipe and shall carry the seal of the National Sanitation Foundation (NSF). No couplings, organic solvents or glue, lead shot or lead wool will be used in joining the riser pipe. Monitoring wells will generally be topped with a vented cap, however, any flush mounted wells will have a water tight cap to prevent surface water infiltration.

FIGURE 5-1

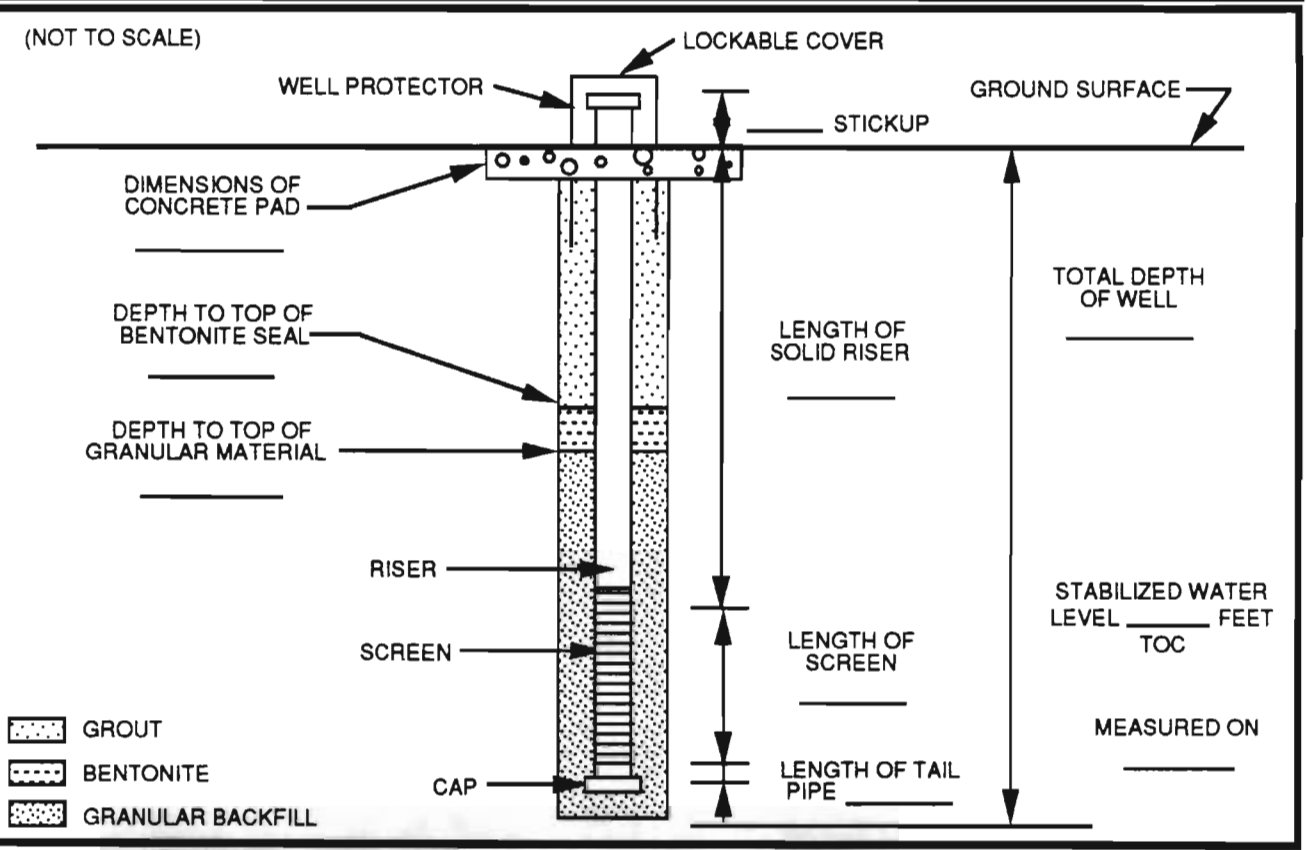
TYPE II MONITORING WELL INSTALLATION DIAGRAM

LAW ENVIRONMENTAL, INC.
GOVERNMENT SERVICES DIVISION
KENNESAW, GEORGIA

JOB NAME _____
WELL NO. _____ JOB NO. _____
DATE _____ TIME _____
WELL LOCATION _____

GROUND SURFACE ELEVATION _____
TOP OF SCREEN ELEVATION _____
REFERENCE POINT ELEVATION _____
TYPE SAND PACK _____ GRADATION _____
SAND PACK MANUFACTURER _____
SCREEN MATERIAL _____
MANUFACTURER _____
RISER MATERIAL _____
MANUFACTURER _____
RISER DIAMETER _____
DRILLING TECHNIQUE _____
AUGUR SIZE AND TYPE _____
REMARKS _____

BENTONITE TYPE _____
MANUFACTURER _____
CEMENT TYPE _____
MANUFACTURER _____
BOREHOLE DIAMETER _____
SCREEN DIAMETER _____ SLOT SIZE _____
LAW ENVIRONMENTAL, INC.
FIELD REPRESENTATIVE _____
DRILLING CONTRACTOR _____
AMOUNT BENTONITE USED _____
AMOUNT CEMENT USED _____
AMOUNT SAND USED _____
STATIC WATER DEPTH (after dev.) _____



QA / QC

INSTALLED BY: _____ INSTALLATION OBSERVED BY: _____
DISCREPANCIES: _____

Well screens will consist of new, commercially fabricated, threaded, flush joint, 2-inch, factory slotted PVC screen. Screen slot size will be compatible with the filter pack gradation. A threaded PVC plug will be provided for the bottom of the well. The screen will be positioned in the water table to allow monitoring of the uppermost water-bearing unit encountered. The top of the screen will extend above the water table so seasonal fluctuations will be accounted for. All risers and screens will be set plumb and true to line. Centralizers will be used to ensure the completed monitoring well functions properly. The well pipe assembly will be hung in the borehole, prior to the placement of the filter pack, and not allowed to rest on the bottom of the hole to keep the well assembly straight and plumb.

5.1.2 Filter Pack

A sand filter pack will be installed in the annulus between the boring and the well screen. The sand size will be based upon the type of soil expected for the screened interval. The filter pack gradation will be selected based on the availability of the appropriately sized material in the area and on the type of material in the formations.

The sand filter pack will consist of clean, inert, noncarbonate silica sand. Care will be taken to prevent bridging by continuously probing and measuring the thickness of the sand pack as it is placed. The sand filter pack will be tremied from a minimum of one foot below the bottom of the well screen to two to four feet above the top of the well screen. In wells with screens set close to the surface, the sand pack will extend to approximately one foot above the top of the screen.

5.1.3 Bentonite Seal

A minimum three-foot thick bentonite pellets or granular bentonite seal will be tremied above the artificial sand pack in the annular space of the well. Bentonite pellets will be used to form the bentonite seal. In wells where the screen is close to the surface a minimum of 1 foot of bentonite seal must be placed. The bentonite pellets will be tamped and hydrated from the approved water source. The bentonite seal will be allowed to hydrate a minimum of 12 hours prior to placement of grout for the Type II wells.

5.1.4 Grout Mixture

A non-shrinking cement-bentonite grout mixture will be placed in the annular space between the top of the bentonite seal and the ground surface. The cement-grout mixture will consist of Portland cement (ASTM-C150) and clean water from the approved water source in the proportion of not more than seven gallons per 94 pound bag of cement. Additionally, three percent by weight of bentonite powder will be added to the mixture to help reduce shrinkage, if permitted by state regulations. A tremie pipe will be used to place the grout mixture into the annular space. The tremie pipe will be located within 10 feet of the top of the bentonite seal. Pumping shall continue until undiluted grout flows from the boring at the ground surface.

5.1.5 Well Completion Details

The well riser will be enclosed with a larger diameter steel security casing rising 24 inches above ground level and set into the concrete pad. It is anticipated that the riser pipe will extend above the ground approximately 18 to 24 inches. The steel

casing will have a drain hole near the base for drainage purposes. The security cap will have a hinged locking cap feature. Keyed-alike pad-locks will be provided for each of the wells. Two sets of duplicate keys will be provided to the Base Environmental Office at GAFB. The steel security cap will be painted with a rust-inhibiting paint to prevent corrosion. Three two-inch diameter or larger protective posts will be equally spaced around the well and embedded in the concrete pad. The protective posts will extend 3 feet above and 2 feet below ground level.

Some wells may be required to be finished flush with the ground or pavement if they are in areas of heavy traffic. Flush finished wells will also be equipped with a lock and shall be protected from the entry of surface fluids into the well.

A 3-foot by 3-foot by 4-inch thick concrete pad will be installed around each of the aboveground monitoring wells at the site. The ground immediately surrounding the top of the well will be sloped away from the well. The pad will be sloped slightly from the well to the edges of the pad to allow for surface water runoff. The design will be installed in a manner so as to prevent frost heaving which could damage the well.

5.1.6 Abandonment Procedures

If a monitoring well is disapproved by the CEMRK or is abandoned by LAW for any reason, the hole will be completely backfilled with cement grout. The grout mixture will be the same as described in section 5.1.4.

6.0 MONITORING WELL DEVELOPMENT

Each monitoring well will be developed no sooner than 48 hours but within two weeks after placement of grout. Development protocol will be as follows:

- Measure static water level of water.
- Measure total well depth. Calculate the volume of water in the well and annulus.
- Development of the well shall consist of pumping and/or surging for a minimum of four hours or until the water is clear and free of sand. A minimum of five well volumes shall be removed. Temperature, specific conductivity, turbidity (ASTM D-1899) and pH will be monitored before, during and after development.
- Record physical characteristics of water throughout well development (color, odor, turbidity, etc.).
- Record the total quantity of water removed (five well volumes or to dryness three times).
- Measure static water level after at least 24 hours.
- After final development, collect one liter of water from the well in a clear glass jar, label and photograph it and submit a 35mm color slide to CEMRK as part of the well log. Photo must be a closeup and suitably backlit to show the clarity of the water.

A dedicated teflon bailer will be installed in each monitoring well and will remain with the well after completion of the contract. Well development data will be recorded on the form shown in Figure 6-1.

FIGURE 6-1

LAW ENVIRONMENTAL, INC.
GOVERNMENT SERVICES DIVISION

JOB NAME _____ JOB No. _____

BY _____ DATE _____ SHEET _____ OF _____

WELL DEVELOPMENT DATA

1. Well No. _____
2. Date of Installation : _____
3. Date of Development : _____
4. Static Water Level : Before Development _____ ft.: 24 Hours After _____ ft
5. Quantity of Water Loss During Drilling, If Used _____ Gal.
6. Quantity of Standing Water in Well and Annulus Before Development _____ Gal.

	Start	During		End
7. Specific Conductance (umhos/cm)	_____	_____	_____	_____
Temperature (c°)	_____	_____	_____	_____
pH (s.u.)	_____	_____	_____	_____

8. Depth From Top of Well Casing to Bottom of Well _____ ft.
9. Screen Length _____ ft.
10. Depth to Top of Sediment : Before Development _____ ft.; After Development _____ ft.
11. Physical Character of Water : _____
12. Type and Size of Well Development Equipment : _____
13. Description of Surge Technique, If Used : _____
14. Height of Well Casing Above Ground Surface : _____ ft.
15. Quantity of Water Removed : _____ Gal. Time for Removal : _____ Hr./Min.
16. 1-Liter Water Sample Collected : _____ (Time)
17. Turbidity in Nephelometric Units _____ NTUs

*Development Conditions : 1) Well Water if Reasonably Clear
2) Sediment Thickness 5% of Screen Length
3) Removal of 5 Well Volumes, Including Saturated Filter Annulus
4) Stabilization of Specific Conductance and Water Temperature

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7.0 IN-SITU HYDRAULIC CONDUCTIVITY TESTING

Hydraulic conductivity tests can be performed on each monitoring well following sampling. The tests which will be performed at this site are known as the "slug in" and "slug out" tests. The "slug in" test involves inserting a slug (solid PVC rod) into the water column in the well to raise the water level. The water level recovery to static water level is recorded over time using an electronic pressure transducer. Readings will be taken continuously and recorded until the static water level is reached. The slug is removed for the "slug out" test and recovery of the water level back to static water level is recorded over time using a hydrologic computer monitor.

The data results of the hydraulic conductivity test are then calculated. The following formula (Bouwer, 1989) is utilized to calculate hydraulic conductivity (K):

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2L_e} * \frac{1}{t} * \ln \frac{Y_o}{Y_t}$$

Where: r_c = well radius

R_e = effective radial distance over which the head difference is dissipated

r_w = radial distance between well center and undisturbed aquifer

L_e = height of saturated screen

Y_o = water level Y at time zero

Y_t = water level Y at time t

t = time since Yo

The formation permeability will be computed using appropriate predictive equations.

8.0 DISPOSAL OF DRILL CUTTINGS AND FLUIDS

8.1 DRILL CUTTING

Drill cuttings generated during drilling activities will be placed in drums that are DOT approved for transport of hazardous materials. "Potentially-hazardous materials" will be interpreted to mean materials with OVA readings exceeding 5 ppm above background levels. Drums will be properly labeled and placed on pallets prior to being moved. Labeling of drums will include:

- type of material enclosed
- boring number
- date
- site name
- Base Environmental Coordinator telephone number
- CEMRK telephone number

LAW Environmental will move the drums once to a location on GAFB as specified by the Base Environmental Coordinator.

8.2 DRILLING FLUIDS AND DEVELOPMENT WATER

Drilling fluids, associated sediments and development water will be containerized in drums. Drums will be mounted on pallets and transported by GAFB personnel to a staging area at the facility. After chemical analysis of sampling points are complete, CEMRK will contact the environmental personnel at GAFB concerning proper drum disposal procedures.

9.0 REFERENCES

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