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WIPP Underground and Surface Surveying Program

Cognizant Department: Engineering

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REVISION NUMBER	DATE ISSUED	DESCRIPTION OF CHANGES
8	02/11/19	• Updated NWP Logo on cover page. • Section 5.1, updated NWP/Engineering to NWP/Mine Engineering.
9	11/09/23	• Changes made were identified during the Blue Sheeting process during the SIMCO transition; therefore only an editorial correction is needed. • Changed the NWP logo to the WIPP logo. • Changed Nuclear Waste Partnership to Waste Isolation Pilot Plant. (NWP to WIPP)

ACRONYMS AND ABBREVIATIONS

CBFO	Carlsbad Field Office
CCA	Compliance Certification Application
CE	Cognizant Engineer
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
FGCS	Federal Geodetic Control Subcommittee
GPS	Global Positioning Survey
K	kilometer
mm	millimeter
NAD 27	North American Datum of 1927
NGS	National Geodetic Survey
QA	quality assurance
QAPD	Quality Assurance Program Description
SDD	System Design Description
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This document defines the WIPP surveying program and responsibilities currently being carried out by the WIPP Mine Engineering Surveyors. The program plans and functions are designed to provide location and alignment information necessary to establish precise horizontal and vertical control for all aspects of underground and surface configuration. Surveying activities currently consist of, but are not limited to, the following:

- Underground site configuration, control, and update
- Surface site configuration, control, and update
- Operations and engineering support
- Geotechnical ground control support
- Surface subsidence monitoring

These activities are implemented and controlled by this document, FGCS standards and WP 13-1, Waste Isolation Pilot Plant Quality Assurance Program Description.

1.1 Background

The surveying program provides surveying services and information to WIPP Geotechnical and Mine Engineering for planning, engineering and/or documentation purposes. The surveying program also provides basic information to other WIPP sections and departments so that the safe disposal of TRU and mixed waste can be demonstrated both in the short-term (during the operational life of the facility) and in the long-term (following decommissioning), while satisfying all regulations governing permanent isolation of the waste. The program provides construction surveying for WIPP engineering, planning, and documentation purposes, but does not include construction surveying for contractors. Drivers for this program include the Mine Safety and Health Administration requirements (Title 30 CFR Part 57, Safety and Health Standards-Underground Metal and Nonmetal Mines, DOE/CBFO [U.S. Department of Energy Carlsbad Field Office] 96-2184, Compliance Certification Application [CCA]; and SDD AU00, Underground Facilities and Equipment). The program also helps ensure that the facility is operated safely and that the data are available to make decisions for managing and performing engineering and operational activities. Each surveying activity is controlled by this surveying program, which describes the general scope of the survey, its methodology, and QA requirements.

To satisfy the listed regulatory drivers, certain activities and functions are required of the Mine Engineering Surveyors. These commitments are listed as follows:

- Perform an annual subsidence monitoring survey.
- Publish an annual report of subsidence survey data, including a comparison with prior years' data.
- Maintain, replace, and expand the subsidence monument network, as required.
- Maintain state-of-the-art leveling equipment and capability.

1.2 WIPP Surveying History and Accuracy Requirements

Surveying was one of the first activities to take place at the WIPP site. Coordinates for the site were brought in from the NGS monument "Rustler." New Mexico State Plane Coordinates North American Datum of 1927 (NAD 27) are used at WIPP for control. In general practice at WIPP, these coordinates are truncated for use as the site coordinate system. To arrive at the site coordinates, 490,000 feet were dropped from the Northing and 660,000 feet were dropped from the Easting of the New Mexico State Plane Coordinates NAD 27. The base point for the WIPP site was the section corner common to Sections 20, 21, 28, and 29 in T.22 S., R.31 E. During 1986, a surveying contractor was retained to resurvey the site to bring in coordinates and transfer them underground. Surveys were run from the NGS monuments "Berry" and "Brininstool," using NAD 27 values. Because the original base point had been lost, a new base point (PT 30) was chosen and new plant coordinates were calculated for all existing points. It is important to remember that plant coordinates are on a rectangular grid while State Plane Coordinates take into account that the earth is a spheroid. It is not possible to make a direct comparison of the two systems for more than one point at a time.

A resurvey of the underground was conducted in 1993. Horizontal locations were traversed, and the true bearings were checked using a gyro-compass. Additionally, a level survey was conducted through 20 benchmarks located throughout the underground. To minimize the effects of salt creep, the horizontal location points are placed in the roof on the center line of the drifts and vertical benchmarks are placed in the drift walls at approximately mid-height of the drift.

The vertical surveying monitoring commitments in the CCA divides the monitoring into three phases: developmental, operational, and postclosure. During the initial developmental phase (in 1977), 314 kilometers of First Order, Class I survey was performed by the NGS. The NGS network was resurveyed in 1981 and the relative movement between Carlsbad and the WIPP site was measured to be about 2 centimeters. The relative motion across the network was down to the east and up to the west.

The 1981 NGS survey also established new survey lines that connected the previous First Order benchmarks through Carlsbad to Second Order survey lines through Eunice and Hobbs. During this survey, benchmarks were placed over the Nash Draw from the north end to the Remuda Basin, over potash mines, the WIPP site, and the San Simon Sink.

Independent of the NGS work, but using the established First Order, Class I NGS benchmarks, an additional 52 benchmarks were installed by surveying companies working under contract to WIPP. The benchmarks were installed in a grid on approximately 1,000-foot centers. This grid covers the WIPP planned repository and extends about 1,000 feet beyond the edge of the planned extent of the waste panels. Second Order, Class II FGCS specifications were used for these benchmarks. This work was completed in 1986.

A GPS was conducted in 1994 by the WIPP Site Survey Section in conjunction with a contractor. The GPS was used to check horizontal control and independently verify the Second Order, Class II subsidence survey conducted in 1994. In 1996, the Mine Engineering Surveyors, in conjunction with a contractor, performed a survey using First Order, Class I level specifications from the Berry Monument, 20 miles east of the WIPP site. The survey included the 52 existing subsidence monuments at the site and looped back to close on the Berry Monument.

At the start of the closure phase, it is anticipated that a review of all past subsidence surveys and the adequacy of the existing subsidence stations will be conducted. New subsidence stations, if needed, will be installed to FGCS standards. A survey that achieves First Order, Class I accuracy may then be conducted. Information from this survey will be combined with published information from all previous work to form a baseline database for subsidence information in accordance with the CCA. The CCA states that this postclosure survey is to be repeated in three years. Thence, it is to be repeated every ten years for the next 100 years or until the DOE determines that further surveys are not required.

The U.S. Department of Commerce is responsible for establishing and maintaining basic control networks for the nation. The Department of Commerce carries this out through the NGS which establishes surveys, then adjusts and publishes the results on horizontal and vertical geodetic control networks. As part of the control program, the FGCS prepares classification and standards for geodetic control surveys. The following tables outline general requirements for horizontal and vertical control.

CLASSIFICATION, STANDARDS OF ACCURACY AND RECOMMENDED USES

Horizontal Control					
Classification	**First Order Class I**	**Second Order Class I**	**Second Order Class II**	**Third Order Class I**	**Third Order Class II**
Relative accuracy between directly connected points	1 part in 100,000	1 part in 50,000	1 part in 20,000	1 part in 10,000	1 part in 5,000
Recommended uses	Primary national network. Metropolitan area surveys. Scientific studies.	Area control which strengthens the national network. Subsidiary metropolitan control.	Area control which contri-butes to, but is supplemental to, the national network.	General control surveys referenced to the national network. Local control surveys.	

Vertical Control					
Classification	**First Order Class I**	**First Order Class II**	**Second Order Class I**	**Second Order Class II**	**Third Order**
Maximum loop misclosure where K is the length of the loop in kilometers	4mm √K	5mm √K	6mm √K	8mm √K	12mm √K
Recommended uses	Basic framework of the national network. Regional crustal movement studies. Extensive engineering projects.	Secondary framework of the national network and metropolitan area control. Local crustal movement studies. Large engineering projects. Tidal boundary reference. Support for lower-order surveys.		Densification within the national network. Rapid subsidence studies. Local engineering projects. Topographic mapping.	Small scale topographic mapping. Establishing gradients in mountainous areas. Small engineering projects. May or may not be adjusted to the national network.

Horizontal surveys at WIPP are conducted to FGCS accuracy standards for Second Order, Class II surveys. The Second Order, Class II level of accuracy is the standard recommended for the type of surveying performed at WIPP by the FGCS. It was also established as such by the original design basis documents and is carried through into the AU00 SDD. First Order, Class I results are routinely obtained by the Mine Engineering Surveyors. Subsidence surveys are carried out in the same manner as vertical surveys. In subsidence measurements, the error is determined by both the equipment used and the distances between the stations. As defined by the FGCS a First Order, Class I level survey has a maximum loop error of 4mm $\sqrt{K}$ where K is the length of survey loop in kilometers. A Second Order, Class II level survey has a maximum loop error of 8mm $\sqrt{K}$ or two times the error of a First Order survey. Technological advances in electronic digital levels allow the user to obtain numerical results that far exceed the minimum Second Order, Class II standard.

2.0 ADMINISTRATION

2.1 Organization

The WIPP organizational structure is described in WP 13-1, Waste Isolation Pilot Plant Quality Assurance Program Description. The Mine Engineering Surveyors reports to the manager of Geotechnical and Mine Engineering. The Underground and Surface Surveying Program is within the cognizance of the AU00 system.

2.2 Responsibilities

The AU08 Underground and Surface Surveying CE and Mine Engineering Surveyors are responsible for achieving and maintaining quality in the WIPP Underground and Surface Surveying Program.

2.3 Training and Qualifications

Personnel who perform specific tasks associated with surveying, surveying data collection, survey data reduction, and quality control measures are trained and qualified in the application of the specific requirements to complete their tasks.

The survey training and qualification standards are as follows:

2.3.1 Cognizant Engineer and/or Chief Surveyor

- Training
  - Engineering degree or equivalent
  - Successful completion of specific training on surveying instruments used at WIPP
  - Completed training as required by WP 09, Conduct of Engineering
- Experience
  - Five years experience in the surveying field
- Proficiency
  - Proficiency in the use of precision surveying equipment specified for the program as demonstrated by passing the board examination for CE
  - Proficiency in the use of related surveying software as demonstrated by passing the board examination for CE

2.3.2 Mine Engineering Surveyor

- Training
  - Successful completion of specific training of surveying instruments used at WIPP or demonstrated proficiency approved by the Cognizant Manager
- Experience
  - One year experience in the surveying field
- Proficiency
  - Demonstrated proficiency in the use of precision surveying equipment specified for the program by successfully completing surveys with closures within Second Order, Class II specifications

2.3.3 Rodman

- Training
  - Field orientation at the start of surveys and continued instructions as the survey progresses
- Experience
  - None required

3.0 TECHNICAL PROGRAM DESCRIPTION

The WIPP Underground and Surface Surveying Program is divided into three parts: underground, surface, and subsidence monitoring. Underground and surface surveying covers all surveying performed underground and on the surface to provide location, alignment and elevation information for all departments concerned with surface operations and TRU waste handling. Control points are maintained upon which the location, alignments, and elevations are based. This information is also used for updating existing drawings and surface maps. Subsidence monitoring provides for leveling and horizontal control of all the subsidence monuments within the 16 square miles of the surface properties (WIPP Land Withdrawal Area). These surveys are conducted either by the Mine Engineering Surveyors, or by qualified contractor/vendor personnel under the direct supervision of the Mine Engineering Surveyors. Finally, this plan gives the Mine Engineering Surveyors the flexibility to provide qualified surveys and survey information to any other internal WIPP section, provided the request is approved by the Geotechnical and Mine Engineering manager.

3.1 Underground Surveying Program

3.1.1 Purpose

The purpose of the Underground Surveying Program is to maintain accurate location information of the underground structures and to provide alignment for new excavations. The Underground Surveying Program ensures continuing confirmation of underground configuration through surveys. These surveys generate data that are used in underground planning, underground extensions, and TRU and mixed waste emplacement. Information from the surveys is used to document the existing extent, size, and location of the entries crosscuts, panels, and rooms of the underground. Activities associated with this program include control surveys, level surveys, alignment point installation, grade point installation, laser alignment, and as-found surveys. Other surveying activities are performed as needed.

Underground surveying is the only way to provide information for the construction and precise location of underground structures. Because of the safety constraints inherent in handling and emplacement of TRU and mixed waste in the WIPP underground, state-of-the-art surveying equipment and methods are used. The Underground Surveying Program provides information basic to the design, construction, and operation of the repository.

3.1.2 Methodology

Routine underground surveys are carried out in accordance with common industry practice, and in accordance with standards specified by the FGCS. Other surveys which are in development, or which are not routine, are performed in accordance with common industry practice or individual program plans.

Routine Surveys

Horizontal Control Surveys are made as the repository is excavated to provide accurate location of existing and planned openings.

Vertical Control Surveys are made as the repository is excavated to provide precise elevation and vertical control of existing and planned openings.

Alignment Surveys are performed as required to provide alignment and grade points for mining operations as excavation of the repository proceeds. Alignment surveys include the setting of laser alignment instruments to coincide with the horizontal control grade points.

Mapping Surveys provide information of the existing location, size, and shape of the underground structures.

Location Surveys provide precise location information on geotechnical instruments and stationary underground structures.

Other Underground Surveying Activities

Other underground surveying activities are performed as required. An example of other surveying activities might include a shaft plumbing survey.

Data Processing, Distribution, and Storage

All survey data are collected electronically, downloaded, and processed using approved software programs. Distribution of information is accomplished by electronic files. A hard copy is provided to customers as required. Storage of survey information is maintained on the Mine Engineering Surveyors' computers, and a back-up file resides on the WIPP Intranet. A hard copy of the information is also maintained in the Mine Engineering Surveyors' files.

3.2 Surface Surveying Program

3.2.1 Purpose

The purpose of the Surface Surveying Program is to maintain accurate location information of surface structures and to provide location and topographical information for planning and construction of new surface structures. The Surface Surveying Program ensures continuing confirmation of site configuration through surface surveys. These surveys generate data that are used in site planning and new surface projects. Information from the surveys is used to document the existing extent, size, and location of the site facilities as they exist. Activities associated with this program include control surveys, level surveys, and existing condition surveys. Other surveying activities are performed on an "as needed" basis.

Surface surveying is the only way to provide information on the construction and precise location of facility structures. Because of the safety constraints inherent in handling of TRU and mixed waste at WIPP, state-of-the-art surveying equipment and methods are used. The Surface Surveying Program provides information basic to the design, construction, and operation of the surface facilities.

3.2.2 Methodology

Surveys performed on a routine basis are carried out in accordance with common industry practice, and in accordance with standards specified by the FGCS. Other surveys which are in development, or which are not routine, are performed in accordance with common industry practice, or individual program plans.

Routine Surveys:

Horizontal Control Surveys are made as needed for horizontal control.

Vertical Control Surveys are made as needed for vertical control.

Topographic Surveys are performed as required to provide planning and construction information for surface projects.

Mapping Surveys provide information of the existing location, size, and shape of existing surface facilities.

Other Surface Surveying Activities

Other surface surveying activities will be performed as required. An example of other surveying activities might include a GPS.

Data Processing, Distribution, and Storage

All survey data are collected electronically, downloaded, and processed using approved programs. Distribution of information is accomplished by electronic files. A hard copy is also provided to a customer, if needed. Storage of survey information is maintained on the Mine Engineering Surveyors' computers and a backup file resides on the WIPP Intranet. A hard copy of the information is also maintained in the Mine Engineering Surveyors' files.

3.3 Subsidence Monitoring Program

3.3.1 Purpose

Subsidence is defined as the vertical movement of the land surface anywhere within a defined subsidence basin. Specifically, subsidence monitoring comprises the precise measurement of the relative vertical movement of the land surface, which can be in the form of uplift (upwards movement) or subsidence (downwards movement) relative to an assumed fixed reference point. The fixed reference point is assumed to be fixed since it is placed outside the subsidence basin. However, it is also subject to some of the same factors and processes that affect and cause surface movement. Thus, it may also be in motion. The techniques used to monitor subsidence measure the vertical height difference between an array of markers on the surface and are typically performed with a leveling survey. Under normal conditions, one reference benchmark (ideally, one outside the potential subsidence basin) is utilized as the standard and the relative movement of other stations or benchmarks are compared to it in order to detect vertical differential movement over a period of time.

Subsidence can be caused by a number of factors. Potential examples could include mining, hydrocarbon (petroleum) exploration and production, petroleum production-related water injection and disposal, water well drilling and completion, geological deformation, and dissolution. Nash Draw is a major subsidence feature near WIPP, caused by the dissolution of evaporites in the upper Salado and lower Rustler formations. Near WIPP, localized mine-induced subsidence is associated with areas where pillars were removed during second-pass extraction in potash mines.

Subsidence monitoring of the surface area over the underground excavations is a consequence of several government and WIPP requirements. SDD AU00 states, "The design of the mine will result in no more than one inch surface subsidence within 500 feet of the waste shaft." This is one of the original design parameters to ensure protection of the WIPP surface structures. The size of the underground shaft pillar area and the layout of the WIPP mine plan are based on this parameter among others. Calculations to ensure this low level of subsidence around the waste shaft were made by WIPP architects/engineers.

SDD AU00 is the driver for the annual subsidence survey around the WIPP waste shaft, which is conducted according to the specifications of a Second Order, Class II Survey as stated by the FGCS. This classification allows for a maximum of about 2/5-inch vertical error per mile of survey. Thus, the maximum survey error is small enough that it will not mask any subsidence that might occur within 500 feet of the waste shaft.

The Subsidence Monitoring Program monitors vertical ground movement over the underground openings at WIPP. Monitoring stations were installed on the surface over the completed and planned underground excavations in a grid with spacing of approximately 1,000 feet. Precise level surveys are conducted annually to determine any surface movement of the subsidence stations.
Subsidence monitoring was selected by the DOE as a basic long-term monitoring tool. The initial subsidence survey is considered as the baseline condition. Because subsidence monitoring is performed annually, it is also useful as an active institutional control (short-term) tool. Subsidence monitoring is nonintrusive by nature and can be related to numerical assessments. Subsidence monitoring can detect substantial and detrimental, or slight and insignificant deviations from expected repository performance by comparing current subsidence values to previous subsidence survey values. Subsidence monitoring can be implemented independent of site utilities, providing useful data for a reasonable cost over a relatively long time period, and it requires minimum maintenance to sustain a high-quality performance level.

Subsidence monitoring provides information on vertical surface movement in mining areas due to creep closure of underground openings. This closure results in a subsidence basin on the surface the extent of which depends on the underground extraction. Establishing permanent stations over the underground openings and periodically traversing through these stations with precise level surveys can determine the subsidence profile, provided these surveys are continued far enough into the future to allow the subsidence to reach the surface.

The Backfill Engineering Analysis Report (WEC 1994) evaluates the potential for, and predicts subsidence caused by, the mining of WIPP's shafts, drifts, and waste disposal rooms. These calculations account for a range of emplaced waste volumes, waste densities, and backfill types. Subsidence was also calculated for conditions where no backfill would be used.

This study predicts the maximum subsidence expected, and was performed to specifically estimate subsidence for long-term repository performance monitoring. It does not account for other factors that may influence subsidence, such as local petroleum exploration and production, and potash mining.

The Subsidence Monitoring Program provides the capability to assess the responses of the surface and underground facility due to surface subsidence.

3.3.2 Methodology

The activities associated with the Subsidence Monitoring Program are designed to:

- Provide time-related spatial information on surface subsidence within an area of 500 feet of the waste shaft during the operational phase of the repository

- Provide time-related spatial information on surface subsidence over the influence area of the underground openings with which subsidence predictions can be compared

- Provide an annual written report during the operational phase

The process by which subsidence information is obtained may change with changing technology. Nothing in this plan will limit the adoption of new technology provided the performance of subsidence surveys follow the specifications described in the FGCS specifications and procedures for subsidence leveling surveys.

The following are activities of the Subsidence Monitoring Program:

Subsidence Station Maintenance - Subsidence stations are maintained as needed. Restoration, replacement, and installation of new stations will be performed according to FGCS specifications and procedures for Second Order, Class II surveys.

Testing - When in use, daily tests are performed on all equipment used to ensure proper operation and calibration.

Subsidence Surveys - Subsidence surveys are performed annually until closure. After closure, in accordance with the CCA, subsidence surveys will be performed on the first and third year, then at ten-year intervals for the next 100 years, or as long as the DOE deems necessary.

Report and Database - A report is generated each year that details the current subsidence survey and summarizes previous years' values. Survey information will be maintained in electronic files in two locations. Backup electronic files of the information are maintained on the WIPP Intranet.

Review - Data, plots, graphics, and reports generated by the annual subsidence survey will be reviewed and signed by the CE as required by the WIPP QAPD and the CCA.

4.0 QUALITY ASSURANCE

The WIPP Underground and Surface Surveying Program is governed by the WIPP QAPD. Steps to ensure quality will be incorporated into the technical processes used for engineering surveying activities, as needed. The Geotechnical and Mine Engineering manager, or assigned designee, is responsible for developing and maintaining this program. Surveying and subsidence surveying at WIPP performed by qualified contractor/vendor personnel are under the direct supervision of the WIPP Geotechnical and Mine Engineering Manager. Vendor personnel who perform surveying-related work must meet the following minimum standards:

- Five years' experience in field surveying
- Demonstrated proficiency in the use of various precision leveling equipment specified for the monitoring program(s)
- Demonstrated proficiency in the use of various related surveying software specified for the monitoring program(s)
- Demonstrated proficiency in the use of various GPS-related equipment and software

4.1 Survey Equipment Control

Survey equipment processes use sound surveying/scientific principles and appropriate standards. WIPP's QA program and WIPP engineering require that tests be performed on all equipment when in use to ensure proper operation and calibration.

Surveying equipment are controlled and calibrated in accordance with WIPP procedures. Results of calibrations, maintenance, and repair will be documented. Calibration records will identify the reference standard and the relationship to national and international standards or nationally accepted measurement systems. Calibration reports and operability tests are maintained by the WIPP Metrology Office.

WP 10-AD.01, Metrology Program, requires, at a minimum of every two years or in accordance with manufacturer's recommendations, that all equipment be given complete maintenance and calibration checks by approved vendor(s) or a qualified laboratory to ensure that the equipment is properly calibrated and/or in proper working condition.

For subsidence measurement equipment, maintenance and calibration are performed by approved vendors in accordance with national standards. Equipment is maintained and calibrated by vendors on the WIPP QA-approved Qualified Supplier's List. The WIPP QA Department will process and ensure the adequacy of routine maintenance performed by the vendor.

4.2 Procurement

Procurement of equipment is carried out in accordance with the appropriate policies and procedures for the determined quality management level. Technical requirements and services will be developed and specified in procurement documents. If deemed necessary, these documents will require suppliers to have an adequate QA program to ensure that required characteristics are attained.

4.3 Instructions, Procedures, and Drawings

Quality-affecting activities performed by, or on behalf of, the surveying programs are performed in accordance with FGCS standards, WIPP approved work instructions, and/or WIPP approved written plans.

4.4 Document Control

The Geotechnical and Mine Engineering manager identifies the individuals responsible for the preparation, review, and approval of surveying engineering controlled documents. Documents generated as a result of the subsidence surveys are reviewed by cognizant technical engineering personnel to ensure their adequacy and accuracy. Controlled documents are reviewed in accordance with DOE and DOE/WIPP QA/review procedures.

4.5 Control of Purchased Material, Equipment/Services

Measures are taken, in accordance with current WIPP procurement policies and procedures, to ensure that procured items and services conform to specified requirements. These measures will generally include one or more of the following:

- Evaluation of the supplier's capability to provide items or services, in accordance with requirements, including the previous record in providing similar products or services satisfactorily

- Evaluation of objective evidence of conformance, such as supplier submittals

- Examination and testing of items or services upon delivery

If it is determined that additional measures are required to ensure quality in a specific procurement, additional steps may be provided for procurement documents and implemented by the Mine Engineering Surveyors personnel and/or the QA Department. These additional assurances may include source inspection and audits or surveillances at suppliers' facilities.

4.6 Identification and Control of Items

Measures are used to ensure that only correct and accepted items are used at WIPP. All items that potentially affect the quality of the WIPP Underground and Surface Surveying Program will be identified and controlled to ensure traceability and prevent the use of incorrect or defective items.

4.7 Software Requirements

Computer program testing activities that affect quality-related activities performed by WIPP or its suppliers are accomplished in accordance with approved procedures as specified by WP 13-1, Waste Isolation Pilot Plant Quality Assurance Program Description.

Test requirements and acceptance criteria will be specified, documented, and reviewed and will be based upon applicable design or other pertinent technical documents. Required tests, including verification, hardware integration, and in-use tests, will be controlled.
Testing of software will verify the capability of the computer program to produce valid results for test problems encompassing the range of permitted use defined by the program documentation.

Depending upon the complexity of the computer program being tested, requirements may range from a single test of the completed computer program to a series of tests performed at various stages of computer program development to verify correct translation between stages and proper working of individual modules. This will be followed by an overall computer program test.
Regardless of the number of stages of testing performed, verification testing and validation will be of sufficient scope and depth to establish that test requirements are satisfied and that the software produces a valid result for its intended function.

4.8 Handling, Storage, and Shipping

Handling, storage, and shipping of surveying equipment will be coordinated in accordance with the manufacturer's recommendations.

4.9 Control of Nonconforming Conditions/Items

Conditions adverse to quality will be documented and classified with regard to their significance. Corrective actions will be taken accordingly.

Equipment that does not conform to specified requirements will be controlled to prevent its use. Faulty items will be tagged and segregated. Repaired equipment will be subject to the original acceptance inspections and tests prior to use.

4.10 Corrective Action

Conditions adverse to acceptable quality will be documented and reported in accordance with corrective action procedures and corrected as soon as practical. Immediate action will be taken to control work, and its results, performed under conditions adverse to acceptable quality in order to prevent degradation in quality.

The Geotechnical and Mine Engineering manager, or designee, will investigate any deficiencies in activities.

4.11 Records Management

Identification, preparation, collection, storage, maintenance, disposition, and permanent storage of records will be in accordance with approved WIPP procedures.

Generation of records will accurately reflect completed work and facility conditions while complying with statutory or contractual requirements. Records will be transferred and protected from loss and damage in accordance with WP 15-RM, WIPP Records Management Program.

4.12 Audits and Independent Assessment

Planned and periodic assessments will be conducted to measure management item quality and process effectiveness, and to promote improvement. The organization performing independent assessments will have sufficient authority to carry out its responsibilities. Persons conducting technical assessments will be technically qualified and knowledgeable of the items and processes to be assessed.

4.13 Data Reduction and Verification

Computer programs, commercial data processing applications, and manual calculations that collect or manipulate/reduce data will be verified. Verification must be performed before the presentation of final results of their use in subsequent activities. If it becomes necessary to present or use unchecked results, transmittals and subsequent calculations will be marked "DRAFT" until such time that the results are verified and determined to be correct.

5.0 IMPLEMENTATION MATRIX

5.1 WIPP/Mine Engineering

WIPP/Mine Engineering will be the cognizant technical organization with regard to the implementation of the WIPP Underground and Surface Surveying Program, including subsidence monitoring. As such, WIPP/Mine Engineering is responsible for the performance, methodology, calculations, and other associated activities involving the collection, interpretation, and presentation of required data necessary to implement the program at WIPP. For surface surveys outside the protected area, WIPP/Mine Engineering personnel will ensure compliance with the National Environmental Policy Act (Pubic Law 91-190), if/as applicable, prior to initiating survey activities. WIPP13-1/Mine Engineering is also responsible for the annual subsidence monitoring survey report as well as all other necessary documentation. The annual subsidence monitoring survey report will be published within each calendar year.

REFERENCES
DOCUMENT NUMBER AND TITLE
Title 30 CFR Part 57, Safety and Health Standards-Underground Metal and Nonmetal Mines
National Environmental Policy Act, Public Law 91-190
DOE/CAO 96-2184, Compliance Certification Application
SDD AU00, Underground Facilities and Equipment
WP 09, Conduct of Engineering
WP 10-AD.01, Metrology Program
WP 13-1, Waste Isolation Pilot Plant Quality Assurance Program Description
WP 15-RM, WIPP Records Management Program
Backfill Engineering Analysis Report, IT Corporation (1994)
Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys, Federal Geodetic Control Committee (now Federal Geodetic Control Subcommittee) [1975] 1980, Reprint