

GLOBAL BLUEPRINTS FOR CHANGE

**First Edition--Prepared in Conjunction with the International Workshop on
Disaster Reduction convened on August 19-22, 2001**

The Global Blueprints for Change contain guidance for working together to improve the capability to identify indicators of physical, social, enterprise, and environmental vulnerabilities throughout the world and to select and implement realistic solutions to reduce them towards acceptable levels.

**Theme A: LIVING WITH NATURAL AND TECHNOLOGICAL HAZARDS
Topic A.7: Improving Real Time and Near Real Time Communications**

"Management Plan for the USA Advanced National Seismic System"

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MANAGEMENT PLAN FOR THE ADVANCED USA NATIONAL SEISMIC NETWORK

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Abstract: This Blueprint for Change is based on experience in the United States that was mandated by Public Law 106-503. It will provide guidance that will assist communities throughout the world in improving their capability for adopting and using real time communicating systems for the benefit of all sectors of their community. The Advanced National seismic Network (ANSS) will consist of urban monitoring networks to record strong shaking of the ground and in structures, regional and national monitoring networks, regional and national data centers, data archive and distribution facilities, and two portable seismic networks for aftershock studies and research. The implementation of the ANSS will require the purchase and installation of over 7,000 new seismic recording instruments and the modernization of regional and national earthquake data and information centers.

Background

In 1997 Congress directed the U.S. Geological Survey (USGS) to “prepare an assessment of seismic monitoring in the United States.” This directive was contained in a reauthorization of the National Earthquake Hazards Reduction Program (NEHRP), Public Law 105-47. In compliance with this directive, the USGS prepared a report entitled *An Assessment of Seismic Monitoring in the United States: Requirement for an Advanced National Seismic System (USGS Circular 1188)* which was submitted to Congress in the spring of 1999. That report gave the justification and funding estimates for an Advanced National Seismic System (ANSS).

In the most recent reauthorization of NEHRP (Public Law 106-503), Congress directed that the USGS provide a 5-year Management Plan for the establishment and operations of the ANSS (see Preface). This management plan is submitted in accordance with Public Law 106-503.

Justification for the ANSS

Of all the natural hazards facing the United States, earthquakes represent the single largest potential source for casualties and damage. Although damaging earthquakes occur relatively

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infrequently compared to floods or severe windstorms, their consequences can be staggering. As recent earthquakes around the world have demonstrated, high population densities and development pressures, particularly in urban areas, are increasing vulnerability and risk. The Federal Emergency Management Agency (FEMA) estimates that the current annualized earthquake loss for the United States is \$4.4 billion per year (*HAZUS 99 Estimated Annualized Earthquake Losses for the United States*, FEMA #366, September, 2000). This estimate, however, represents the expected loss averaged over many years. If a large-magnitude earthquake strikes a major metropolitan area, the actual loss will be significantly larger.

Although the future occurrence of earthquakes is inevitable, catastrophic losses are not. Mitigation efforts directed at both short-term response and long-term preparation can greatly reduce the impact of these events. Modern seismic monitoring systems provide the necessary foundation of basic data and information to accomplish mitigation efforts within both time frames.

In particular, modern seismic monitoring technology can provide:

- seconds to tens of seconds of warning following a strong earthquake, depending on the location of the epicenter,
- rapid assessments of the distribution and severity of earthquake shaking for use in emergency response,
- rapid assessment of the impact of earthquake shaking on critical structures, such as lifelines and business facilities,
- information for correctly characterizing earthquake hazards for improving building codes and land-use planning,
- critically needed data on the response of buildings and structures during earthquakes, for safe, cost-effective design, engineering, and construction practices in earthquake-prone regions, and
- data and information on processes triggered by earthquakes, such as landslides and tsunamis.

This management plan consists of three major elements:

Organization. The organization is based on regional planning and implementation with national support and oversight. The basic building blocks of the organization exist in regional and national seismic monitoring activities. The plan calls for regional advisory committees to provide direction and oversight for urban and regional efforts. An ANSS National Steering Committee will oversee the development of the entire system and report to the Director of the USGS. Technical committees provide standards and specification to all elements.

Implementation. The USGS will purchase all new equipment and will provide technical support to assist regional networks in the installation of this equipment. The installation schedule will “ramp up” with time in order to obtain necessary installation permits and to train an installation workforce. Thus, equipment purchases must be concentrated in the early years given a constant authorization level at about \$34 million per year.

Operations. Operations of the ANSS will be based on regional and national level activities integrated into a single national system with common and compatible practices at all levels. The estimate of the annual operational costs of the entire system is \$50 million; three times the current USGS level of support for such activities.

The ANSS will consist of urban monitoring networks to record strong shaking of the ground and structures, regional and national monitoring networks, regional and national data centers, data archive and distribution facilities, and two portable seismic networks for aftershock studies and research. The implementation of the ANSS will require the purchase and installation of over 7,000 new seismic recording instruments and the modernization of regional and national earthquake data and information centers.

The ANSS is a challenge that must be met to reduce the impacts of future earthquakes in the United States.

Assessment of Current Seismic Monitoring Capability

Seismic monitoring in the United States has not kept pace with increased earthquake risk (due to urban development), with technological advances, and with opportunities to deliver improved products and services. Due to limited funding, seismic monitoring equipment has become outdated, and long-term support for network operations is inadequate and unstable. Monitoring coverage is based on an uneven patchwork of regional networks that offer only sparse coverage of threatened urban centers. The designs of many of the existing seismic networks and the instrumentation employed are directed toward detecting small, local earthquakes or larger shocks at greater distances. These instruments are over-driven by rare, but important, nearby large magnitude earthquakes. This, in turn, results in the loss of valuable information about building and site response to strong shaking. Modernization of equipment has been slow and piecemeal at best, despite the availability of a range of new technologies that can revolutionize seismic monitoring and dramatically accelerate earthquake mitigation efforts. We are losing valuable opportunities to issue earthquake alerts, to expedite and focus emergency response, and to collect the data needed over the long term to develop improved hazard assessments, engineering and construction practices, and land-use planning.

ELEMENTS OF AN ADVANCED SYSTEM

The report, *An Assessment of Seismic Monitoring in the United States: Requirement for an Advanced National Seismic System (USGS Circular 1188)*, submitted to Congress in 1999, developed the concept of integrated earthquake monitoring on three scales—urban, national,

and regional. The concept of a thoroughly integrated, technologically advanced ANSS calls for five basic elements:

- **Urban** seismic monitoring capable of recording strong ground shaking and the response of buildings and other structures during moderate and large earthquakes,
- **Regional** seismic monitoring of active geologic sources, such as earthquake-producing faults and volcanic activity,
- **National** seismic monitoring to ensure a recording capability down to a uniform magnitude level nationwide, and serve as the national monitoring backbone and backup to regional systems,
- **Portable seismograph arrays** that can be deployed rapidly following an earthquake to record the ground motion of aftershocks in areas of significant damage, and
- **Regional and national data centers** with the capability to collect and process data in real time, to rapidly disseminate notifications of earthquake occurrence and impact, and to provide other information products and services on earthquakes in general and on specific earthquake loss reduction practices.

Each of these elements is an essential part of an integrated, national system.

ESTIMATED DEVELOPMENT COSTS

USGS Circular 1188 provided estimated development costs for the elements of the ANSS. These estimates are reproduced here in Table 2.1; however, they are revised slightly in this plan.

Table 2.1. Initial Estimated Costs for Full ANSS Implementation

National monitoring: Expand USNSN to 100 modern seismographs.	Purchase and install 44 additional modern seismographs, including satellite communications, at \$62,500 each.	\$2,750,000
Regional monitoring: Complete modernization of regional seismic networks.	Purchase and install 1000 modern seismographs, including communications systems, at \$31,250 each.	\$31,250,000
Urban monitoring: Strong-motion monitoring at ground sites (free-field) for warning and rapid damage assessment.	Purchase and install 3,000 strong-motion recorders, including communications systems, at \$18,750 each.	\$56,250,000
Urban monitoring: Strong-motion monitoring in structures for rapid damage assessment and earthquake	Purchase and install 3,000 strong-motion recorders, including communications	\$56,250,000

engineering.	systems, at \$18,750.	
Regional network centers: Modernization to manage new data and functions.	Modernization and standardization of hardware and software at regional centers.	\$20,000,000
National network center: Modernization to manage new data and functions.	Modernization and standardization of hardware and software at the National Earthquake Information Center.	\$2,000,000
Two portable arrays for aftershock recording and special studies.	Purchase two (25 seismographs each) at approximately \$56,250 per station.	\$2,812,500
Total		\$171,312,500

Organizational Structure of the ANSS

Strategic Plan:

Overall responsibility for implementation and operation of the ANSS lies with the USGS, but the USGS intends to collaborate on ANSS development and operations with other Federal and State agencies and with the earth science and engineering communities with interests in seismic monitoring. Fundamental to the success of the ANSS is the need to promote partnerships among those working at local, regional, and national levels committed to reducing earthquake losses. These partnerships are necessary in order for the ANSS to be coordinated nationally, designed and implemented regionally, and supported locally. Recognizing that earthquake hazard and risk varies from region to region, the ANSS management structure emphasizes regional implementation and national integration.

To begin planning and implementing the ANSS, an Interim National Steering Committee was established in early 2000 with representatives from various professional and regional groups. This interim committee met twice, in February and July of 2000, to develop the organizational structure.

The ANSS National Steering Committee provides comprehensive guidance and oversight for the entire ANSS effort. Regional and national networks advisory committees provide guidance and oversight for the ANSS at their respective geographic and specialty levels. Implementation and operations are carried out through a National Implementation Committee made up of regional and national working groups. The working groups consist of representatives of existing regional and national seismic monitoring activities. A Technical Integration Committee provides the technical specifications for the various components of the system.

In its formative stage, the ANSS structure may appear to be “committee heavy.” This is considered necessary in order to give all of the existing interests a voice in developing the

ANSS organization and to set the technical design and specifications of the system. Over time, the number of committees and the committee activity in general will be reduced.

Regional Collaboration

Today, there are some 40 organizations involved in local, regional, or national seismic monitoring or earthquake information distribution activities in the United States. These organizations will be the building blocks of the ANSS. The Interim Steering Committee, however, felt that fewer, larger regional coordination groups should be established for planning and coordinated implementation. This means that existing regional networks and data centers will participate for planning and implementation purposes with other regional interests. In addition, vital local coalitions among seismologists, emergency managers, earthquake engineers, and other stakeholders can be strengthened and nurtured through planning and participation at the regional and State levels.

ANSS regional boundaries are designed to coincide with State boundaries for a number of practical reasons. All States have a geological survey, emergency services units, and, often, seismic safety commissions and universities that operate regional networks. States thus provide the organizational framework for engaging public officials at local, county, and State levels and for promoting the ANSS and related mitigation efforts.

Current ANSS regions are:

- Alaska
- California
- Hawaii
- Intermountain West
- Mid-America
- Northeast United States, and the
- Pacific Northwest

A list of States within each region is given in the Appendix 8.2.

Within each region, a Regional Working Group implements and operates the ANSS. The Regional Working Group is composed of representatives that have monitoring or reporting responsibilities within the region. It may include seismic networks that are not currently supported by the USGS. Each working group shall elect a Regional Coordinator, who serves as chair and chief spokesperson for ANSS in the region. If for some reason the election of a Regional Coordinator poses difficulty, the USGS may appoint a coordinator with the concurrence of the working group. This individual also represents the region on the National Implementation Committee. The duties of a Regional Coordinator may require a significant

portion of an individual's professional time for which compensation should be provided by the USGS.

Guidance for each Regional Working Group is provided by a Regional Advisory Committee, which is comprised of end users of seismic information (e.g. practicing engineers, emergency managers, seismologists, utility operators, transportation officials, etc.). The Regional Advisory Committee reviews planning documents and provides guidance on the development and operation of the ANSS within the region. Importantly, the Regional Advisory Committee critiques and reviews proposed instrument site locations, taking into consideration the appropriate distribution of regional and urban sites. The urban monitoring component of the ANSS will likely require local or State-level advisory groups, linked to the Regional Advisory Committee, to guide implementation. The Regional Advisory Committee should be a strong advocate of the ANSS and is thus expected to foster enhanced participation at the local and regional level from interested parties, including representatives from the private sector.

The chairperson of each Regional Advisory Committee must work closely with the corresponding Regional Coordinator to communicate the particular needs of local constituents and to ensure that these needs are accommodated in the implementation plans. The chairperson is also expected to participate in an annual presentation of these plans to the ANSS National Steering Committee.

EXISTING NATIONAL MONITORING ACTIVITIES

Currently, there are several seismic recording and earthquake notification activities carried out at the national level. The National Earthquake Information Center, the United States National Seismograph Network, and the National Strong Motion Program conduct these activities. These elements are central to the ANSS effort and must be integrated within it.

The National Networks Working Group is made up of managers or representatives of national level activities. Some of these programs, such as the global and strong motion networks, have existing advisory committees that will be accepted as adjuncts to the ANSS organizational structure.

NATIONAL MANAGEMENT

The National Implementation Committee (NIC) consists of coordinators from each of the seven ANSS regions, managers or representatives of national activities, and the ANSS Manager. (A single individual may represent more than one national level activity within the NIC.) The NIC is responsible for integrating the implementation plans of each region into a national plan that is modified to accommodate annual funding appropriations, performance of the individual regions, and national priorities. As such, the NIC is charged with developing an implementation schedule that is both balanced and achievable. It is responsible for building a system that: 1) is well integrated across the regions, 2) follows consistent standards and protocols, and 3) meets implementation and operational milestones and performance goals.

The ANSS Manager coordinates the planning activities of the NIC and has overall responsibility for ANSS implementation. This individual will be a USGS employee with an appropriate staff. The ANSS Manager works with the Regional Coordinators and the national activity representatives to ensure that annual performance goals are met and implementation efforts remain on schedule. This person directs the National Implementation Committee in the development of plans and budget guidelines on a multiyear basis. The ANSS manager is also the chief spokesperson for ANSS at the national level.

NATIONAL OVERSIGHT

Oversight of the ANSS is accomplished through an ANSS National Steering Committee (NSC). This committee critiques and reviews the annual implementation plans proposed by the NIC and communicates with the NIC through the ANSS Manager. The Committee meets semiannually to review ANSS progress, including an annual meeting with the NIC and the Chairperson of each of the regional and national advisory committees. In this way, the NSC is apprised of ANSS issues at both the national and regional levels. The ANSS NSC reports regularly to the Director of the USGS and provides overall direction of the ANSS. The composition of the ANSS NSC is designed to ensure broad representation of critical stakeholders.

Membership of the ANSS NSC is made of representatives nominated from the following organizations:

- Consortium of Strong Motion Operating Systems (COSMOS) - one member
- American Association of State Geologists (AASG) – one member
- National Emergency Management Association (NEMA) – one member
- Earthquake Engineering Research Institute (EERI) – three members
- Incorporated Research Institutions for Seismology (IRIS) – one member
- Seismological Society of America (SSA) - one member
- USGS Central Geologic Hazards Team – one member
- USGS Western Earthquake Hazards Team – one member

The three other NEHRP agencies—the Federal Emergency Management Agency, the National Science Foundation, and the National Institute of Standards and Technology—will be asked to fill advisory (nonvoting) seats on the Steering Committee.

TECHNICAL SPECIFICATION AND INTEGRATION

The ANSS must establish technical specifications for individual components and subsystems and for the integration of these components into a unified system. Individual components and subsystems include:

- seismometers and digitizers (data loggers) that record ground shaking,
- data communications networks,
- data processing systems,
- systems and protocols for notifications of earthquake occurrence and effects, and
- data archiving and distribution systems that ensure long-term access to earthquake information and data needed for research in engineering and earth sciences.

A Technical Integration Committee (TIC) has been established to oversee the development of guidelines and standards under which the entire ANSS will operate. The TIC consists of a chair (non-USGS), a vice-chair (USGS), and four other members with experience and expertise in engineering applications, national and regional network operations, and data archiving and distribution.

The Technical Integration Committee has formed five subcommittees charged with developing design and performance standards for the system and procurement specifications for ANSS equipment. The specialties of the subcommittees are:

- Instrumentation,
- Site Installation,
- Data Analysis,
- System Architecture and Interconnection, and
- Data Archiving and Distribution.

Other subcommittees may be formed as needed.

Although the TIC is responsible for developing guidelines and technical standards for the ANSS, the responsibility for implementing and operating the ANSS within these criteria rests with the National Implementation Committee.

Implementation Strategy and Planning Tasks

The management structure defined in the previous section provides the organizational framework necessary to fully implement an Advanced National Seismic System. The fundamental principles of the ANSS implementation strategy are:

- National oversight and support,
- Planning and implementation at the regional-to-local level with national support,
- Standardized equipment, compatible software and data processing, and uniform products and services, and
- Integration of all elements.

The basic building blocks for implementation of the ANSS are existing regional and national seismic networks and data centers. These elements are in place and functioning today, and it is logical to base the implementation of the ANSS on this foundation. Nevertheless, implementation of the ANSS will require certain changes in the management philosophy and operations of all participating seismic monitoring facilities in the United States.

Achieving a fully integrated ANSS within 5 years will require a new approach to managing resources. This approach must realistically account for the present and future capacity of existing organizations and for regionally diverse needs. It is not feasible or realistic simply to provide additional funds to each of these organizations and make them fully responsible for implementation of the ANSS in their region. Successful implementation of ANSS by FY 2006 requires that national support be provided for procurement of major equipment components, common software development, instrument installation, and system integration. This plan is written for implementation of the ANSS to occur over a 5-year period, FY 2002 – FY 2006.

The five steps in instrument installation—site selection, site permitting, site preparation, equipment installation, and completion of telecommunication links—are all labor intensive. Because the necessary technical staff is not in place today, a supplementary technical workforce must be developed, trained, and made available during a short period of time. Accordingly, engineering field service support will be available, through a national level contract, to regional working groups for the installation and maintenance of equipment. Regional Coordinators, in consultation with the ANSS Manager, will define specific tasks under this contract within their region. It is unlikely that this workforce can be fully developed in the first year of ANSS implementation. This implementation plan therefore provides for a ramp-up of the instrumentation-installation activity, allowing time for the training and field deployment of technical expertise. These practical considerations, along with a constant funding level of about \$34 million annually, require that much of the equipment be purchased during the first 2 years.

PLANNING AND PROCUREMENT TASKS FOR FY 2001

In order for full implementation to begin in FY 2002, certain planning and procurement tasks must be accomplished in FY 2001. These tasks are summarized below.

ANSS Management. The USGS must establish an ANSS management office whose main duties are the management and implementation of the ANSS. A senior grade manager, with the capability to execute complex, large-scale projects should lead this group. Additional required staff are: an administrative assistant, procurement and logistic specialists, and a contracting officer. In addition, the office must have access to technical expertise in telecommunications and systems engineering.

Milestone:

- Establish the ANSS Management Office by October 2001.

System Architecture. An integrated seismic system that links urban, regional, and national elements requires an overarching system design. Design requirements involve specifications on the functions of regional and national monitoring centers, on the interaction between centers, on back-up monitoring support, and on the interaction between centers and other elements of the system. A subcommittee of the TIC is designing the system architecture. Initiation of many subordinate tasks required for the development of the system does not have to wait until the complete system architecture is defined, because the nature of these tasks is generally understood and accepted. However, system architecture must be completed early so that the individual elements can be integrated into a complete operation.

Milestone:

- Develop initial specifications for system architecture by September 2001.

Network Implementation. The planning and implementation of the ANSS at the regional level is the responsibility of the regional advisory committees and regional working groups. Regions should begin planning now for efficient deployment of both urban and regional stations, consistent with the goals in USGS Circular 1188. This planning and implementation shall be consistent with the overall system design. The USGS will provide a template for these plans.

Milestones:

- Develop regional implementation plans for FY 2002 by August 2001.
- Develop general 5-year implementation plan for each region by December 2001.

Equipment Specifications and Procurement. Equipment specifications are being developed by a subcommittee of the TIC. Specifications include requirements for reliability, dynamic range, bandwidth, sensitivity, and connectivity. Separate specifications may be required for urban-ground, urban-structure, regional and national installations. Common specifications for different types of installations will be used when possible.

Milestones:

- Complete instrument specifications by April 2001.
- Instrument procurement solicitation by May 2001.
- Instrument procurement for FY 2002 issued by October 2001.

Site Installation. Modern seismic sensors and data recorders are highly sensitive over a broad range of frequencies. New sites and upgraded sites will therefore require improved infrastructure to ensure high-fidelity recording of ground motions from earthquakes. All sites will require technical specifications for infrastructure and installation procedures. Instruments in structures will require special attention on a case-by-case basis to ensure that useful engineering data is collected. The Site Installation Standards Subcommittee of TIC is preparing guidelines for site installation procedures and standards.

Milestone:

- Complete site installation guidelines for urban-ground, urban-structure, regional and national stations by October 2001.

Instrumentation Installation and Maintenance. The technical and engineering support needed for the installation and maintenance of the ANSS does not exist with the present staff at national and regional monitoring centers. The USGS will develop a national level, technical service contract with a single qualified firm to provide the necessary engineering and logistical support. The contract will be structured so that support personnel meet the variable needs of each region and reside in the region they support. The work will be carried out under the general direction of the ANSS manager and regional coordinators, with direct personnel supervision through the structure of the contracted company.

Milestones:

- Develop technical specifications for the national support contract by May 2001
- Solicit bids for the national technical support contract by June 2001.
- Award national technical support contract FY 2002 by October 2001.

Urban Monitoring

USGS Circular 1188 calls for installation of 3,000 ground-based urban stations and 3,000 structure-based instruments in a total of 26 cities at risk to damaging earthquakes. Seismic data in the urban environment will be used to determine strong shaking patterns just after earthquakes and to design and build safer structure to withstand future earthquakes. Detailed plans for the location, scheduling and installation of new urban sites will be done regionally through regional working groups, with assistance from regional advisory committees and the National Strong Motion Program. Although these plans are not yet available, a general model can be constructed that clearly outlines the overall level of effort required in each region to meet the program goals within 5 years.

This model is based on the following constraints and assumptions:

- Strong motion recording systems cost about \$10,000 per unit and ancillary equipment and installation costs are about \$10,000 per site. Costs for urban-ground and urban-structure sites vary widely due to local conditions; nevertheless, the use of \$20,000 for average equipment and installation costs should be sufficient for planning purposes.
- Approximately 2-3 man-weeks are required, on average, to complete all phases of installing an urban ground-based station (site selection, site permitting, site preparation, instrument installation, and telecommunications). The time required for installations in structures will vary with each site.
- One hundred and ninety-six urban stations will be installed by ANSS by the end of FY 2001. If the 91 urban stations recently installed in the Los Angeles region are included as consistent with the ANSS effort, the total grows to 287.
- Installation of urban stations in FY 2002 requires procurement and delivery of new systems in early FY 2002, necessitating final technical specifications on urban instrumentation in FY 2001.
- All of the equipment needed in FY 2002 and FY 2003 shall be purchased in FY 2002. All of the equipment needed in FY 2004 and 20% needed in FY 2005 shall be purchased in FY 2003. Eighty percent of the equipment

needed in FY 2005 shall be purchased in FY 2004. Half of the equipment needed in FY 2006 shall be purchased in each of FY 2005 and FY 2006.

REGIONAL MONITORING

USGS Circular 1188 calls for replacement or installation of 1,000 broadband seismic stations for regional monitoring activities. Data from these installations will be used to monitor active earthquake and volcanic areas at a level of detail that can be used in research and in forecasting of future activity. Data regional working groups and advisory committees will determine the location and number of regional sites to be upgraded or installed, but the overall level of activity should approximate that given in Table 5.2.

Assumptions made and action items needed for deployment of regional network stations by the end of FY 2006 are:

- Equipment costs are about \$25,000 per site, and ancillary hardware and installation costs are about \$10,000 per site.
- Approximately 3 man weeks are required, to complete all phases of either upgrading or installing new regional monitoring stations, *i.e.* site selection, site permitting, site preparation, instrument installation, and telecommunications, system testing, and verification of operation.
- Some existing regional network sites will be upgraded, reducing site selection, permitting, and installation requirements.
- One hundred and fifty of the regional stations recently installed in southern California are counted toward the 1,000 stations called for under regional monitoring.
- Final technical specifications on regional monitoring instrumentation are required in FY 2001.
- Three hundred units will be purchased in FY 2002; 100 in FY 2003; 200 in FY 2004; 130 in FY 2005; and 120 in FY 2006.

REGIONAL WORKING AND ADVISORY GROUPS WILL MAKE RECOMMENDATIONS FOR THE NUMBER OF SITES TO BE INSTALLED OR UPGRADED WITHIN EACH REGION.

UNITED STATES NATIONAL SEISMOGRAPH NETWORK

USGS Circular 1188 cites the need to expand the United States National Seismograph Network (USNSN) to 100 stations by installing 44 new stations. This network provides uniform, but less detailed, monitoring in regions not covered by regional networks. It also serves a backup to regional operations in case of disruption by a devastating earthquake or

other cause. Expansion of the USNSN will involve either installing new sites or upgrading existing regional network sites.

Assumptions regarding USNSN stations are:

- Site location will be coordinated with the Incorporated Research Institutes for Seismology, State geological surveys, regional seismic networks, and others with interests in national seismic monitoring,
- Equipment costs are about \$40,000 per site, and ancillary hardware and installation costs are about \$20,000 per site,
- All equipment will be purchased in FY 2002, and
- Approximately four stations will be installed in FY 2002 and 10 stations per year between FY 2003 – FY 2006.

This augmentation of the USNSN will be done in collaboration with the Global Seismograph Network and the EarthScope/USArray effort sponsored by the National Science Foundation.

PORTABLE NETWORK

USGS Circular 1188 cites the need for two portable seismic arrays to study aftershocks following moderate and large earthquakes, particularly in areas where station coverage may be sparse. These studies are essential for defining the exact nature (location, depth, geometry) of faults that cause damaging earthquakes and for understanding variations in local geology that produce site amplification and resonance associated with concentrated damage. When not deployed in aftershock studies, the arrays may be used to characterize the geologic structure in seismically active areas.

The planning assumptions for portable seismic arrays are:

- Technology for portable seismic arrays is similar to that used in permanent seismic networks, so much of the instrumentation purchased for regional or urban monitoring meets the needs for portable monitoring.
- Two arrays of 25 stations each are needed for aftershock and site characterization studies.
- The cost of the equipment for two portable seismic arrays is approximately \$2.0 million (\$40,000 per instrument, including ancillary electronic and computer equipment). The equipment will be purchased in FY 2002.

- An additional \$200,000 per year is required to maintain the portable equipment; this cost is included in the operational budget.

NATIONAL EARTHQUAKE INFORMATION CENTER

The National Earthquake Information Center (NEIC) provides uniform seismic monitoring coverage of the United States for earthquakes greater than about magnitude 3.5 and for damaging earthquakes worldwide.

Under the ANSS, the role of the NEIC will be expanded to:

- Provide manned, 24-hour-per-day, 7-days-a-week (24x7) operations for global and national earthquake monitoring and notification,
- Serve as a backup for any regional center that may become inoperative due to a damaging earthquake or other cause, and
- Develop and distribute additional data and new products for news media, emergency management and other public officials, research scientists, and public information.

These expanded capabilities will cost approximately \$2 million to implement. In FY 2002, NEIC will go to 24x7 operations. Communications upgrades, software development for expanded capabilities, and testing will take place during FY 2002 – FY 2005. The new system will be fully operational by the end of FY 2005.

REGIONAL EARTHQUAKE INFORMATION CENTERS

Regional Earthquake Information Centers (REICs) will play a key role in providing information products and services in earthquake-vulnerable areas. As part of a coordinated infrastructure for information delivery under the ANSS, REICs may provide at the regional and local levels: (1) time-critical information for public safety, (2) data and information for long-term earthquake loss reduction, and (3) general information and expert services on earthquakes.

The number of ANSS REICs depends on a variety of factors such as the geographic distribution of seismic hazards and the location of urban areas at risk. The number of REICs that will receive ANSS support will be determined through a systematic review of all regions in FY 2002. This review process will involve the USGS, the National Implementation Committee, and the ANSS National Steering Committee. Performance goals for the REICs, include:

- Operation of compatible hardware and software data acquisition systems so that time-critical data and information can be reliably exchanged among REICs and between each REIC and NEIC,

- Development of common analysis and processing procedures so that all products and information produced by REICs are consistent and easily comparable and collated, and
- Establishment of standardized notification messages and services so that reports of earthquake information to the general public are issued uniformly and consistently nationwide.

The design requirements for the REICs processing, analysis, and notification systems will be developed in FY 2001 and FY 2002 through the Data Analysis and Products Subcommittee of the TIC. The purchase of hardware and the implementation of acquisition and processing systems at the REICs will be done in FY 2003 – FY 2004. Prototype systems already exist but require technical review for system-wide compatibility, performance, and possible augmentation.

DATA ARCHIVAL AND DISTRIBUTION

Critical to the success of the ANSS is the ability of the research and engineering communities to easily access seismic data for earthquake, tsunami, and volcano hazards mitigation research and engineering applications. USGS Circular 1188 did not address the need to develop data archival and distribution systems, but instead mentioned using existing facilities. The Data Management Center of the Incorporated Research Institutions for Seismology, USGS, and the National Science Foundation supported archiving centers in California are examples of facilities that can be augmented to handle archiving and distribution of ANSS data and information for the user community.

In FY 2001 and FY 2002, the Data Archiving and Distribution Subcommittee of the TIC will provide design requirements for the distribution of seismic data and information to archival facilities from the REICs and NEIC. Development of hardware and software to accommodate ANSS data and information at designated archiving centers will occur from FY 2002 – FY 2006.

Implementation Costs

All yearly budgets are within the authorized levels approved by Congress. The program schedule could be adjusted to extend over a longer period; however, the total costs would increase. The implementation plan presented here achieves efficiencies through large hardware procurements and a staged installation schedule. Equipment procurements are concentrated in the first 3 years to allow for a ramp up in the equipment installation effort.

The USGS currently spends approximately \$14.5 million per year in support of seismic monitoring and reporting operations nationwide. Eventually, all of this amount will be redirected toward operational support of the ANSS. However, this redirection needs to be

implemented on an incremental basis so that current operations are not interrupted in order to maintain newly installed equipment

Operational costs are based on the following assumptions

- The cost of operating and maintaining a new station is not budgeted until the following fiscal year.
- Urban sites – The average cost to operate and maintain an urban site is \$5,000 per year. Costs in FY 2002 are for the operation of 196 ANSS sites installed in previous years and for 91 southern California sites.
- Regional sites – New ANSS equipment at regional sites will cost \$6,000 per year to operate and maintain. Costs in FY 2002 are for the operation of 150 southern California regional sites.
- National sites – National sites cost \$10,000 per year to operate and maintain. Costs in FY 2002 cover the 56 existing national sites.
- Portable network – Costs to operate and maintain a portable array are \$100,000 per year, but could increase to \$400,000 to cover the full costs of deployment.
- NEIC – Current costs for NEIC are about \$2.5 million per year. These costs are expected to double as the functions of NEIC expand and a fully manned 24x7 schedule is achieved.
- Regional centers – Current USGS costs for cooperative agreements with regional centers are about \$3 million annually. These costs are expected to double as the functions and data volumes at these centers increase. Costs for salary support for regional coordinators are included in the operations of regional centers.
- Data archive – Cost of data archival and distribution are expected to increase incrementally to about \$1 million per year.
- USGS Management – USGS management costs of about \$500,000 per year are included in the implementation budget until FY 2007. These costs include the salaries and operations of the USGS ANSS office, including coordination expenses.
- Approximately \$6.6 million of current operating funds can be directly associated with anticipated ANSS operations in FY 2002. Over a 5-year period (2003–2007) an additional \$1.6 million per year of current operating funds can be redirected to ANSS operations.