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**U.S. Department of Energy
Grand Junction Office Remedial Action Project
Final Report of the Radiological
Release Survey of Building 19
at the Grand Junction Office Facility**

September 1997

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GRAND JUNCTION OFFICE

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Grand Junction Office Remedial Action Project

**Final Report
of the Radiological Release Survey
of Building 19 at the
Grand Junction Office Facility**

September 1997

Prepared for
U.S. Department of Energy
Albuquerque Operations Office
Grand Junction Office

Prepared by
WASTREN-Grand Junction
Grand Junction, Colorado

WASTREN-Grand Junction has been granted authorization to conduct remedial action under the Decontamination and Decommissioning Program. Remedial action was conducted at the DOE-GJO facility in accordance with all applicable or relevant and appropriate requirements.

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Signature Page

Prepared by:



R. K. Johnson, Senior Technical Specialist
L & R Technical Services

9/15/97
Date

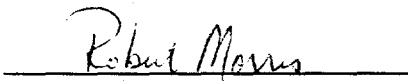

S. G. Corle, Technical Lead
Grand Junction Office Remedial Action Project
Holmes & Narver Services, Inc.

9/16/97
Date

Approved by:


J. W. Gardner, Project Manager
Grand Junction Office Remedial Action Project
Holmes & Narver Services, Inc.

9/16/97
Date


R. L. Morris, Radiation Protection Program Manager
WASTREN-Grand Junction

9/16/97
Date


B. H. Young, Project Manager
U.S. Department of Energy
Grand Junction Office

9/16/97
Date

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Abstract

The U.S. Department of Energy (DOE) Grand Junction Office (GJO) occupies a 61.7-acre facility along the Gunnison River near Grand Junction, Colorado. This site was contaminated with uranium ore concentrates and mill tailings during vanadium refining activities of the Manhattan Engineer District, and during sampling, assaying, pilot milling, storage, and brokerage activities conducted for the U.S. Atomic Energy Commission's domestic uranium procurement program. The DOE Defense Decontamination and Decommissioning Program established the GJO Remedial Action Project (GJORAP) to clean up and restore the facility lands, improvements, and underlying aquifer. *WASTREN-Grand Junction* is the site contractor for the facility and the remedial action contractor for GJORAP.

Building 19 and the underlying soil were found not to be radiologically contaminated; therefore, the building can be released for unrestricted use. Placards have been placed at the building entrances indicating the completion of the radiological release survey and prohibiting the introduction of any radioactive materials within the building without written approvals from the GJO Facilities Operations Manager. This document was prepared in response to a DOE-GJO request for an individual final release report for each GJO building.

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Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	<i>U.S. Code of Federal Regulations</i>
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FOS	Facilities Operations & Support contractor (<i>WASTREN-Grand Junction</i>)
FUSRAP	Formerly Utilized Sites Remedial Action Program
GJO	Grand Junction Office
GJORAP	Grand Junction Office Remedial Action Project
GJPORAP	Grand Junction Projects Office Remedial Action Project
ICRP	International Commission on Radiological Protection
IVC	independent verification contractor (Oak Ridge National Laboratory)
LTSM	long-term surveillance and maintenance
MDC	minimum detectable concentration
ORNL	Oak Ridge National Laboratory
RDC	radon decay-product concentration
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SFMP	Surplus Facilities Management Program
TAR	Technical Assistance & Remediation contractor (MACTEC-ERS)
U.S.C.	United States Code
WL	working level

I. Introduction and Background

This report summarizes the results of the radiological release survey for Building 19 at the U.S. Department of Energy Grand Junction Office (DOE-GJO) facility. After all Grand Junction Office Remedial Action Project (GJORAP) remedial action is completed, the DOE-GJO facility will be transferred to the Long-Term Surveillance and Maintenance (LTSM) Program to monitor the passive restoration of the underlying aquifer. Additional reports summarize the remediation and release surveys of the exterior land areas, the other buildings, and associated utilities on the DOE-GJO facility.

Description of Facility

The DOE-GJO facility (Figure 1) is located approximately 0.6 mile (1 kilometer) south and west of populated areas of the city of Grand Junction in Sections 26 and 27, Township 1 South, Range 1 West, Ute Principal Meridian, Mesa County, Colorado. The facility occupies 61.7 acres (25 hectares) of floodplain within an accretionary bend along the east bank of the Gunnison River.

The elevation of the DOE-GJO facility is approximately 4,560 feet, or 1,390 meters (m). The facility is situated on silty sandy gravel underlain by mudstone bedrock. Two bodies of water with associated wetlands are located on the DOE-GJO facility: the North Pond and the South Pond. A freshwater alluvial aquifer underlying the facility is in direct hydraulic contact with the ponds and the Gunnison River. A semiarid climate prevails.

Access to the occupied portion of the facility currently is restricted by security personnel and a fence. There are approximately 36 structures on the facility. Beyond the fence are vehicle parking lots to the east and an earthen dike along the Gunnison River to the west and north. The area adjacent to the facility to the north was formerly Black Bridge Park, now owned by DOE. The facility is bordered on the east by the Union Pacific Railroad right-of-way.

DOE-GJO facility lands were acquired by the U.S. War Department in 1943 for the Manhattan Engineer District. A vanadium refinery was operated on the site from 1943 to 1946 to treat and concentrate uranium oxide. The U.S. Atomic Energy Commission operated a uranium-concentrate sampling plant and assay laboratory on the site until 1974. Pilot-scale uranium ore mills were operated from 1953 to 1958, processing 30,000 tons (27,200 metric tons) of ore (DOE 1987a). Mill operations were the primary source of contaminated materials at the DOE-GJO facility, resulting in the on-site burial of approximately 247,000 cubic yards (189,000 cubic meters) of uranium mill products. Other potential sources of contamination included laboratory and vehicle-maintenance wastes and byproducts, and activities related to sampling and stockpiling uranium concentrates (including yellowcake— U_3O_8). Approximately 22 acres (8.9 hectares) of open land and 19 buildings were contaminated.

Description of Project

In 1984, the DOE-GJO facility was accepted into the DOE Surplus Facilities Management Program (SFMP) for the purpose of eliminating health hazards resulting from uranium mill tailings and associated contaminated materials at the facility; and to bring contaminated portions of the facility, including the underlying aquifer, into compliance with applicable environmental regulations (DOE 1989a).

The facility was transferred to the DOE Decontamination and Decommissioning (D&D) Program in 1988. The D&D Program is responsible for the surveillance and maintenance of surplus DOE facilities, and performing any necessary decontamination and decommissioning activities. DOE-GJO has specific responsibility for GJORAP under the D&D Program.

WASTREN-Grand Junction (WASTREN) is the Facilities Operations & Support (FOS) contractor for DOE-GJO, and is the remedial action contractor for GJORAP. The GJORAP

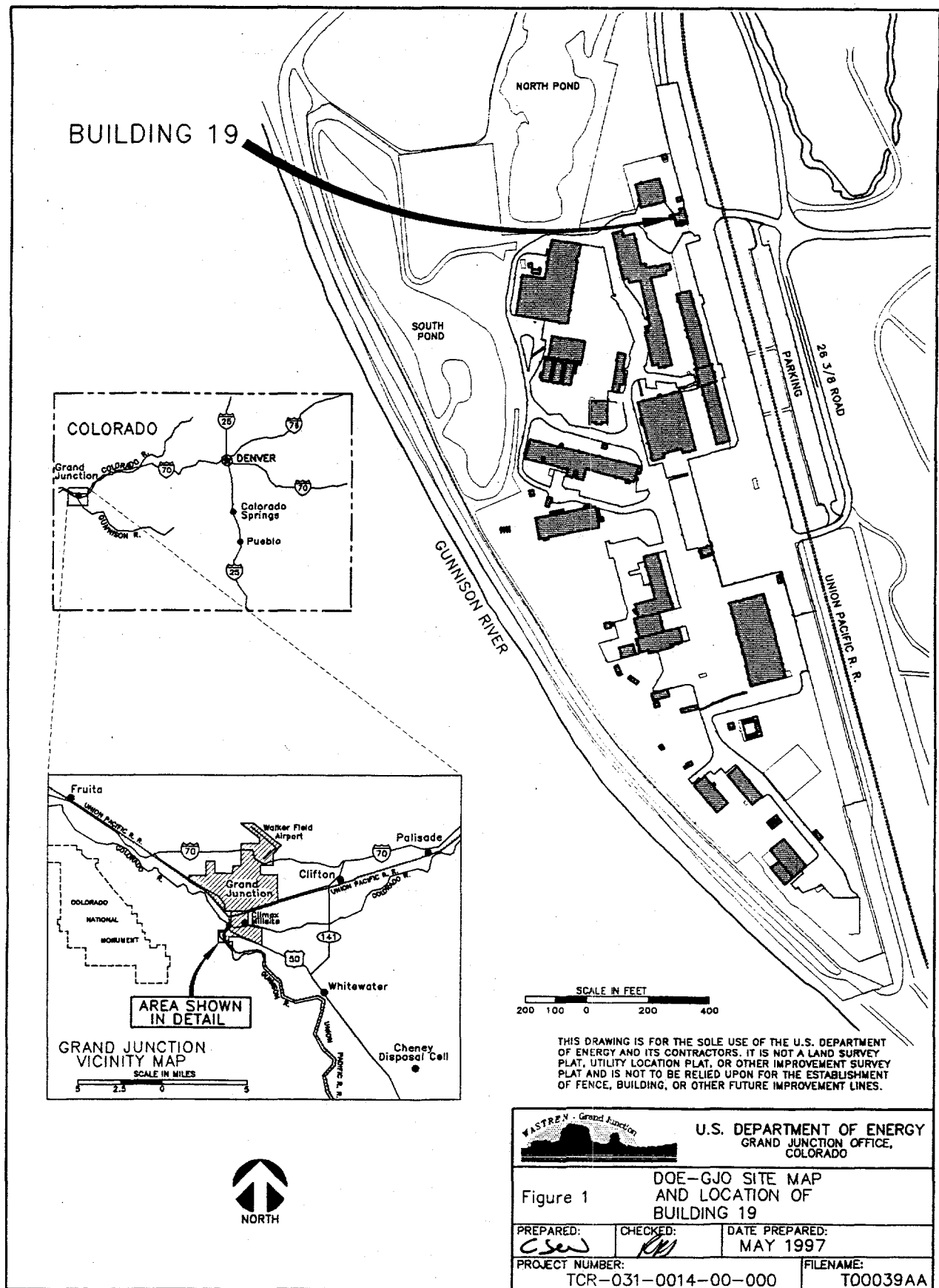


Figure 1. DOE- GJO Site Map and Location of Building 19

organization and implementation strategy was defined in the *Grand Junction Projects Office, Remedial Action Project Remedial Action Plan* (DOE 1990d). The project originally was administered as the Grand Junction Projects Office Remedial Action Project (GJPORAP).

Description of Building 19

Building 19 was constructed on the DOE-GJO facility in 1948 and was used as the Main Gate. Currently, the building serves as a guardhouse (North Gate) and office space for security personnel. Major modifications of the structure occurred in 1953 and 1967.

The building has a footprint of approximately 994 square feet, or 92.3 square meters (m²). It is constructed of a wood frame on a concrete slab, with sheet steel siding and a flat built-up roof. The interior walls are constructed of wood framing and sheetrock.

Basis for Remedial Action

In 1980, the U.S. Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 *United States Code* [U.S.C.] 9601). In 1986, Congress amended CERCLA with the Superfund Amendments and Reauthorization Act (SARA). Section 120 of SARA and Executive Order 12580, *Superfund Implementation*, directed DOE to coordinate with the U.S. Environmental Protection Agency (EPA) to respond to actual or potentially imminent releases of hazardous substances into the environment at federally-owned DOE facilities. D&D Program policy specifies that remedial action will be conducted in accordance with DOE Order O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, and all other applicable environmental regulations.

The DOE-GJO facility was evaluated using the CERCLA Hazard Ranking System. Although the resulting score of 14.6 (DOE 1989b) did not qualify the facility for placement

on the National Priorities List, remedial action under GJORAP conformed to the applicable provisions of CERCLA, as amended by SARA, the Uranium Mill Tailings Radiation Control Act (42 U.S.C. 7901), the National Environmental Policy Act (42 U.S.C. 4321), and other applicable Federal and State regulations. Remedial action was conducted with an emphasis on maintaining all health and safety risks as low as reasonably achievable.

II. Decommissioning Criteria, Objectives, and Work Scope

Applicable Guidelines and Standards

Table 1 presents the guideline documents that specify the authorized limits for releasing GJORAP buildings and open land (the applicable authorized limits are provided in Table 3). Remedial action activities on the facility have been conducted in accordance with approved plans and procedures (Appendix A) which incorporate the applicable provisions of Title 10, *U. S. Code of Federal Regulations*, Part 830 (10 CFR 830), Section 120, "Quality Assurance Requirements."

III. Work Performed

Remedial Investigation/Feasibility Study and Record of Decision

The Remedial Investigation/Feasibility Study—Environmental Assessment for GJPORAP was released in 1989 (DOE 1989a). Building 19 was not included in this study because it was outside the original scope of GJPORAP. Consequently, the release survey of this building was not addressed in the Record of Decision (ROD) (DOE 1990a).

Post-ROD Changes—An Explanation of Significant Differences will be prepared at the conclusion of GJORAP remedial action activities to address departures from the ROD, including the release survey of Building 19.

Table 1. Applicable or Relevant and Appropriate Standards

Type of Occurrence	Standard
Contamination in Soil	40 CFR 192 ^a FUSRAP/SFMP Guidelines ^b DOE Order 5400.5 ^c
Surface Activity (building surfaces)	FUSRAP/SFMP Guidelines ^b DOE Order 5400.5 ^c
Gamma Exposure Rate (interior areas only)	40 CFR 192 ^a FUSRAP/SFMP Guidelines ^b DOE Order 5400.5 ^c
Radon Decay-Product Concentration (interior areas only)	40 CFR 192 ^a FUSRAP/SFMP Guidelines ^b DOE Order 5400.5 ^c

^a40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings."

^bGuidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites (DOE 1987b).

^cDOE Order 5400.5, Radiation Protection of the Public and the Environment.

Characterization

A three-month-long radon decay-product concentration (RDC) measurement, completed in February 1990, was 0.011 working level (WL) (DOE 1990c).

Building 19 was included in the 1993 comprehensive survey of the structures at the DOE-GJO facility. No radiological contamination was identified (Chem-Nuclear Geotech, Inc. 1993).

One deposit of contaminated soil, located within 3 m of the building, was assessed and remediated as verification area V-488 during the decontamination and decommissioning of the exterior land areas (DOE 1995a). The excavation was 9 inches (23 centimeters) deep. Radionuclide concentrations (including background) in a composite sample collected at the bottom of the excavation were 1.9 picocuries per gram (pCi/g) for radium-226 (Ra-226), and 3.3 pCi/g for thorium-230 (Th-230). The sample was not analyzed for total uranium. Gamma exposure rates at the bottom of the excavation ranged from 14 to 24 microrentgens per hour (μ R/h).

Identification and removal of nonradiological hazardous materials is not required for radiological release of DOE-GJO buildings; however, when these materials are identified they are managed as required by appropriate regulations. Building 19 was surveyed for nonradiological hazardous materials in 1995. The linoleum floor tile was found to contain non-friable asbestos (DOE 1995b).

Remedial Design

A remedial design was not required because no radioactive contamination was identified with Building 19.

IV. Final Release Survey

Building 19 was surveyed in February and May 1997 in accordance with the *Survey Plan for Releasing the Buildings at the Grand Junction Projects Office for Unrestricted Use* (DOE 1995c).

The soil areas adjacent to and beneath Building 19 were classified as unaffected because the associated exterior land area had been assessed and remediated and no

contamination was found to extend beneath the building (DOE 1995a). One exterior soil survey unit was established: Survey Unit 3 (180 m²) consisting of the exterior ground surfaces within 3 m of the building foundation.

The building surfaces were also classified as unaffected because existing survey data and the history of the building indicated low potential for contamination. Two survey units were established: Survey Unit 1 (276 m²) consisting of the exterior walls, roof, and underside of the roof overhang; and Survey Unit 2 (314 m²) consisting of the interior walls, floor, and ceiling.

Oak Ridge National Laboratory (ORNL) at Grand Junction was the independent verification contractor (IVC) for GJORAP. Oversight activities were conducted by representatives of the FOS Safety & Health Group and GJORAP Project Management.

Instrumentation

Radiation detection instruments were calibrated and used in accordance with the FOS *Calibration and Control Program Manual*. The instruments were checked daily for current calibration and proper operation. Calibrations used traceable standards and complied with 10 CFR 835, "Occupational Radiation Protection," DOE Order O 420.1, *Facility Safety*, and DOE Order O 440.1 *Worker Protection Management for DOE Federal and Contractor Employees*. Minimum detectable concentrations (MDCs) were calculated to ensure sufficient instrument sensitivity for

measuring beta-gamma activity and gamma exposure rates at or below the authorized limits (*WASTREN* 1997b). MDCs are provided in Appendix B, Table B-1.

Background Determinations

Gamma-exposure-rate and radionuclide-concentration background values, determined for the DOE-GJO facility during previous investigations, are summarized in Table 2. Beta-gamma background activities used for this release survey were based on an average ambient air activity of 1500 disintegrations per minute per 100 square centimeters (dpm/100 cm²) plus material-specific activities determined from measurements collected on construction materials similar to those used on the DOE-GJO facility (*WASTREN* 1997a, DOE 1997). The applicable beta-gamma background activities are listed in Appendix B, Tables B-2 through B-4.

Reference Grids

A 1-m by 1-m survey grid, tied to the southwest corner of the building and the DOE-GJO facility survey grid, was established for the building-surface survey units. Survey Unit 3 (exterior ground surfaces) was divided into eight approximately equal verification cells of 25 m² or less.

Scanning Results

One hundred percent of the exposed ground surface and the floor were scanned for gamma activity. Gross gamma exposure rates for the

Table 2. Gamma Exposure Rate and Soil Concentration Background Values for the DOE-GJO Facility

Criterion	Background Value	Source of Data
Gamma Exposure Rate	14 μ R/h	DOE 1986
Radium-226 Concentration in Soil	1.0 pCi/g	DOE 1990b
Thorium-230 Concentration in Soil	2.0 pCi/g	DOE 1990b
Total Uranium Concentration in Soil	2.0 pCi/g	DOE 1990b

Key: μ R/h = microrentgens per hour; pCi/g = picocuries per gram

exterior ground surfaces and the floor are shown in Appendix B, Figures B-1 and B-2.

One-square-meter grid blocks were scanned for beta-gamma activity at randomly-selected locations on the building surfaces. Measured activities are listed in Appendix B, Tables B-2 and B-3.

Direct Measurements

Direct beta-gamma measurements were taken within the scanned grid blocks for statistical analysis. These measurement results are provided in Appendix B, Tables B-2 and B-3. Results of additional measurements taken at selected locations and behind building surfaces are included in Appendix B, Table B-4. Measurement locations are shown in Appendix B, Figures B-1 through B-7. The projected upper limits of the mean activities, calculated at the 95 percent confidence level, indicate that the surface activities on the building surfaces do not exceed the authorized limits (Appendix B, Table B-7). The additional measurements indicated no significantly elevated activities, also.

In addition to measurements on building surfaces, direct measurements were taken on the exterior soil surfaces (beneath pavement) within 3 m of the building to screen for uranium. No significantly elevated activities were measured (Appendix B, Table B-4).

Alpha activity was not measured because any alpha-emitting contaminant at this site would also emit a detectable beta particle. For surfaces, uranium is the alpha-emitting contaminant of concern. Since uranium emits beta and alpha particles in a ratio nearly 1:1, compliance with authorized limits for beta-gamma activity demonstrates compliance with authorized limits for alpha activity.

Interior and exterior gamma exposure rates were measured 1 m above the floor or ground. Measurement locations are shown in Appendix B, Figures B-1 and B-2, and results

are provided in Appendix B, Table B-5. The projected upper limits of the mean exposure rates, calculated at the 95 percent confidence level, indicate that the gamma exposure rates do not exceed the interior authorized limit or exterior guideline (Appendix B, Table B-7).

RDC Results

The average of three RDC measurements taken in Building 19 during a three-month-long period in 1997 was 0.0022 WL, which indicates that the working level is below the authorized limit.

Sample Results

Soil samples were collected at the location of highest surface gamma exposure rate within each verification cell. The samples were analyzed for Ra-226, Th-230, and total uranium. The results demonstrate that the radionuclide concentrations do not exceed the authorized limits for radionuclide concentrations in hot spots or averaged over 100 m² (Appendix B, Table B-6). The projected upper limits of the mean concentrations, calculated at the 95 percent confidence level, indicate that the radionuclide concentrations do not exceed the authorized limits.

V. Cost and Schedule

Project costs and the schedule for the release survey of Building 19 will be presented in a summary final report addressing all GJORAP buildings.

VI. Occupational Exposure

Health and safety procedures were followed in accordance with *The GJO Health and Safety Standards* and *The GJO Site Radiological Control Manual* to ensure personnel associated with the release survey activities were protected from radiological and nonradiological hazards.

VII. Waste Volumes

Building 19 did not require remediation; therefore, no radiologically-contaminated materials were generated.

VIII. Final Condition

All release requirements identified for GJORAP have been met for Building 19 (Table 3). The IVC will issue a Statement of Verification to signify concurrence that the release survey has achieved program objectives.

Building 19 can be released for unrestricted use. Placards have been placed at the building entrances indicating the completion of the radiological release survey and prohibiting the introduction of any radioactive materials within the building without written approvals from the GJO Facilities Operations Manager.

Because of the limitations of current technology and procedures for identifying and remediating radiologically-contaminated materials, unknown deposits of contamination may be found in the future. The potential for encountering contamination during future construction activities will be determined and at-risk activities will be monitored for radiological and nonradiological contamination. The DOE-GJO facility is routinely surveyed for radiation and other hazards.

At the time of this report, contamination is still present in other buildings located on the DOE-GJO facility; access to these areas is controlled and will be addressed by future GJORAP remedial actions. Once the interior remedial actions are completed, the DOE-GJO facility will be managed as an LTSM site by DOE until the alluvial aquifer is restored by natural flushing.

IX. Lessons Learned

Several lessons were learned during release survey activities involving the DOE-GJO

buildings in FY 1997. The experience gained has been applied to subsequent surveys, and should be considered for use on other DOE projects. The following lessons have been learned:

- Radiological protection managers should ensure that survey technicians and their trainers are fully trained and tested on every type of equipment that will be used for performing release surveys. A small quantity of unusable data were collected because survey crew members misinterpreted the display on a new type of survey instrument. Although the problem was caught early, it could have resulted in a large quantity of useless and expensive data. Special care is required when new types of equipment are introduced into the field. Furthermore, it may be desirable to involve manufacturers' technical representatives in the initial training and testing of personnel who will use the equipment.
- Project team members should be encouraged to think critically about all project activities so that wasteful or otherwise inappropriate practices are recognized and eliminated as soon as possible. An example of this process occurred when personnel not directly involved in the release surveys questioned the practice of measuring beta-gamma background activity on surfaces in the same buildings being surveyed for release. This practice could mask contamination by incorporating its activity in the background measurement, thus compromising the validity of release survey results. A subsequent study of beta-gamma activities contributed by common building materials indicated that most background measurements for beta-gamma activity in the DOE-GJO buildings can be performed by measuring ambient background activity in air.
- Good communication and coordination of activities is essential for limiting unnecessary delays and costs. For example,

Table 3. Certification Summary for All Survey Units

Certification Criteria	Number of Observations	Authorized Limit	Results ^a
Surface Activity (building surfaces only)	77 direct beta-gamma measurements	Alpha or beta-gamma activity shall not exceed 5,000 dpm/100 cm ² fixed averaged over 1 m ² .	Maximum beta-gamma = 650 dpm/100 cm ² $\mu_{95\%}$ = 130 dpm/100 cm ² for Survey Unit 2 $\mu_{95\%}$ = -90 dpm/100 cm ² for Survey Unit 3
	0 smears ^b	Alpha or beta-gamma activity shall not exceed 1,000 dpm/100 cm ² removable.	Maximum direct beta-gamma = 650 dpm/100 cm ²
	64 scan beta-gamma measurements ^b	Alpha or beta-gamma activity shall not exceed 15,000 dpm/100 cm ² maximum averaged over 100 cm ² .	Maximum direct beta-gamma = 650 dpm/100 cm ²
Gamma Exposure Rate (habitable areas only)	23 static measurements ^c	$\leq 20 \mu\text{R/h}$ above background ^d	Maximum rate = -1.5 $\mu\text{R/h}$ $\mu_{95\%}$ = -2.2 $\mu\text{R/h}$
	100% floor scan	$\leq 20 \mu\text{R/h}$ above background ^d	Ranged from -2.7 to 0.3 $\mu\text{R/h}$
Radon Decay-Product Concentration (habitable areas only)	3 three-month measurements	Annual average shall not exceed 0.02 WL, to the extent practicable, and in no case shall exceed 0.03 WL.	\bar{x} = 0.0022 WL
Radionuclide Concentrations in Soil	8 individual samples	Ra-226 and Th-230: Shall not exceed 5 pCi/g above background ^d in the 15-cm surface layer, averaged over 100 m ² .	Ra-226: \bar{x}_{max} = 1.9 pCi/g \bar{x} = 1.4 pCi/g $\mu_{95\%}$ = 2.5 pCi/g Th-230: \bar{x}_{max} = 1.1 pCi/g \bar{x} = 0.4 pCi/g $\mu_{95\%}$ = 1.9 pCi/g
	None	Shall not exceed 15 pCi/g above background ^d in any 15-cm-thick soil layer more than 15 cm below the surface, averaged over 100 m ² .	Not applicable
	8 individual samples	Total uranium: Shall not exceed 106 pCi/g above background ^d in any 15-cm-thick layer, averaged over 100 m ² .	\bar{x}_{max} = 4.9 pCi/g \bar{x} = 3.6 pCi/g $\mu_{95\%}$ = 6.1 pCi/g
Soil Hot-Spot Criteria	As required for samples exceeding authorized limits	Limit = (authorized limit) \times (100/area) ^{0.5}	Not applicable: maximum concentrations are below authorized limits.

^aNet results (background subtracted).

^bCompliance was demonstrated by a combination of scans and direct measurements. Direct measurements were made at locations of highest elevated activity if elevated activity was present. Otherwise, direct measurements were made at the centers of the 1-m² grid blocks.

^cGamma exposure rates were measured 1 m above the floor.

^dBackground values are summarized in Table 2.

Table 3 (continued). Certification Summary for All Survey Units

Key for Table 3:

dpm/100 cm ²	=	disintegrations per minute per 100 square centimeters
cm	=	centimeter(s)
m ²	=	square meter(s)
μ _{95%}	=	upper limit of the true population mean at the 95 percent confidence level

μR/h	=	microrentgens per hour
WL	=	working level
Ra-226	=	radium-226
Th-230	=	thorium-230
pCi/g	=	picocuries per gram
\bar{x}	=	mean of all sample concentrations
\bar{x}_{\max}	=	maximum concentration averaged over a contiguous 100 m ² area

organizations that prepare survey plans should also be involved in the release surveys. A staff member from the organization that prepared the GJORAP survey plan met with the survey crews each morning and occasionally during each day to answer survey crews' questions and observe the work. As a result, problems related to staffing, recording data, reading survey instruments, and interpreting the plan were identified and corrected before they resulted in delays to the project or significantly increased costs.

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_____, 1995b. *Comprehensive Asbestos Inspection Report*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, October.

_____, 1995c. *Survey Plan for Releasing the Buildings at the Grand Junction Projects Office for Unrestricted Use*, prepared by Rust Geotech for the U.S. Department of Energy Grand Junction Projects Office, Grand Junction, Colorado, December.

_____, 1997. *Survey for Determining Background Activities of Common Building Materials*, prepared by WASTREN-Grand Junction for the U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado, August.

WASTREN-Grand Junction, 1997a. *Ambient Air Activity for Release Surveys of Buildings 11, 19, 29, 30B, 54, and 56*, memorandum from S.G. Corle to GJORAP Building Files, U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado, August 8.

_____, 1997b. *MDC Calculations for GJORAP*, memorandum from R.L. Morris to S.G. Corle, U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado, August 22.

Appendix A

Applicable Program and Quality Assurance Requirements and Procedures

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The following manuals and guidance documents were used as applicable for conducting GJORAP administrative and performance activities. The specific manuals and documents pertinent to the activities associated with the release survey of this building are noted in the text of this report.

Joint Contractor Manuals

The GJO Quality Assurance Manual (GJO 1)

The GJO Health and Safety Standards (GJO 2)

The GJO Site Radiological Control Manual (GJO 3)

The GJO Training Manual (GJO 4)

The GJO Construction Procedures Manual (GJO 5)

The GJO Environmental Procedures Catalog (GJO 6)

The GJO Formality of Operations Manual (GJO 7)

The GJO Emergency Preparedness & Response Plan (GJO 8)

FOS Contractor Manuals

Safety and Health Manual

Environmental Compliance Manual

Operations Management Manual

Information Services Manual

Project Management Controls System Description

Budget Manual

Site Management Manual

Calibration and Control Program Manual

Information Management Support Manual

Grand Junction Projects Office Remedial Action Project Quality Assurance Program Plan (P-GJPO-141, Rev. 6)

Grand Junction Projects Office Remedial Action Project Records Management Plan (P-GJPO-143)

Grand Junction Projects Office Remedial Action Project Health and Safety Plan (P-GJPO-144, Rev. 7)

Engineering Support Procedures Manual

AutoCAD Standards Manual

Analytical Chemistry Laboratory Administrative Plan and Quality Control Procedures

Analytical Chemistry Laboratory Handbook of Analytical and Sample Preparation Procedures, Volumes I, II, III, and IV

TAR Contractor Manual

Field Services Procedures Manual (Manual MAC-3000)

Other Guidance

10 CFR 830, "Nuclear Safety Management."

10 CFR 835, "Occupational Radiation Protection."

40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings."

40 CFR 261, "Identification and Listing of Hazardous Waste."

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan."

A Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD Version 4.0, Argonne National Laboratory, June 1989.

"Approval of the Grand Junction Projects Office Remedial Action Project: National Environmental Policy Act and Comprehensive Environmental Response, Compensation, and Liability Act Documents," DOE, February 29, 1990.

"Calculation of Total Uranium Specific Activity From Total Uranium Chemical Concentration by Weight," Rust Geotech, November 11, 1994.

Community Relations in Superfund: A Handbook, EPA, January 1992.

Defense Decontamination and Decommissioning Program: Program Management Plan, DOE, December 1989.

DOE Order O 420.1, *Facility Safety*

DOE Order O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, Change 2.

DOE Order 5700.6C, *Quality Assurance*, Change 1.

DOE Order 5820.2A, *Radioactive Waste Management*.

Environmental Implementation Guide for Radiological Survey Procedures, draft report, DOE, November 1992.

GJPORAP/IVC Project Management Summary, ORNL, May 1994.

Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, U.S. Nuclear Regulatory Commission, 1982.

Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Rev. 2, DOE, March 1987.

Interim Final Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment, EPA, July 1989.

Limits for Intakes of Radionuclides by Workers, International Commission on Radiological Protection (ICRP), August 1982.

Manual for Conducting Radiological Surveys in Support of License Termination, NUREG/CR 5849 [draft], prepared by Oak Ridge Associated Universities for the U.S. Nuclear Regulatory Commission, June 1992.

Procedures for Completion and Deletion of National Priority List Sites, EPA, October 1988.

Project Plan for the U.S. Department of Energy Grand Junction Projects Office Remedial Action Project, DOE, March 1986.

Proposed GJPORAP Release Criteria and Scope Impacts," DOE, July 20, 1989.

Public Participation in Environmental Restoration Activities, DOE, November 1991.

Quality Assurance Program for Nuclear Facilities, ANSI/ASME NQA-1, American Society of Mechanical Engineers, 1989.

Recommendations of the ICRP, ICRP, August 1987.

Record of Decision for Remedial Action at the Climax Uranium Company Uranium Mill Site, Grand Junction, Colorado, DOE, August 1988.

SFMP Resource Manual, DOE, 1989.

Verification and Certification Protocol for the Office of Environmental Restoration, Formerly Utilized Sites Remedial Action Program and Decontamination and Decommissioning Program, Rev. 3, DOE, November 1990.

*Work Plan for Independent Verification of the
Grand Junction Projects Office Remedial Action
Project, ORNL, October 1991.*

Appendix B

Final Radiological Conditions

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Appendix B Table Summary

Table B-1 provides MDC calculation results for the instruments used for beta-gamma activity and gamma exposure rate measurements. Beta-gamma scan and direct-measurement survey data for the building surfaces are listed in Tables B-2 and B-3. Table B-4 presents the results of additional measurements made during the release survey. Interior and exterior static gamma exposure rate measurement data are provided in Table B-5. Listed in Table B-6 are the soil sample results for the exterior ground area located within 3 meters of Building 19. Table B-7 presents the statistical summary of the measurement results.

Appendix B Figure Summary

The verification cells and sample and measurement locations for the exterior ground area are shown on Figure B-1. Figures B-2 through B-7 show the locations where beta-gamma scans were performed and direct measurements were made on the surfaces of the building. Interior gamma scans of the floor surface and static gamma measurement locations (1 m above the floor) are shown on Figure B-2.

Table B-1. Survey Instrumentation Sensitivities

Type of Measurement	Instrumentation		MDC ^a	
	Detector	Meter	Static	Scan
Beta-Gamma	Eberline SHP-340 Gas Proportional	Eberline E-600	530 dpm/100 cm ²	1700 dpm/100 cm ²
Gamma	Same as meter	Mount Sopris SC-132 Portable Scintillometer ^b	Not calculated ^c	3.4 μR/h

^aCalculations include background counts for a specified time period. Equations and calculations are provided in *MDC Calculations for GJORAP (WASTREN 1997b)*.

^bThe instrument has a 1.5 x 1.5-inch sodium iodide detector.

^cThe calculation of MDC for static gamma measurements is not appropriate due to empirical characteristics of the measurement method and associated variables. However, instrument detection is expected to be at least as sensitive as the scan MDC.

Key for Table B-1:

MDC = minimum detectable concentration
dpm/100 cm² = disintegrations per minute per 100 square centimeters
μR/h = microrentgens per hour

The following equations and factors were used to calculate instrument sensitivities (from *WASTREN 1997b*):

$$\text{Static MDC}_{\beta-\gamma} = \frac{3 + 4.65 * \sqrt{C_b}}{T * e_T * A * K} = \frac{3 + 4.65 * \sqrt{230}}{1 * 0.19 * 73 * 0.01} = 530 \text{ dpm/100 cm}^2$$

$$\text{Scan MDC}_{\beta-\gamma} = \frac{\frac{d' * \sqrt{B_r * T}}{T}}{\sqrt{E_{hf}} * e_T * A * K} = \frac{\frac{2 * \sqrt{230 * 1/60}}{1/60}}{\sqrt{1} * 0.19 * 73 * 0.01} = 1700 \text{ dpm/100 cm}^2$$

$$\text{Scan MDC}_{\gamma} = \frac{\frac{d' * \sqrt{B_r * T}}{T}}{\sqrt{E_{hf}} * e_i * K} = \frac{\frac{2 * \sqrt{6300 * 1/60}}{1/60}}{\sqrt{0.65} * 450 * 1} = 3.4 \text{ μR/h}$$

Where:

MDC_{β-γ} = minimum detectable concentration for measuring beta-gamma activities
MDC_γ = minimum detectable concentration for measuring gamma exposure rates
C_b = background counts for a count time T
T = count time or observational interval in minutes
e_T = total detector efficiency in counts per disintegration (based on 1997 calibration)
A = probe area in square centimeters
K = unit or time conversion factors
d' = index of sensitivity
B_r = background count rate in counts per minute
E_{hf} = human factors efficiency
e_i = instrument efficiency in counts per minute per μR/h (based on 1997 calibration where exposure rate (μR/h) = cps x 0.0748 + 6.03; therefore 105 cps = 13.9 μR/h, and 1 μR/h = 450 cpm)

Table B-2. Survey Unit 1 Surface Measurement Data

Loc. No.	Surface	Media	Background Activity ^a	Scan Beta-Gamma Activity				Direct Beta-Gamma Activity	
				Gross Max.	Gross Min.	Net Max.	Net Min.	Gross	Net
1	Exterior Wall	Steel	1500	1814	916	314	-584	1339	-161
2	Exterior Wall	Steel	1500	1882	1017	382	-483	1340	-160
3	Exterior Wall	Steel	1500	1699	1010	199	-490	1334	-166
4	Exterior Wall	Steel	1500	2350	885	850	-615	1470	-30
5	Exterior Wall	Steel	1500	1858	1167	358	-333	1463	-37
6	Exterior Wall	Steel	1500	1939	1155	439	-345	1484	-16
7	Exterior Wall	Steel	1500	1850	630	350	-870	1234	-266
8	Exterior Wall	Steel	1500	1890	680	390	-820	1426	-74
9	Exterior Wall	Steel	1500	1900	780	400	-720	1307	-193
10	Exterior Wall	Steel	1500	1560	870	60	-630	1342	-158
11	Exterior Wall	Steel	1500	1890	795	390	-705	1158	-342
12	Exterior Wall	Steel	1500	2320	1716	820	216	1907	407
13	Exterior Wall	Steel	1500	1995	960	495	-540	1974	474
14	Exterior Wall	Steel	1500	1884	780	384	-720	1710	210
15	Exterior Wall	Steel	1500	1990	1250	490	-250	1399	-101
16	Exterior Wall	Steel	1500	1968	960	468	-540	1465	-35
17	Exterior Wall	Steel	1500	1920	726	420	-774	1664	164
72	Exterior Wall	Steel	1500	1470	1036	-30	-464	1093	-407
73	Roof Overhang	Steel	1500	1467	1090	-33	-410	1471	-29
18	Roof	Roof Coating	2000	2320	1482	320	-518	1977	-23
19	Roof	Roof Coating	2000	2750	1280	750	-720	1920	-80
20	Roof	Roof Coating	2000	2460	1320	460	-680	2220	220
21	Roof	Roof Coating	2000	2950	1995	950	-5	2580	580
22	Roof	Roof Coating	2000	2680	1387	680	-613	2150	150
23	Roof	Roof Coating	2000	2819	1628	819	-372	1948	-52
24	Roof	Roof Coating	2000	2890	1853	890	-147	2530	530
25	Roof	Roof Coating	2000	3030	2350	1030	350	2650	650
26	Roof	Roof Coating	2000	2380	1350	380	-650	2040	40
27	Roof	Roof Coating	2000	2700	1530	700	-470	2340	340
28	Roof	Roof Coating	2000	2900	1460	900	-540	2150	150
29	Roof	Roof Coating	2000	2770	1610	770	-390	2110	110
30	Roof	Roof Coating	2000	2760	1418	760	-582	1961	-39
74	Roof	Roof Coating	2000	2170	1775	170	-225	2080	80

^aBackground activity includes average background ambient air and average material-specific activities (DOE 1997, WASTREN 1997a).

Note: All measurements were read in dpm/100 cm² and were collected with an Eberline E-600 meter with an Eberline SHP-340 probe to measure gross beta-gamma activity.

Table B-3. Survey Unit 2 Surface Measurement Data

Loc. No.	Surface	Media	Background Activity ^a	Scan Beta-Gamma Activity				Direct Beta-Gamma Activity	
				Gross Max.	Gross Min.	Net Max.	Net Min.	Gross	Net
31	Interior Wall	Sheetrock	1500	1665	1230	165	-270	1396	-104
32	Interior Wall	Sheetrock	1500	1560	1118	60	-382	1304	-196
33	Interior Wall	Sheetrock	1500	1587	1058	87	-442	1317	-183
34	Interior Wall	Sheetrock	1500	1460	989	-40	-511	1285	-215
35	Interior Wall	Sheetrock	1500	1440	1110	-60	-390	1396	-104
36	Interior Wall	Sheetrock	1500	1555	1130	55	-370	1174	-326
37	Interior Wall	Sheetrock	1500	1620	842	120	-658	1295	-205
38	Interior Wall	Sheetrock	1500	1523	843	23	-657	1165	-335
39	Interior Wall	Sheetrock	1500	1873	1010	373	-490	1302	-198
40	Interior Wall	Sheetrock	1500	1729	1089	229	-411	1312	-188
41	Interior Wall	Sheetrock	1500	1792	1019	292	-481	1296	-204
42	Interior Wall	Sheetrock	1500	1844	1096	344	-404	1528	28
43	Interior Wall	Sheetrock	1500	1918	1036	418	-464	1351	-149
44	Interior Wall	Sheetrock	1500	1848	1065	348	-435	1288	-212
45	Interior Wall	Sheetrock	1500	1620	921	120	-579	1524	24
46	Interior Wall	Sheetrock	1500	1423	1182	-77	-318	1393	-107
65	Interior Wall	Sheetrock	1500	NM	NM	N/A	N/A	1363	-137
66	Interior Wall	Sheetrock	1500	NM	NM	N/A	N/A	1283	-217
67	Interior Wall	Sheetrock	1500	NM	NM	N/A	N/A	1648	148
75	Interior Wall	Sheetrock	1500	1384	939	-116	-561	1224	-276
76	Interior Wall	Sheetrock	1500	1499	926	-1	-574	1080	-420
77	Interior Wall	Sheetrock	1500	1885	1366	385	-134	1567	67
78	Interior Wall	Sheetrock	1500	1585	1289	85	-211	1365	-135
79	Interior Wall	Sheetrock	1500	1528	922	28	-578	1061	-439
80	Interior Wall	Sheetrock	1500	1510	984	10	-516	1158	-342
81	Interior Wall	Sheetrock	1500	1590	1311	90	-189	1494	-6
82	Interior Wall	Sheetrock	1500	1565	1211	65	-289	1445	-55
83	Interior Wall	Sheetrock	1500	1775	1212	275	-288	1334	-166
84	Interior Wall	Sheetrock	1500	1532	1011	32	-489	1191	-309
85	Interior Wall	Sheetrock	1500	1598	1206	98	-294	1309	-191
47	Floor	Carpet	1500	1940	972	440	-528	1650	150
48	Floor	Carpet	1500	1950	1005	450	-495	1559	59
49	Floor	Carpet	1500	2270	957	770	-543	1512	12
50	Floor	Carpet	1500	2360	911	860	-589	1326	-174
51	Floor	Carpet	1500	2340	1045	840	-455	1735	235
52	Floor	Carpet	1500	2390	846	890	-654	1537	37
53	Floor	Carpet	1500	1885	1213	385	-287	1658	158
54	Ceiling	Sheetrock	1500	1480	990	-20	-510	1246	-254
55	Ceiling	Sheetrock	1500	1633	1048	133	-452	1586	86
56	Ceiling	Sheetrock	1500	1700	1100	200	-400	1402	-98
57	Ceiling	Sheetrock	1500	1254	976	-246	-524	1130	-370
58	Ceiling	Sheetrock	1500	1500	960	0	-540	1388	-112
59	Ceiling	Sheetrock	1500	1460	1000	-40	-500	1284	-216
60	Ceiling	Sheetrock	1500	1710	925	210	-575	1422	-78

^aBackground activity includes average background ambient air and average material-specific activities (DOE 1997, WASTREN 1997a).

Note: All measurements were read in dpm/100 cm² and were collected with an Eberline E-600 meter with an Eberline SHP-340 probe to measure gross beta-gamma activity.

Table B-4. Additional Measurement Data

Loc. No. ^a	Surface	Media	Background Activity ^b	Scan Beta-Gamma Activity				Direct Beta-Gamma Activity	
				Gross Max.	Gross Min.	Net Max.	Net Min.	Gross	Net
Survey Unit 1									
24 a	Roof	Tar	1500	NM	NM	N/A	N/A	2030	530
24 b	Roof	Wood	1500	NM	NM	N/A	N/A	1911	411
24 c	Roof	Gravel/Steel	1500	NM	NM	N/A	N/A	1671	171
24 d	Roof	Wood	1500	NM	NM	N/A	N/A	1509	9
68 a	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	2000	500
68 b	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	1782	282
68 c	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	2200	700
69 a	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	1791	291
69 b	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	1996	496
70 a	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	1448	-52
70 b	Exterior Wall	Wood	1500	NM	NM	N/A	N/A	1120	-380
71 a	Roof	Tar	1500	NM	NM	N/A	N/A	1911	411
71 b	Roof	Wood	1500	NM	NM	N/A	N/A	1742	242
71 c	Roof	Gravel/Steel	1500	NM	NM	N/A	N/A	2210	710
71 d	Roof	Wood	1500	NM	NM	N/A	N/A	1523	23
Survey Unit 2									
58	Ceiling	Metal	1500	2100	1448	600	-52	1474	-26
61 a	Floor	Tile	1700	NM	NM	N/A	N/A	1573	-127
61 b	Floor	Wood	1500	NM	NM	N/A	N/A	1573	73
62 a	Floor	Tile	1700	NM	NM	N/A	N/A	1559	-141
62 b	Floor	Wood	1500	NM	NM	N/A	N/A	1841	341
63 a	Floor	Wood	1500	NM	NM	N/A	N/A	1796	296
64 a	Interior Wall	Wood	1500	NM	NM	N/A	N/A	1389	-111
64 b	Interior Wall	Masonite	1500	NM	NM	N/A	N/A	1605	105
64 c	Interior Wall	Masonite	1500	NM	NM	N/A	N/A	1573	73
64 d	Interior Wall	Sheetrock	1500	NM	NM	N/A	N/A	1553	53
64 e	Interior Wall	Sheetrock	1500	NM	NM	N/A	N/A	1586	86
65 a	Interior Wall	Wood	1500	NM	NM	N/A	N/A	1481	-19
66 a	Interior Wall	Wood	1500	NM	NM	N/A	N/A	1326	-174
67 a	Interior Wall	Wood	1500	NM	NM	N/A	N/A	1395	-105

Table B-4 (continued). Additional Measurement Data

Loc. No. ^a	Surface	Media	Background Activity ^b	Scan Beta-Gamma Activity				Direct Beta-Gamma Activity	
				Gross Max.	Gross Min.	Net Max.	Net Min.	Gross	Net
Survey Unit 3									
19-V-1	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	2660	860
19-V-2	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	2290	490
19-V-3	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	2460	660
19-V-4	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	3030	1230
19-V-5	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	3170	1370
19-V-6	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	2420	620
19-V-7	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	2610	810
19-V-8	Exterior Soil	Soil	1800	NM	NM	N/A	N/A	2670	870

^aAlpha-numeric location numbers (e.g. 24 a) represent intrusive measurements taken on material under or behind the surface material.

^bBackground activity includes average background ambient air and average material-specific activities (DOE 1997, WASTREN 1997a).

Note: All measurements were read in dpm/100 cm² and were collected with an Eberline E-600 meter with an Eberline SHP-340 probe to measure gross beta-gamma activity.

Key for Table B-4:

NM = no measurement

N/A = not applicable

Table B-5. Gamma Exposure Rate Measurement Data

Interior Static Measurements

Loc. No.	Gross		Net ^a
	cps	$\mu\text{R/h}$	$\mu\text{R/h}$
G1	80	12.1	-1.9
G2	80	12.1	-1.9
G3	80	12.1	-1.9
G4	80	12.1	-1.9
G5	80	12.1	-1.9
G6	80	12.1	-1.9
G7	80	12.1	-1.9
G8	70	11.3	-2.7
G9	70	11.3	-2.7
G10	80	12.1	-1.9
G11	70	11.3	-2.7
G12	70	11.3	-2.7

Loc. No.	Gross		Net ^a
	cps	$\mu\text{R/h}$	$\mu\text{R/h}$
G13	70	11.3	-2.7
G14	60	10.6	-3.4
G15	70	11.3	-2.7
G16	70	11.3	-2.7
G17	60	10.6	-3.4
G18	60	10.6	-3.4
G19	70	11.3	-2.7
G20	70	11.3	-2.7
G21	60	10.6	-3.4
G22	80	12.1	-1.9
G23	85	12.5	-1.5

Exterior Static Measurements

Location Number	Gross		Net ^a
	cps	$\mu\text{R/h}$	$\mu\text{R/h}$
19-V-1	100	13.6	-0.4
19-V-2	100	13.6	-0.4
19-V-3	90	12.8	-1.2
19-V-4	100	13.6	-0.4
19-V-5	100	13.6	-0.4
19-V-6	90	12.8	-1.2
19-V-7	90	12.8	-1.2
19-V-8	90	12.8	-1.2

^aBackground gamma exposure rate for the facility is 14 $\mu\text{R/h}$ (Table 2).

Note: Gamma exposure rates were read in cps and were measured with a Mount Sopris SC-132 scintillometer at 1 m above the floor or ground.

Key for Table B-5:

cps = counts per second

$\mu\text{R/h}$ = microrentgens per hour ($\mu\text{R/h} = \text{cps} \times 0.0748 + 6.1$)

Table B-6. Soil Sample Results for Exterior Areas

Sample Number	Cell Area (m ²)	Soil Sample Ticket No.	Sample Depth ^a (cm)	Concentration (pCi/g)					
				Ra-226		Th-230		Total Uranium	
				Gross	Net ^b	Gross	Net ^b	Gross	Net ^b
19-V-1	24.7	NCK 741	8 - 23	1.80 ± 0.37	0.8	0.87	-1.1	1.9	-0.1
19-V-2	22.8	NCK 742	0 - 15	1.78 ± 0.51	0.8	1.5	-0.5	3.1	1.1
19-V-3	22.1	NCK 743	8 - 23	2.42 ± 0.47	1.4	2.1	0.1	4.2	2.2
19-V-4	22.3	NCK 744	8 - 23	1.64 ± 0.41	0.6	2.7	0.7	13.2	11.2
19-V-5	23.3	NCK 745	8 - 23	6.21 ± 0.68	5.2	7.7	5.7	8.7	6.7
19-V-6	20.0	NCP 302	0 - 15	2.33 ± 0.47	1.3	1.3	-0.7	5.1	3.1
19-V-7	22.7	NCP 303	0 - 15	1.46 ± 0.46	0.5	1.3	-0.7	4.4	2.4
19-V-8	22.5	NCP 304	0 - 15	1.57 ± 0.50	0.6	1.5	-0.5	4.5	2.5

^aSubsurface soil sample depths indicate the presence of an overlying pavement not included in the sample.

^bSee Table 2 for background concentrations used to calculate net concentrations.

Notes:

- 1) Ra-226 was analyzed by gamma spectrometry.
- 2) Th-230 and total uranium were analyzed by induction-coupled plasma-mass spectrometry with a flow-injection analysis system.
- 3) Analytical laboratory measurement methods, results, uncertainties, and quality control for these samples are contained in the Grand Junction Office Analytical Laboratory *Analytical Report*, Volumes 1 and 2, for Project L20A41000, June 11, 1997. All Ra-226 results were above minimum detectable activities. Uncertainties were not calculated for Th-230 and total uranium.
- 4) Bolded results were used to calculate the maximum net mean concentrations for contiguous areas totalling approximately 100 m², which are:
Ra-226 = 1.9 pCi/g
Th-230 = 1.1 pCi/g
Uranium = 4.9 pCi/g
- 5) Laboratory results for sample 19-V-5 exceed the Ra-226 and Th-230 standards for the surface layer. However, the sample represents only the lower half of the surface layer. The average net concentrations for the top 15-cm layer, assuming the upper half of the layer (asphalt) contains concentrations at background levels (Table 2), are 2.6 pCi/g for Ra-226 and 3.9 pCi/g for Th-230.

Key for Table B-6:

m² = square meter(s)
cm = centimeter(s)
pCi/g = picocuries per gram
Ra-226 = radium-226
Th-230 = thorium-230

Table B-7. Statistical Summary of Measurement Surveys

Net Building Surface Beta-Gamma Activity

Survey Unit	Surfaces	n	Z _{95%}	Net Activity (dpm/100 cm ²)		
				\bar{x}	s	$\mu_{95\%}$
1	Exterior walls, roof, and roof overhang	33	1.645	52.61	260.11	130
2	Interior walls, floor, and ceiling	44	1.645	-129.93	160.71	-90

Net Interior Gamma Exposure Rates

n	t _{95%,d.f.}	Net Gamma Exposure Rates (μ R/h)		
		\bar{x}	s	$\mu_{95\%}$
23	1.717	-2.46	0.60	-2.2

Net Exterior Gamma Exposure Rates

n	t _{95%,d.f.}	Net Gamma Exposure Rates (μ R/h)		
		\bar{x}	s	$\mu_{95\%}$
8	1.895	-0.80	0.43	-0.5

Net Soil Concentrations (Surface Layer)

Contaminant	n	t _{95%,d.f.}	Net Concentrations (pCi/g)			
			$\bar{x}_{max.}$	\bar{x}	s	$\mu_{95\%}$
Ra-226	8	1.895	1.9	1.40	1.57	2.5
Th-230	8	1.895	1.1	0.38	2.22	1.9
Total Uranium	8	1.895	4.9	3.64	3.63	6.1

Note: See Tables B-2, B-3, B-5, and B-6 for the survey data.

Key for Table B-7:

- dpm/100 cm² = disintegrations per minute per 100 square centimeters
- μ R/h = microrentgens per hour
- pCi/g = picocuries per gram
- n = number of measurements
- t_{95%,d.f.} = Student's t distribution statistic for n-1 degrees of freedom at 95% confidence (n \leq 30)
- Z_{95%} = z distribution statistic at 95% confidence (n>30)

Table B-7 (continued). Statistical Summary of Measurement Surveys

Key for Table B-7 (continued):

- $\bar{x}_{\max.}$ = maximum mean of soil sample concentrations representing contiguous areas totalling approximately 100 m² (not used to calculate s and $\mu_{95\%}$)
 \bar{x} = sample mean
s = sample standard deviation
 $\mu_{95\%}$ = upper limit of the true population mean at the 95% confidence level, derived from:

$n \leq 30$

$$\mu_{95\%} = \bar{x} + t_{95\%, d.f.} \frac{s}{\sqrt{n}}$$

$n > 30$

$$\mu_{95\%} = \bar{x} + z_{95\%} \frac{s}{\sqrt{n}}$$

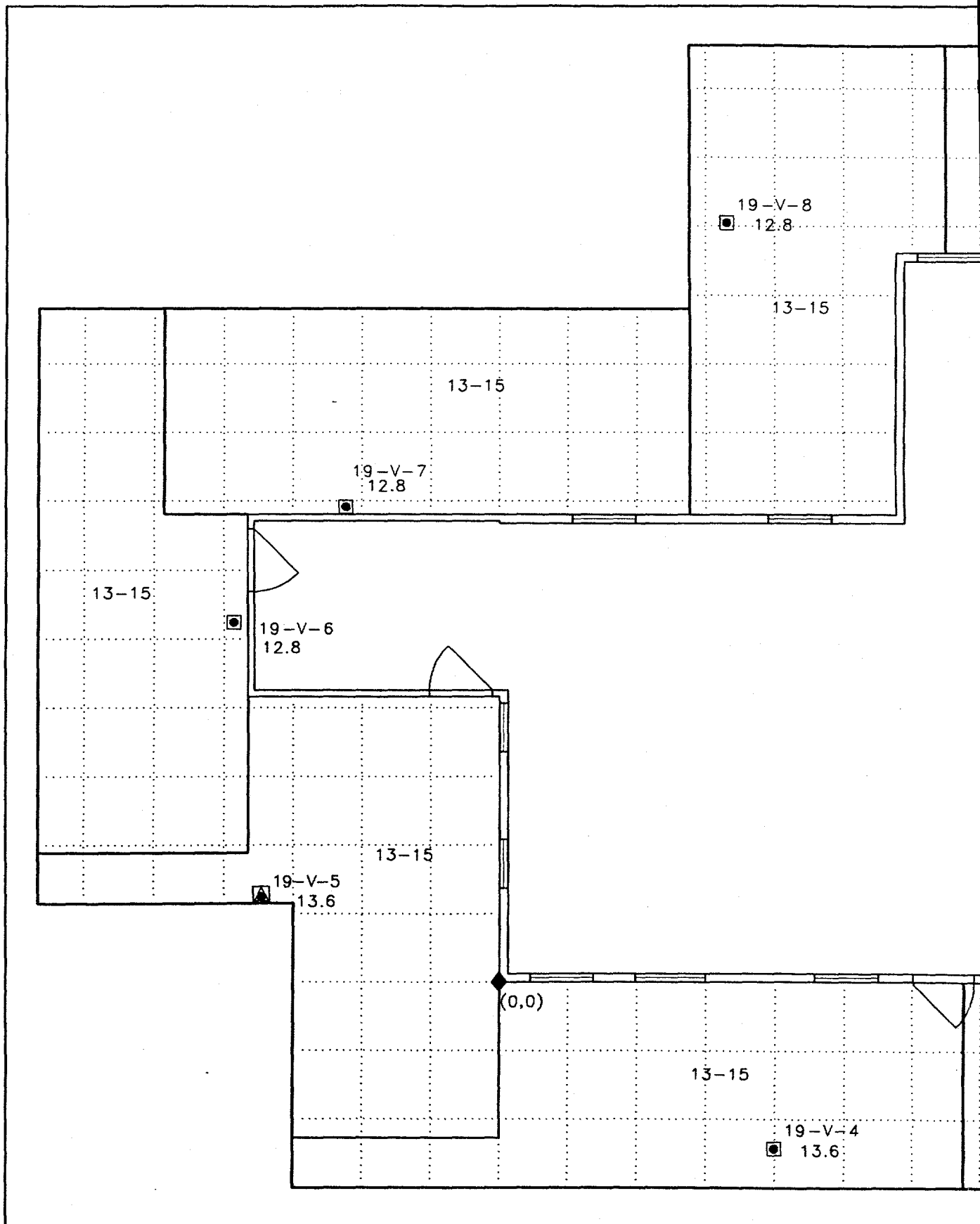
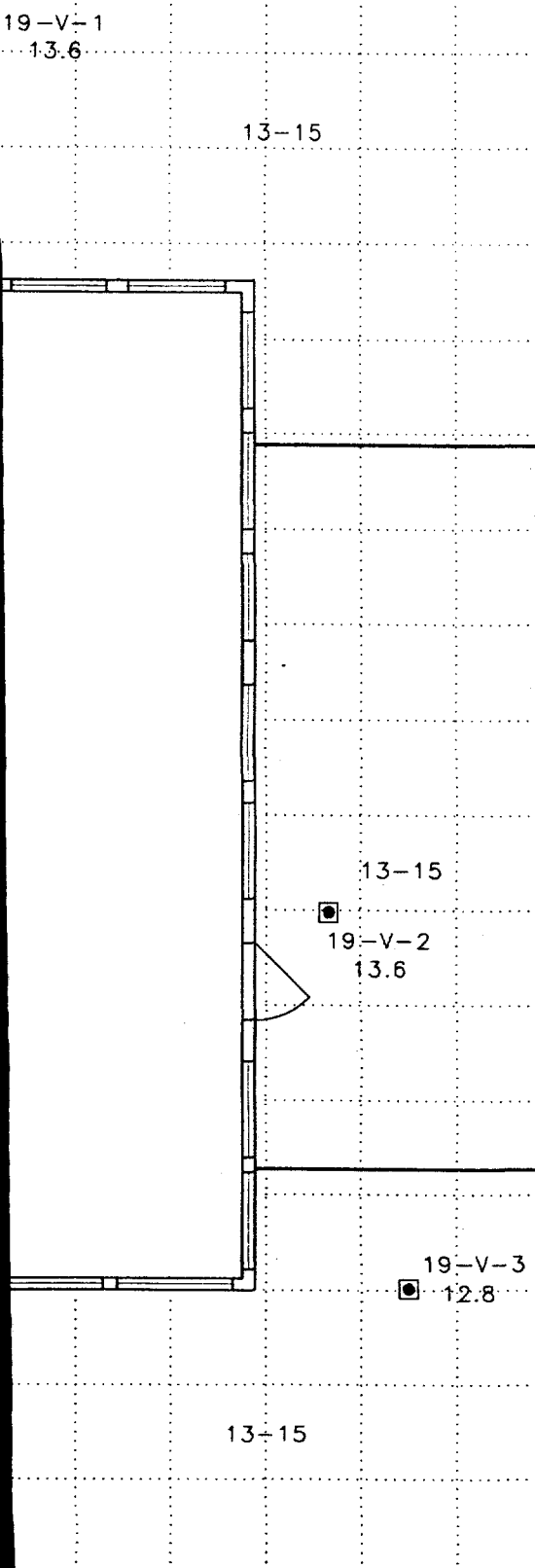


Figure B-1. Building 19



SCALE IN METERS



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
=(453.61,930.11) FACILITY COORDINATE
SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1-METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- △ INTRUSIVE MEASUREMENT LOCATION
- SOIL SAMPLE LOCATION
- 19-V-2 SOIL SAMPLE IDENTIFIER
- 13.6 GAMMA EXPOSURE RATE MEASUREMENT
AT 1M ABOVE GROUND ($\mu R/h$)
- 12-14 GAMMA EXPOSURE RATE RANGE AT GROUND
LEVEL ($\mu R/h$)
- EXTERIOR VERIFICATION AREA BOUNDARY



U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE,
COLORADO

Figure B-1

BUILDING 19
EXTERIOR GROUND
SURVEY

PREPARED:

CHECKED:

DATE PREPARED:

PROJECT NUMBER:

TCR-031-0014-00-000

FILENAME:

T00054AA

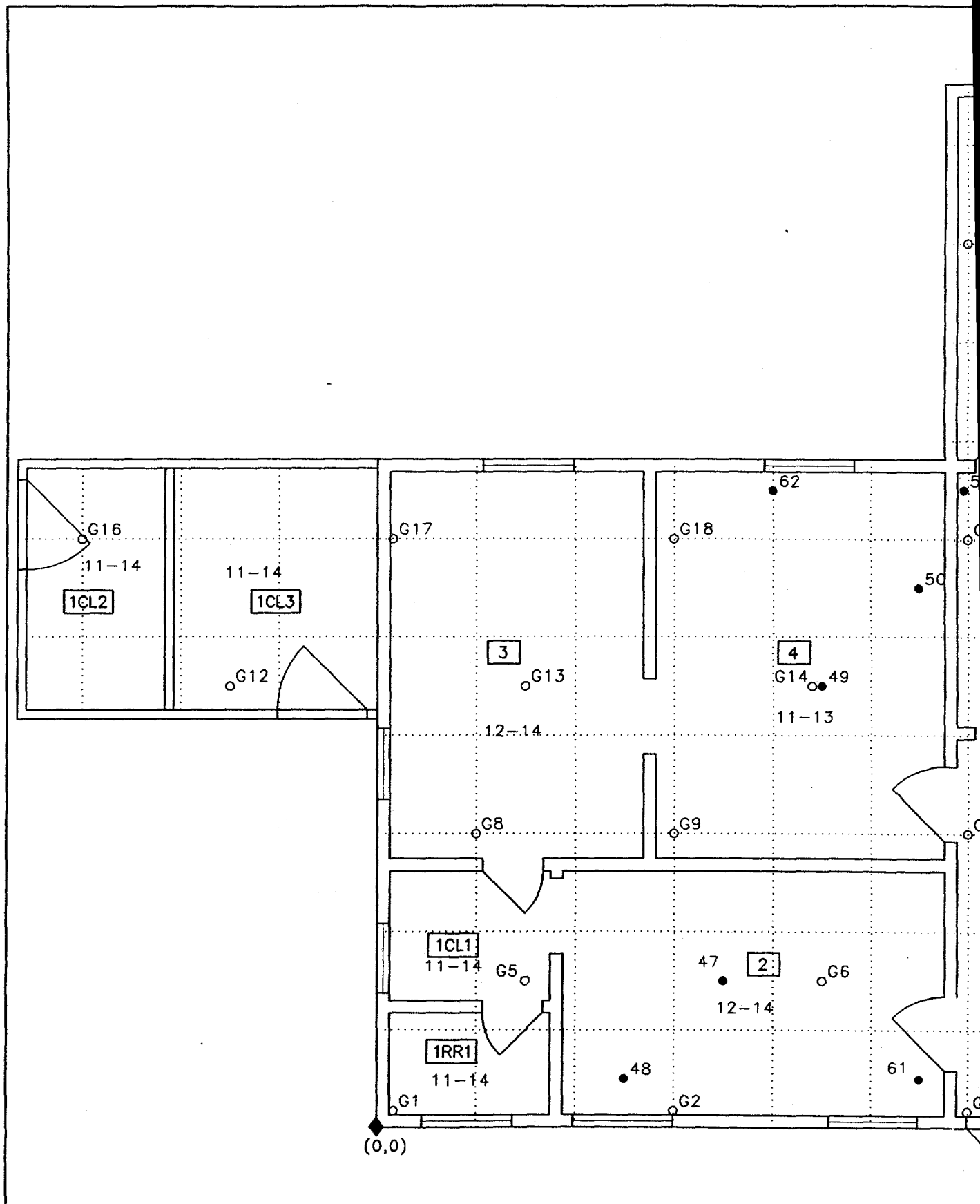
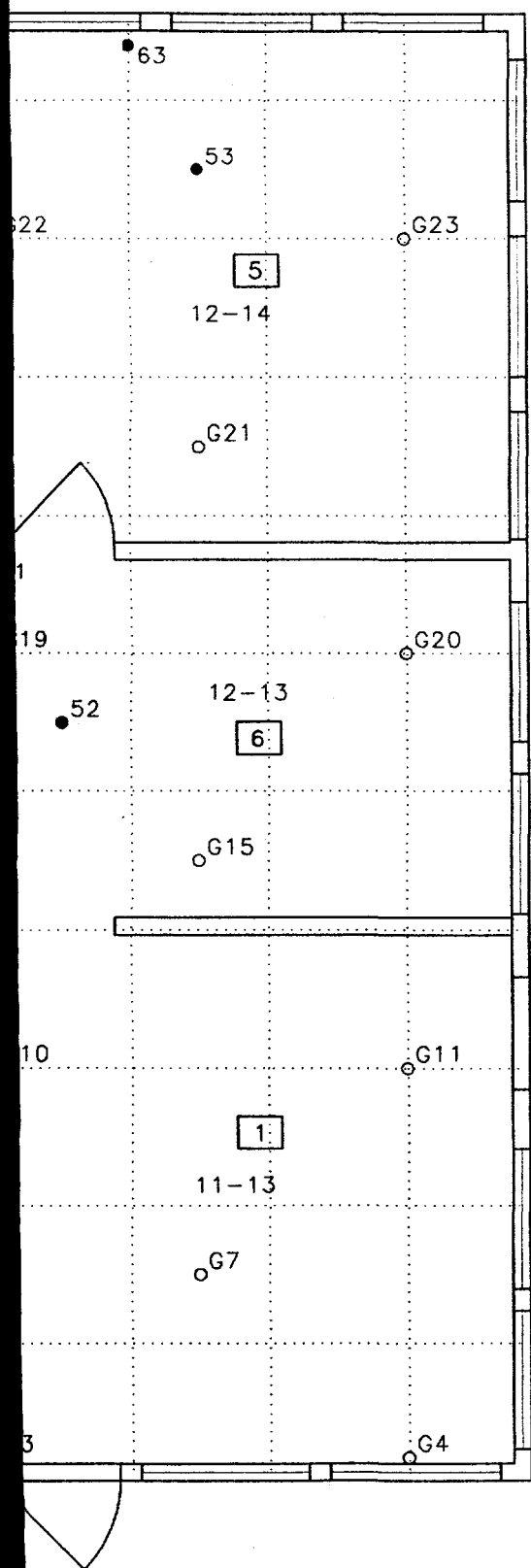


Figure B-2. Building 19 Floor Plan






SCALE IN METERS



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
=(453.61,930.11) FACILITY COORDINATE
SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1 METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- GAMMA EXPOSURE RATE MEASUREMENT LOCATION AT 1M ABOVE FLOOR
- 35 MEASUREMENT LOCATION NUMBER
- 12-14 GAMMA EXPOSURE RATE RANGE AT FLOOR LEVEL (μ R/h)
- 3 ROOM NUMBER

		U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO	
BUILDING 19 FLOOR AND INTERIOR GAMMA SURVEY			
PREPARED: 	CHECKED: 	DATE PREPARED: MAY 1997	
PROJECT NUMBER: TCR-031-0014-00-000		FILENAME: T00052AA	

nd Interior Gamma Survey

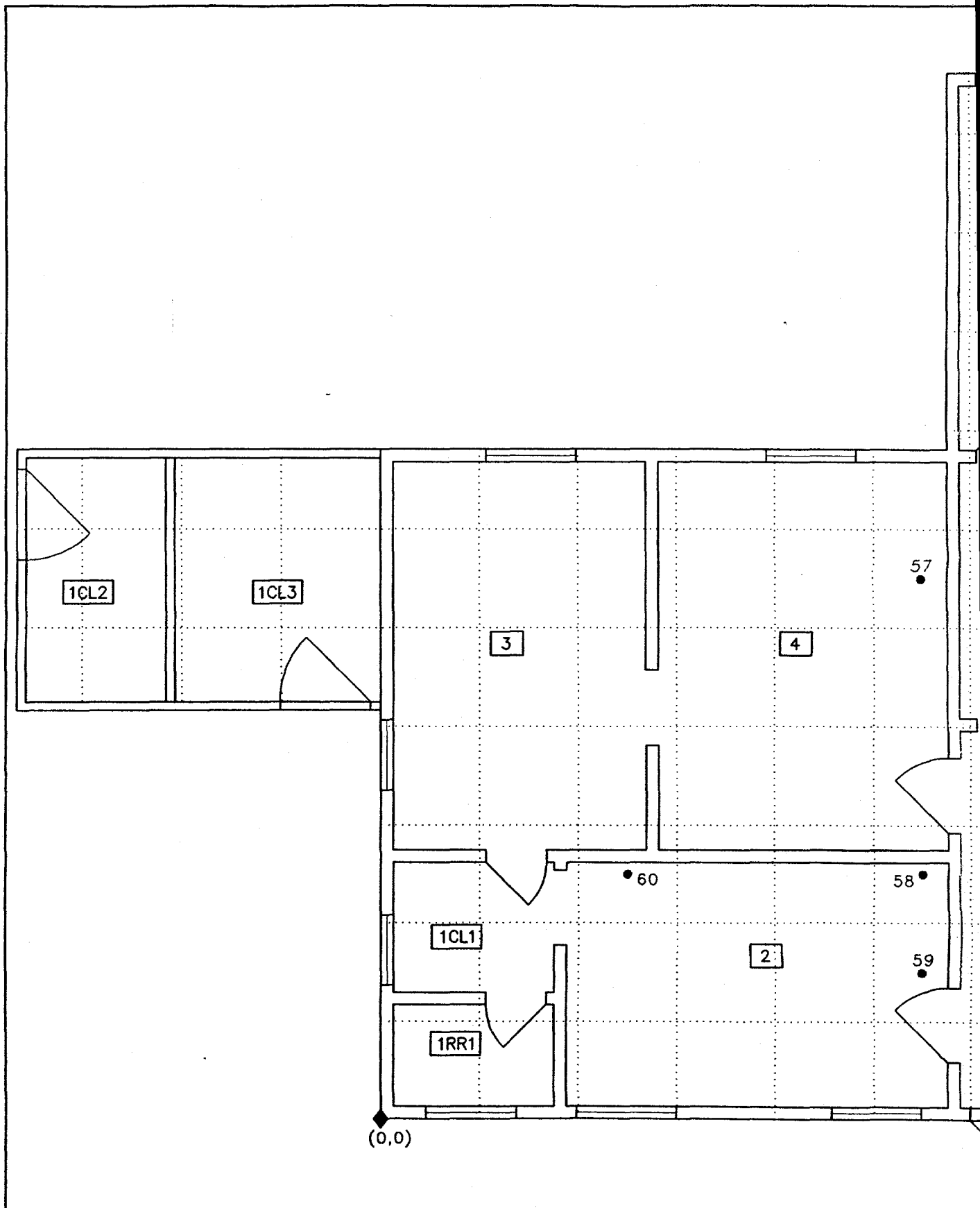
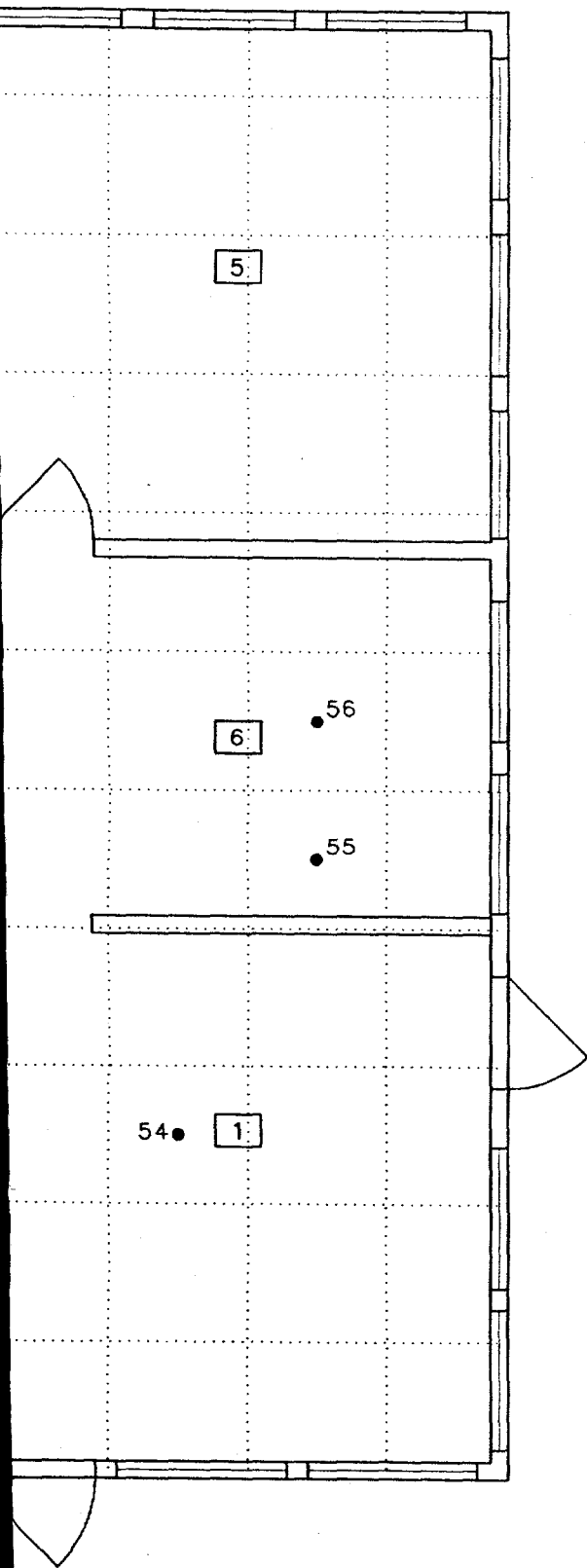


Figure B-3. Building



0 SCALE IN METERS 2



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
=(453.61,930.11) FACILITY COORDINATE
SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1-METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- 35 MEASUREMENT LOCATION NUMBER
- 3 ROOM NUMBER

		U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO	
Figure B-3		BUILDING 19 CEILING SURVEY	
PREPARED: <i>C. Sen</i>	CHECKED: <i>MS</i>	DATE PREPARED: MAY 1997	
PROJECT NUMBER: TCR-031-0014-00-000		FILENAME: T00053AA	

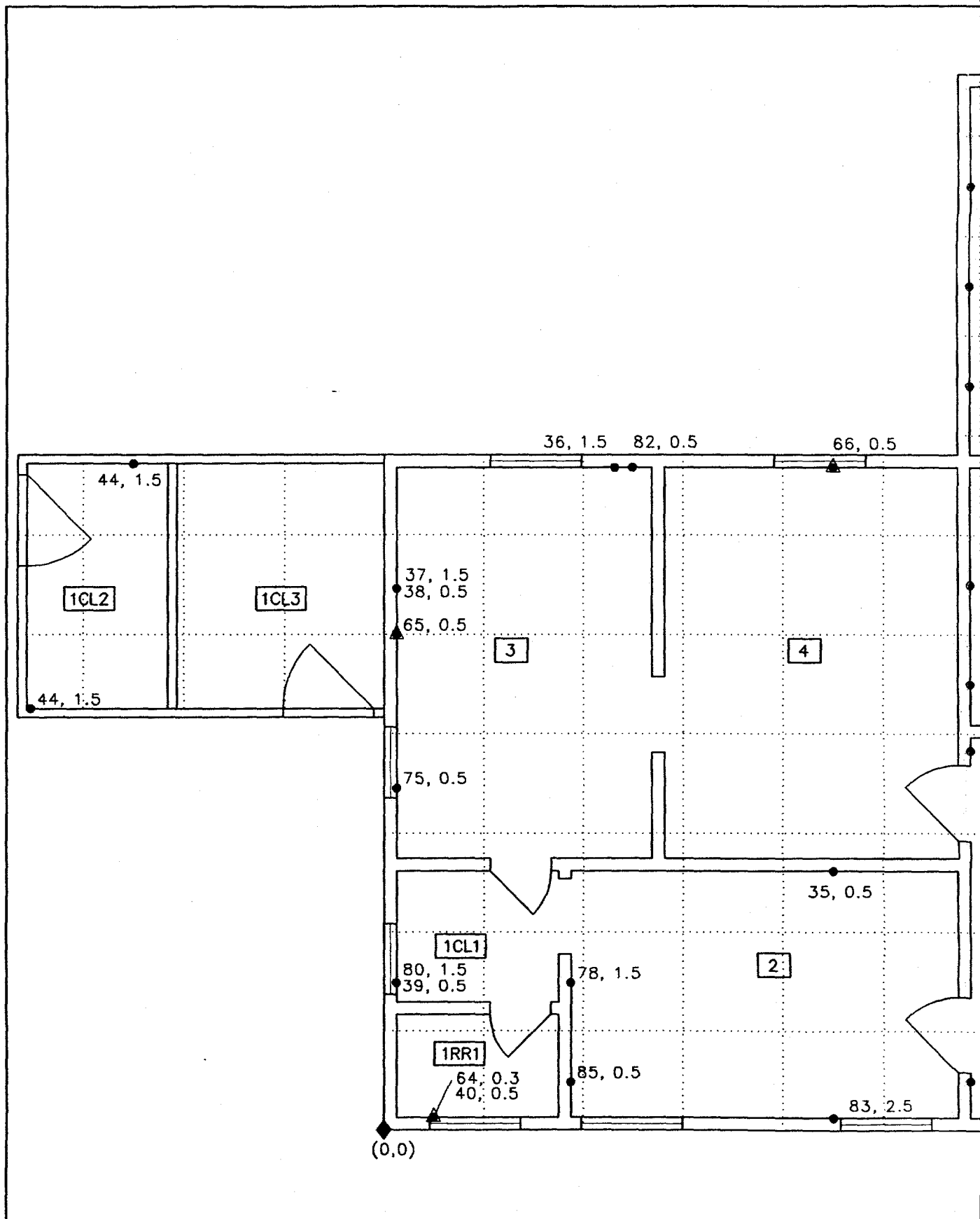
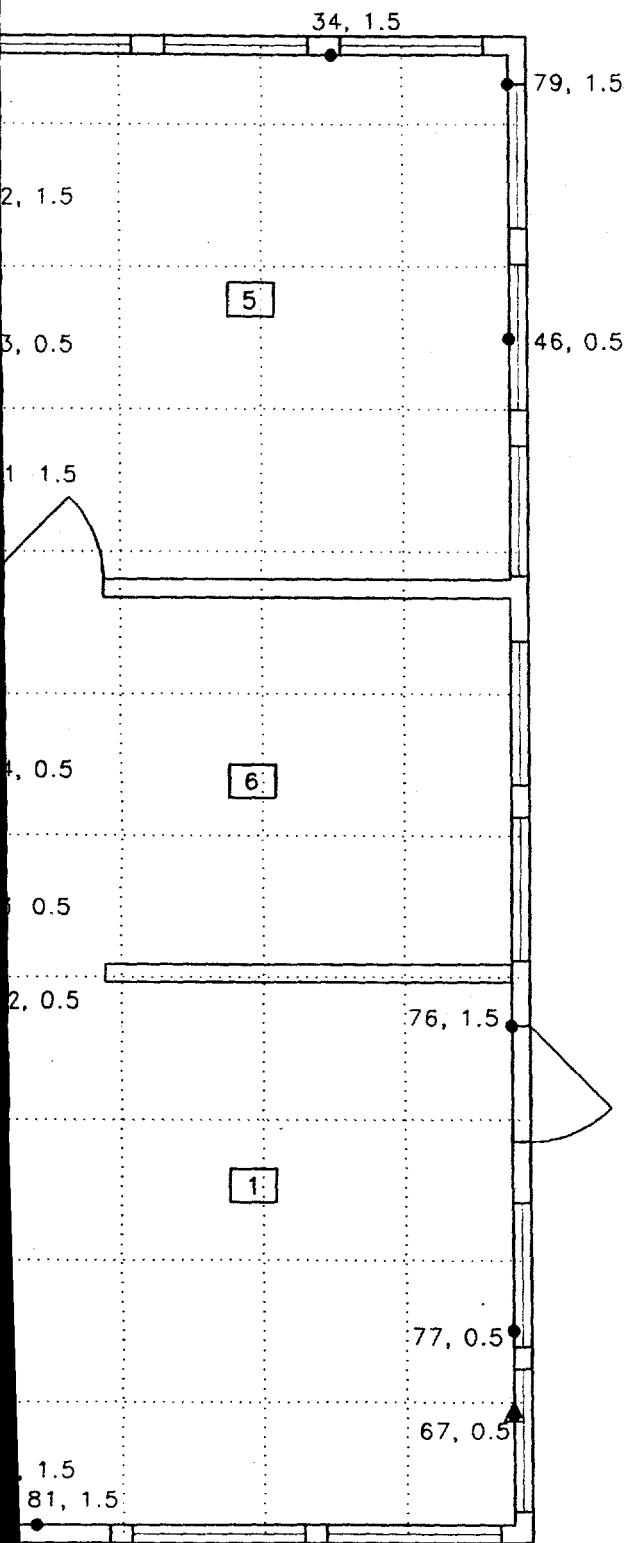


Figure B-4. Building



0 SCALE IN METERS 2



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
=(453.61,930.11) FACILITY COORDINATE SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1-METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- △ INTRUSIVE MEASUREMENT LOCATION
- 35, 1.5 MEASUREMENT LOCATION NUMBER, FOLLOWED BY HEIGHT ABOVE FLOOR (METERS)
- 3 ROOM NUMBER

		U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO	
Figure B-4		BUILDING 19 INTERIOR WALL SURVEY	
PREPARED: <i>Csw</i>	CHECKED: <i>MM</i>	DATE PREPARED: MAY 1997	
PROJECT NUMBER: TCR-031-0014-00-000		FILENAME: T00055AA	

Interior Wall Survey

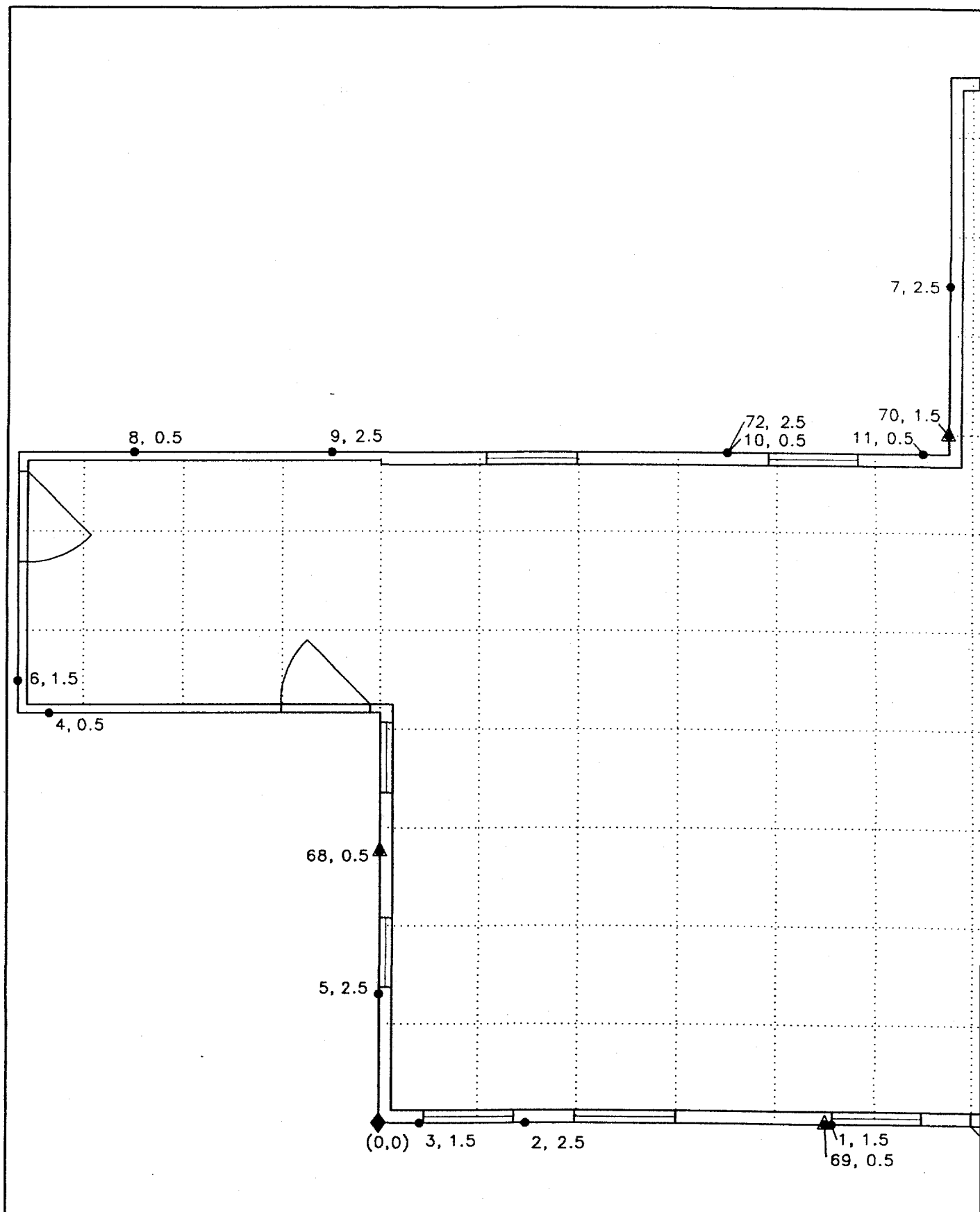
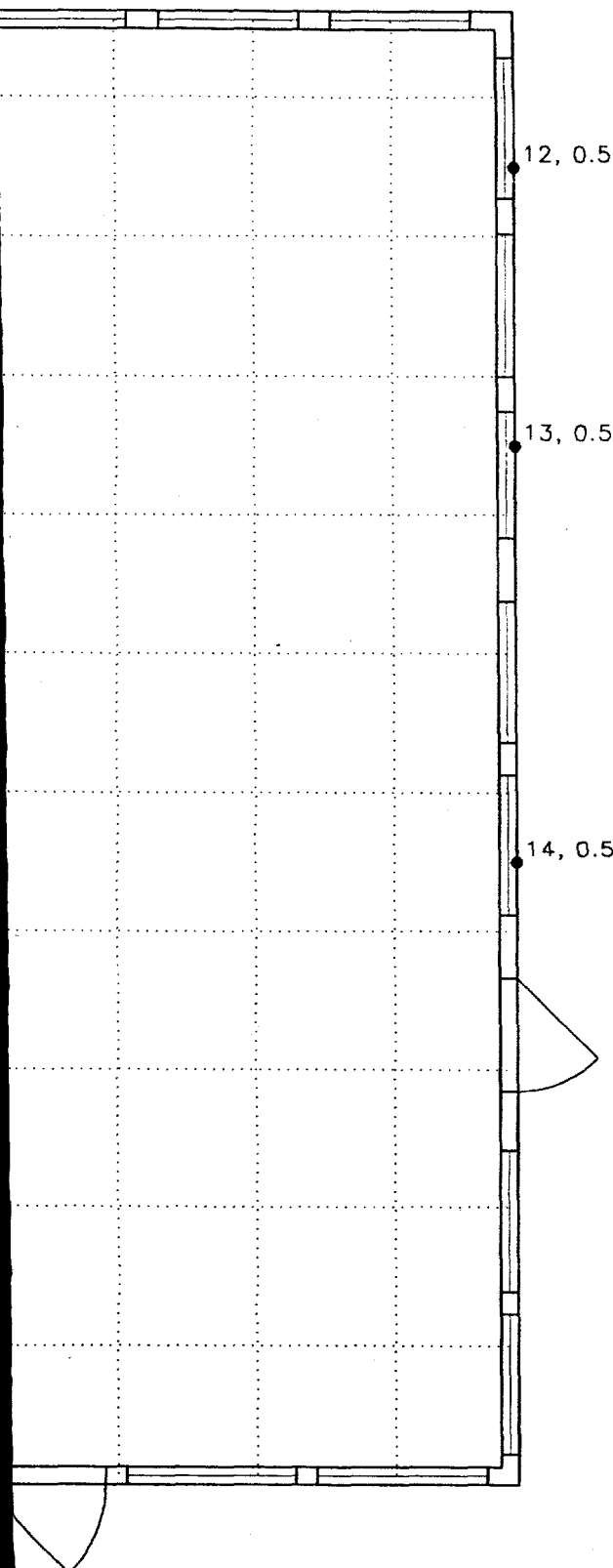


Figure B-5. Building 19






0 SCALE IN METERS 2



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
 =(453.61,930.11) FACILITY COORDINATE SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1-METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- △ INTRUSIVE MEASUREMENT LOCATION
- 35, 1.5 MEASUREMENT LOCATION NUMBER, FOLLOWED BY HEIGHT ABOVE GROUND (METERS)

		U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO	
Figure B-5		BUILDING 19 EXTERIOR WALL SURVEY	
PREPARED: 	CHECKED: 	DATE PREPARED: MAY 1997	
PROJECT NUMBER: TCR-031-0014-00-000		FILENAME: T00056AA	

Exterior Wall Survey

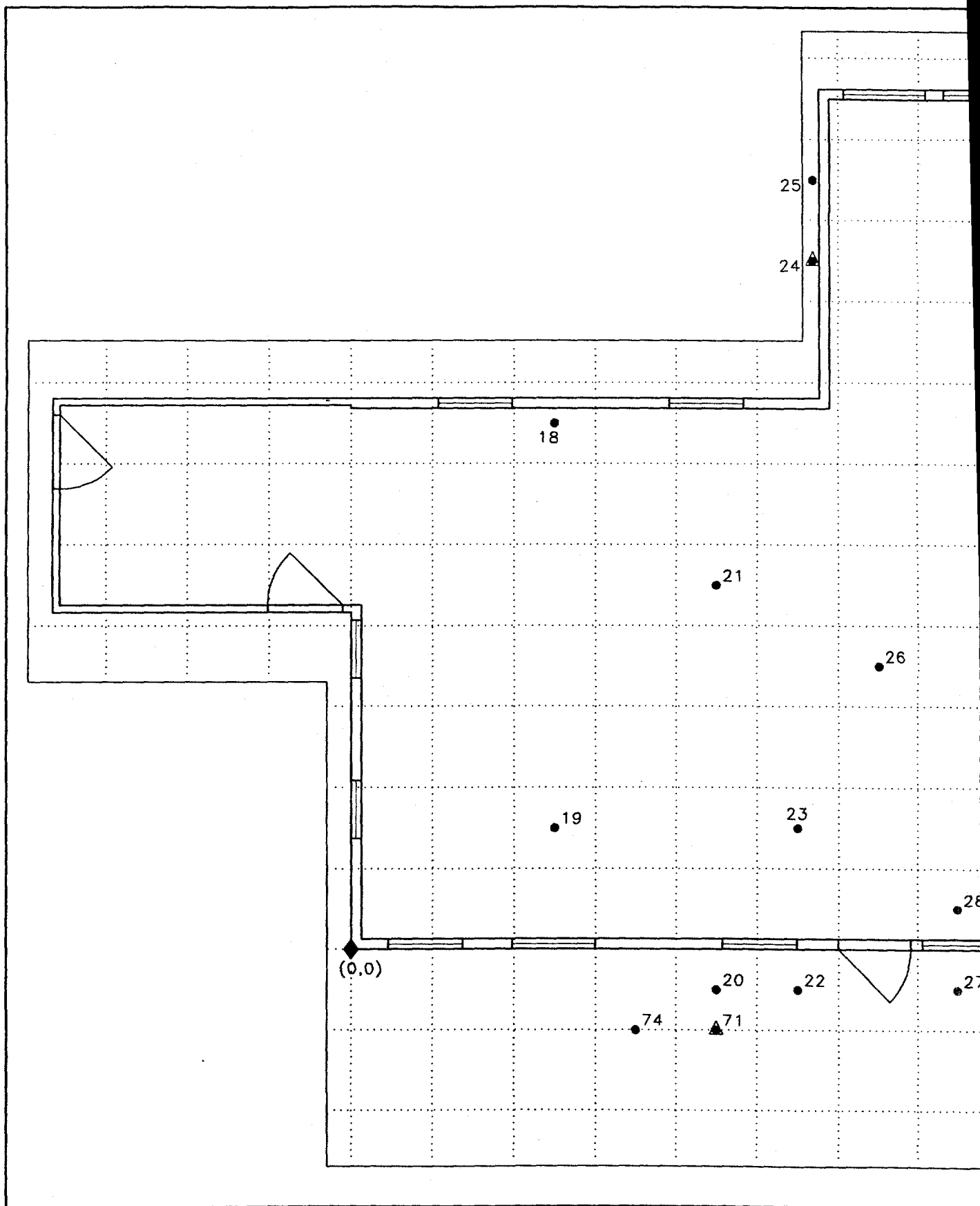
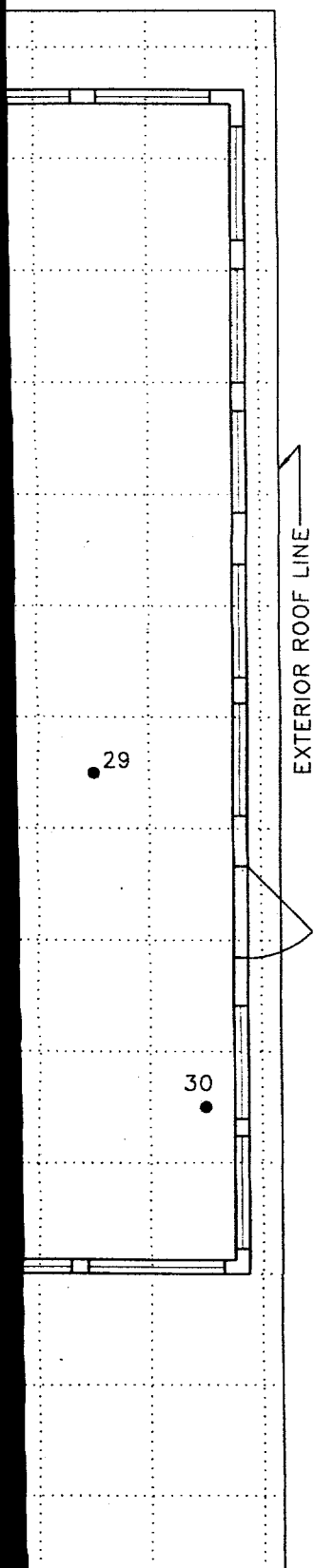


Figure B-6. Building






SCALE IN METERS



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
 =(453.61,930.11) FACILITY COORDINATE
 SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1-METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- △ INTRUSIVE MEASUREMENT LOCATION
- 35 MEASUREMENT LOCATION NUMBER

		U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO	
Figure B-6		BUILDING 19 ROOF SURVEY	
PREPARED: 	CHECKED: 	DATE PREPARED: MAY 1997	
PROJECT NUMBER: TCR-031-0014-00-000		FILENAME: T00057AA	

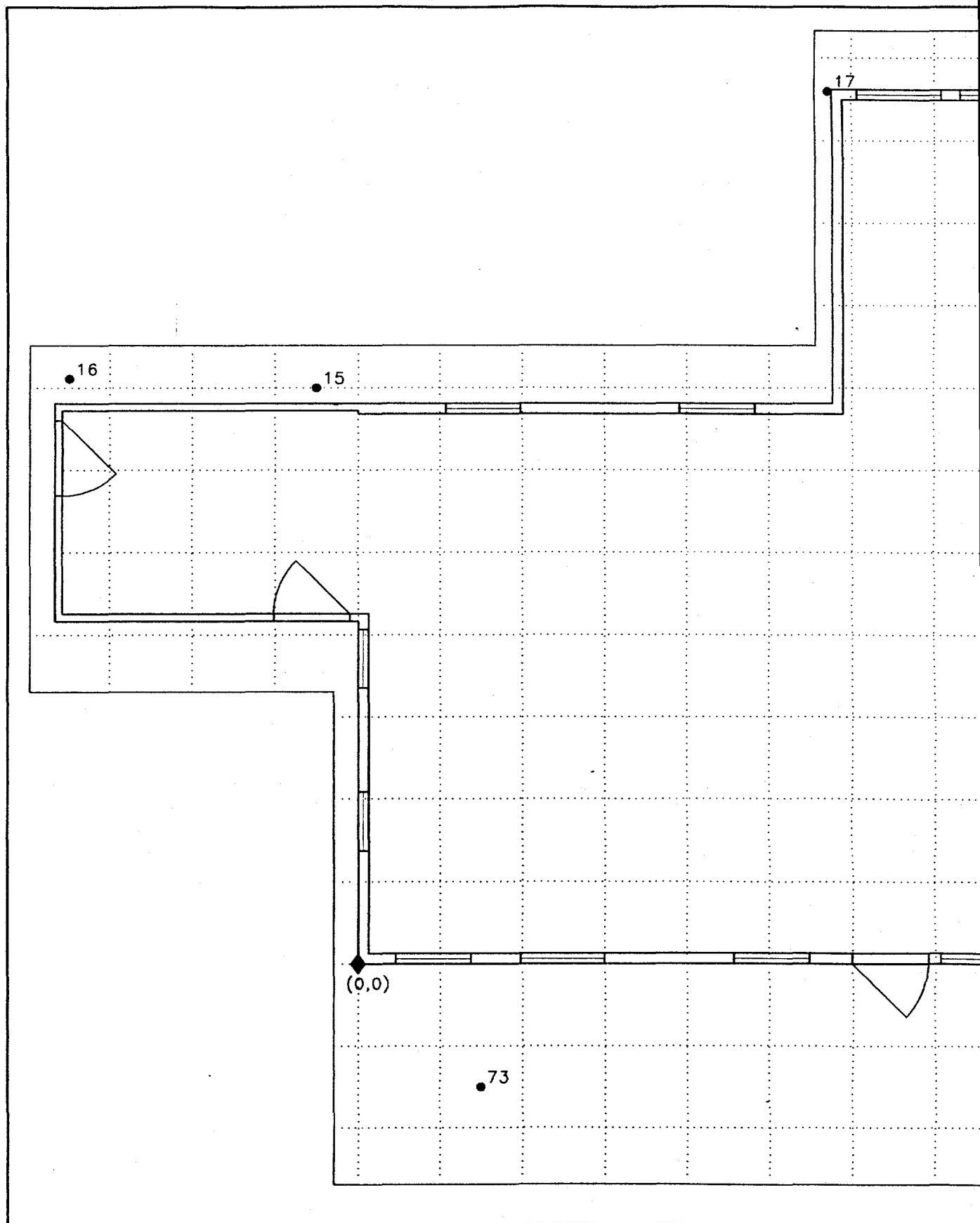
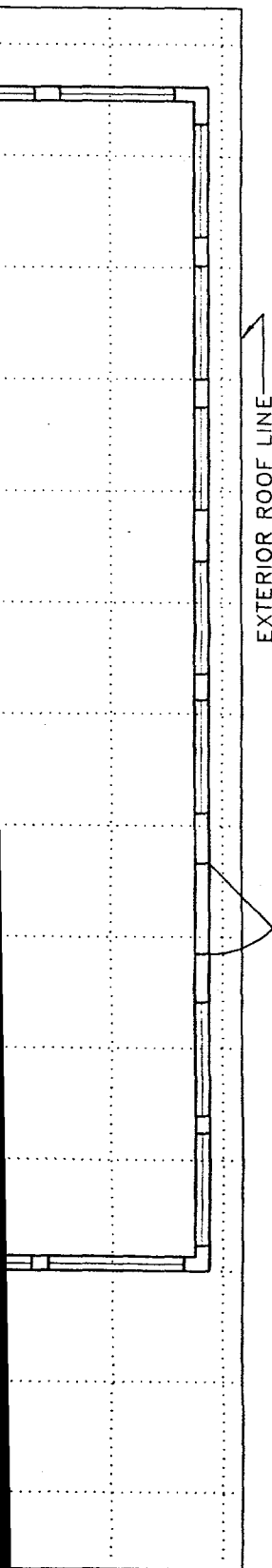
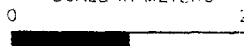


Figure B-7. Building 19 Under



SCALE IN METERS



(X,Y)=(0,0) BUILDING COORDINATE SYSTEM
 =(453.61,930.11) FACILITY COORDINATE
 SYSTEM [METERS]

LEGEND

- ◆ BASE COORDINATE FOR 1-METER GRID SYSTEM
- DIRECT MEASUREMENT LOCATION
- 35 MEASUREMENT LOCATION NUMBER

		U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO	
Figure B-7		BUILDING 19 UNDERSIDE OF ROOF OVERHANG SURVEY	
PREPARED: 	CHECKED: 	DATE PREPARED: MAY 1997	
PROJECT NUMBER: TCR-031-0014-00-000		FILENAME: T00058AA	