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Public Involvement as an Element in Designing Environmental Monitoring Programs

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1. Introduction

The monitoring of various environmental parameters may occur for a wide variety of reasons in numerous venues and at scales both large and small. Significant advances in the realms of data collection and communication technologies, as well as advances in remote sensing, have resulted in the ability to collect, transmit, analyze, manage, and disseminate environmental monitoring data at a scale little imagined only a couple of decades ago. These advances have also significantly increased the opportunities and means by which the public can contribute to environmental monitoring.

Some types of environmental monitoring may be targeted at short and long-term observations of changes in ecological systems that are the result of natural processes and their effects, and do not come under significant public scrutiny. However, quite the opposite is true for monitoring of potential effects of various anthropogenic media, especially with regards to their impact on the safety and health of human receptors and associated ecosystems. Members of the public may view the results of such monitoring with suspicion, especially if collected by government agencies or other organizations that could be perceived as having either caused a situation which requires monitoring, or who have a vested interest in the results of the monitoring. Suspicion among the public about radiation monitoring was a major contributing factor to how the “Community Environmental Monitoring Program,” discussed later in this chapter, was designed. However, even monitoring of natural phenomena can have critics. Challenges exist in involving the public in environmental monitoring for environmental changes that may be a result of global issues such as climate change (IceWatch Canada and Project BudBurst are described in this chapter if the issues are viewed by some members of the public as being of ideological or political creation. Alternatively, with issues such as climate change, some people feel that the problems are so big that their contributions in measuring the effects of it, or reducing activities that contribute to it, will make no difference (e.g., Norgaard 2006).

Members of the public are often more than willing to participate in environmental monitoring, particularly when they and their own communities have a personal stake in the results or when the monitoring process itself provides tangible benefits. However, sometimes the public does not immediately accept the notion that a monitoring program will have benefits. In fact, there are examples where they have, at least initially, concluded that it would have only

resulted in expenses for them. For example, Mori et al. (2005) describes a program of identifying and mitigating landslides in the Republic of Armenia in which it was hoped that the citizens of rural areas could help identify landslide-prone areas too small to be delineated by remote imagery. A key in making the program successful was investing time with people in towns prone to landslides, showing them how recognizing landslide hazards and implementing mitigating measures could help them avoid breakage of waterlines, damage to foundations of homes, and loss of cropland which the people had incurred great cost in time and money in developing. Simply talking about economic impacts of landslides at a national level was of no interest to people at a local level, and even created suspicion that the project was being undertaken to prevent people from freely using their land. The program in Armenia is just one example of how monitoring programs which effectively incorporate significant roles for the public can have a profound effect on the willingness of stakeholders to accept monitoring results, can result in better communication efforts, improve program transparency, and can actually result in a reduction in program costs in some scenarios. However, for these results to come about, the design of the monitoring program must carefully examine how the public perceives the subject, and how they will participate or contribute to the program.

This chapter will discuss the benefits, as well as potential pitfalls, of significant levels of public involvement in environmental monitoring programs. It will highlight mechanisms for designing, implementing, and maintaining viable monitoring programs with significant public components, and provide several real-world examples of programs that are highly inclusive of public stakeholders. Examples will be provided of environmental monitoring that concerns public and ecologic health, emergency response, as well as improved understanding of environmental processes or phenomena. The chapter will also highlight technological advances that have made public participation and transparency much easier to accomplish than in the past.

2. The citizen as scientist

There is a long history of public participation in environmental monitoring and other scientific endeavours. These “citizen scientists” (e.g., Bonney & LaBranche, 2004) have contributed greatly to several scientific bodies of knowledge by providing large, mainly volunteer constituencies, often comprised mostly of individuals without any formal science education or training, who nevertheless are able to carry out various forms of data collection and reporting that might otherwise be difficult or impossible for reasons of funding, time, or geographic distribution, among others. One of the best examples of a long-term monitoring program with significant public involvement is the National Audubon Society’s annual Christmas Bird Count, which has been ongoing for 111 years (<http://birds.audubon.org/christmas-bird-count>, accessed July 2011). From humble beginnings in the year 1900, when twenty-seven individuals took part in the first bird count, the project now includes tens of thousands of participants in more than 15 countries who monitor bird populations and distributions between December 14th and January 5th annually, and enter their results in an online database. Other ornithological research projects have adopted the citizen science model for more regional scale studies (e.g., McCaffrey, 2005). Another area of science that has long embraced citizen scientists is the astronomy community. The 20-millionth observation of a variable star was made by an amateur astronomer in February 2011 as part of a citizen science program that is in its 100th year

(<http://www.aavso.org/>, accessed July 2011). Amateur astronomers also produce a number of regular discoveries of new comets and asteroids that are added to databases of programs (e.g., the Spaceguard Center in the UK: <http://spaceguarduk.com/>, accessed July 2011) that monitor the skies for near-Earth objects that may one day threaten the planet.

There is a growing recognition amongst scientists and those in environmental communication that the establishment of meaningful partnerships with the public and the identification of significant participatory roles for those who are willing to take on associated responsibilities can help facilitate the communication that occurs between interested, concerned citizens and corporations or agencies and the scientists who perform research or monitoring tasks for them (Groffman et al., 2010; Shneider & Snieder 2011; Shafer & Hartwell, 2011, in press). This is especially true in cases where constituents in the media being monitored are anthropogenic in origin and have the potential, either real or perceived, to inflict harm upon human communities and associated ecosystems.

Willingness and interest on the part of citizens to pursue involvement in environmental monitoring may be driven by simple curiosity or, as mentioned above, by concern or fear surrounding the monitored media's potential to inflict harm and/or distrust of the agency or corporation responsible for conducting the monitoring activity. Regardless of the reason, it behoves the scientific community to take advantage of this interest in the name of cultivating a stronger association with the public whose tax dollars often fund the majority of scientific research that occurs in most countries, and whose sometimes heightened perception of risk of a planned activity can often bring a project to a screeching halt, or at least a significant delay. Providing the public with a greater role than the minimum required by legislative regulation can result in the measurer's recognition as a show of good faith, as well as an opportunity to provide a greater public understanding of monitoring and associated activities, and can produce a network of citizens who not only develop a personal ownership in the project or process, but who also become informal communicators in their communities as we shall see in some later examples.

3. Degree of participation

The degree to which the public may participate most successfully in a project will likely be determined by such factors as public visibility of the project, funding, study length, geographical extent, and especially the willingness of those responsible for the operation of a given project to include and define roles for the public that will be of mutual interest and benefit to everyone involved. For purposes of discussion, we separate public participation into two categories: passive and active. Several brief examples of passive participatory programs are given, with discussion focusing on active public participation.

3.1 Passive participation projects

The arrival over the last decade or so of new information technologies is one of the most significant factors driving greater opportunities for public involvement in scientific monitoring and research endeavours (Kim, 2011; Silvertown, 2009). The realization of personal computers in most homes in developed and developing nations, coupled with the advent of email, the internet, the World Wide Web, and cellular "smart" phones and their associated applications (or "apps") have changed the manner and speed with which data can be gathered, transmitted, accessed, analyzed, and reported. While these innovations have made major contributions to all levels of public involvement, they have leant themselves particularly well to what we refer to as "passive" participation.

By passive participation, we refer essentially to the relatively new phenomenon of allowing one's personal home (or work) computer to be used as a computational resource for studies that require significant computer power which may not be directly available due to funding considerations or due to prior commitments in using resources that are locally available. This essentially free and extensive network of computational power can be an extremely invaluable tool to the researcher who has need of it. This type of participation, while not necessarily providing the participating citizen with physical or intellectual involvement, does give the participant the emotional satisfaction of knowing that he or she is contributing to the understanding or resolution of a problem in which he or she is particularly interested. Aside from installing the software and choosing which projects to support, there is no further participation on the part of the volunteer---all computations run in the background while the user is using the computer for other functions, or when the computer is idle. One benefit to this level of participation is that the home user maintains complete control over which projects to support, the timing of the support, and how much computer processing power to allocate. Several examples are provided below.

3.1.1 SETI@home

SETI@home (<http://setiathome.ssl.berkeley.edu/>, accessed July 2011) was the first monitoring project to make use of tens of thousands of personal home computers to process data (Anderson et al., 2002). SETI, which stands for Search for Extraterrestrial Intelligence, has a scientific goal of detecting intelligent life outside of the Earth. One part of SETI involves using large radio telescopes to monitor for the presence of narrow-bandwidth radio signals from outer space which, if detected, would likely be indicative of intelligent origin, since such signals are not known to occur naturally. As of July 2011, SETI@home had more than 1.2 million users, with more than 155,000 actually active when it was accessed, representing 204 countries and over 493 TeraFLOPS average floating point operations per second (http://boincstats.com/stats/project_graph.php?pr=sah, accessed July 2011).

3.1.2 BOINC

The Berkeley Open Infrastructure for Network Computing, or BOINC (<http://boinc.berkeley.edu/>, accessed July 2011) was originally designed to combat the falsification of data by some users of the SETI@home program. BOINC is an open-source software designed for volunteer computing. Since its inception in 2002, it has provided volunteer users worldwide with the opportunity to, among many other things, assist with such endeavours as long-term climate modelling at Oxford University in the UK (<http://climateprediction.net>, accessed July 2011), help with epidemiological modelling of malaria outbreaks being studied at the Swiss Tropical Institute (<http://www.malariacontrol.net/>, accessed July 2011), help the Planetary Science Institute monitor and study the hazard posed by near-Earth asteroids (<http://orbit.psi.edu/oah/>, accessed July 2011), and assist Stanford University in the United States (U.S.) with the monitoring of earthquakes to improve understanding of seismicity in an effort to aid with earthquake preparedness planning (<http://qcn.stanford.edu/>). The "Quake-Catcher" network, as it is called, is also proactive in involving public schools, providing free educational software designed to help teach about earthquakes and earthquake preparedness (Cochran et al., 2009).

3.2 Active participation projects

Active participation refers to those programs that require participants to take an active role in the collection of and/or observation of data, and to record, enter, or otherwise transmit those data. While internet and phone app technologies are usually components of these projects as well, it is often the citizen scientist who must actively enter the data.

3.2.1 Project BudBurst and related programs in Europe

Global climate change is already resulting in the changes in the timing of leafing, flowering, and fruiting of plants (plant phenophases) with a general lengthening of the growing season. While there have been many local records developed, there remain significant geographic gaps and gaps in the types of plants for which phenological records have been developed (Backlund et al. 2008). Project BudBurst, co-managed by National Ecological Observatory Network (NEON) of the U.S. National Science Foundation (Keller et al. 2008) and the Chicago Botanic Garden (http://neoninc.org/budburst/_AboutBudBurst.php , accessed July 2011) is designed to address these data needs through public participation. The principle objective of NEON is establishing observational and experimental sites in 20 ecoclimatic domains in the contiguous U.S. as well as the states of Alaska and Hawaii. Project BudBurst's contribution is in expanding the number of locations and species for which information on the response to climate change is collected in the U.S. and Canada by using citizen scientists referred to as "Project BudBurst Observers." See Fig. 1.



Fig. 1. On-line banner for Project BudBurst, a collaboration between the NEON program funded by the U.S. National Science Foundation and the Chicago Botanic Garden. The project also aims to integrate phenological observation programs initiated by other organizations, universities, and national laboratories.

Similar to a growing number of programs involving stakeholders in environmental observations, extensive information is available for individuals or groups, including school classes, to participate in the program. A "help site" is also available for assisting in selecting sites, targeting plant species, and interpreting phenological phases. Project BudBurst Observers are encouraged to focus on recording first leaf, full leaf, and first flower, relatively easy phenological observations to make, although data is sought on other events too. For registered users, information is available on the website for interpreting these phases and results can be entered in an on-line journal. Similar to other programs described elsewhere in this chapter, results are available on-line in the form of maps that show the 100 most recent observations for a particular phenomena such as first flower and first pollen in the spring, and 50 percent leaf fall for deciduous plants in the fall. By clicking on the icon for one of the recent observations, information and a photo of the plant of interest and the phenological event observed is provided, and the record number is shown. Particularly for younger participants in the program, these types of on-

line results, besides being educational, reinforce that the data they are collecting is contributing to the program.

Although many Project BudBurst participants are making observations on plant species close to where they live or go to school because of the frequency of observations needed at critical times of the year, there are special projects underway. For example, Project BudBurst is teaming with the U.S. Fish and Wildlife Service (USFWS) to have observations made in its refuges that are of particular ecological significance. Also, in different regions, a "most wanted" list of plants is posted and volunteers sought to record data on them.

The U.S. National Park Service (NPS) has been a leader among federal agencies in the U.S. in engaging the public in phenological observations (see "What's Invasive!" later in this chapter). At a workshop in March 2011 lead by the NPS and the USA National Phenology Network (<http://www.usanpn.org>, accessed August 2011), participants from government organizations, nonprofits, and institutions of higher-education met to explore ways of further engaging the public in phenological observations and standardizing protocols to better compare data from different regions. The workshop included discussion on three ongoing efforts at six NPS pilot parks in California including 1) identifying target species to assess resource response to climate change; 2) testing monitoring protocols; and 3) using different approaches to engage the public in phenological observations and documenting the results of projects in "tool kits" on the Web (Sharron and Mitchell, 2011). Material from the workshop is available at <http://www.usanpn.org/nps> (accessed August 2011).

Geographically large, phenological observation networks are not limited to the U.S. and Canada. The International Phenological Gardens program, managed by Humboldt University of Berlin, Germany was founded in 1957 (http://www.agrar.hu-berlin.de/struktur/institute/nptw/agrarmet/phaenologie/ipg/ipg_allg-e/, accessed July 2011). Today the network includes gardens in 19 countries in continental Europe as well as Britain and Ireland, ranging from northernmost Finland to sites in southern European countries including Portugal, Spain, Italy, and Macedonia. However, because the natural environment of Europe has been much more extensively altered than those of North America, the International Phenological Gardens restricts its observations to a limited number of plant species common to a large number of gardens in Europe. Locally, a wider range of plant species have been tracked since 2002 by faculty as well as volunteers associated with the Royal Botanic Gardens in Edinburgh, Scotland (<http://www.rbge.org.uk/science/plants-and-climate-change/phenology-projects/>, accessed July 2011). Although not continuous, phenological research at the Royal Botanic Gardens Edinburgh dates from the 1850s, when curator James McNab began recording the flowering dates of more than 60 species (McNab, 1857).

3.2.2 Citizen scientists and physical phenology

In addition to biological phenology, citizen scientists are contributing to the establishment of records of changes in physical phenology that may be in response to climate change. A good example is "IceWatch Canada." Scientists have found that the freeze-thaw cycles of lakes and rivers in Canada are changing, usually resulting in a longer ice-free period during the year (e.g., Futter, 2003). However, in a country as large (nearly 149 million square kilometers {km²}) and physiographically diverse as Canada, climate change is not consistent across the country either latitudinally or longitudinally. Observations from citizen scientists are helping provide a greater geographic distribution of freeze-thaw cycle records across the country. IceWatch Canada is one element of "NatureWatch"

Canada, managed by Environment Canada, Nature Canada, and the University of Guelph (<http://www.naturewatch.ca>, accessed July 2011). Environment Canada is the principle Canadian agency responsible for environmental protection and natural heritage conservation, as well as for providing developing climate data and making weather forecasts across the nation (<http://www.ec.gc.ca/default.asp?lang=En&n=BD3CE17D-1/>, accessed July 2011). Nature Canada is one of the largest non-profit organizations in Canada supporting protection of rare species of plants and animals, habitat conservation, and environmental education (<http://www.naturecanada.ca>, accessed July 2011).

IceWatch Canada makes extensive use of the Web for recruiting volunteers, providing training on making freeze-thaw observations, and as a platform for stakeholders to submit observations. As part of quality control, citizen scientists must register with the program where on-line resources guide them through selecting observation points and interpreting freeze-thaw cycles.

Two principle events are the goal of "ice watching" to make observations consistent from one location to another. The first event is the date when ice completely covers a lake, bay, or river and stays intact for the winter. The second is when ice completely disappears from the same body of water. This allows the principle measurement to be determined: the length of ice duration during the year. This calculation is the most common historic measurement made of freeze-thaw cycles in the country, allowing modern records to be combined with historic ones, some of the latter being continuous from the early part of the 20th century. While during the middle of the winter or summer observations are rarely important to make, the on-line training for IceWatch Canada emphasizes the importance of daily observations during the freeze-up or ice break-up period.

In addition to observations that contribute to ice duration, data on other phenomena are sought including:

- The first date that ice completely covers the water body, even when this is a temporary event. For some lakes and rivers, the first ice cover is of short duration and the ice partially or totally melts if temperatures rise. In some cases, this may happen several times before the permanent freeze of the winter occurs.
- Similarly in the spring, ice may disappear, but then partially or completely freeze over again before a permanent ice-free stage is established (Fig. 2).

The web site provides detailed instructions in selecting observation points, with a safety message that there should be no need for a citizen scientist to venture out onto an ice-covered water body to complete the observations. In addition, images are provided of lakes and rivers to show complete or partial stages of freeze and thaw to help participants make similar interpretations at their observation points. Volunteers are also asked to make a detailed description of their observation point, including latitude and longitude, in part so that consistent observations can continue to be made if there is a change in the person or organization responsible for a site so that longer records can be kept for the same location. Participants are cautioned to avoid selecting water bodies in the proximity of anthropogenic processes or features such as dams or water intake facilities which may impact normal freeze-thaw cycles.

What types of results are available on line? One is the pattern of freeze and thaw over time for individual sites that are part of the IceWatch Canada network. The second is a map of Canada showing at any given time the spatial distribution of the stages of freeze and thaw across the country. New citizen scientists are continually being sought for IceWatch Canada,

particularly for those parts of the country at higher latitudes where the population of Canada is sparse.



Fig. 2. Although sea ice has partially broken up on this bay, thin ice is beginning to form over the open water areas again. Such observations of episodic ice thaw are one type of observation sought in the IceWatch Canada program.

3.2.3 Citizen scientists, cell phones, and natural resource management

The growing popularity of cellular “smart” phones such as Android™ and iPhone™ with embedded global position system (GPS) capability is allowing citizen scientists to collect and transmit data on environmental phenomena from dispersed locations (Kim, 2011). An example of the use of these tools for natural resource management is the “What’s Invasive!” program for tracking the location of invasive plants. “What’s Invasive!” is a collaboration of the Center for Embedded Networked Sensing (CENS) at the University of California, Los Angeles; the University of Georgia Center for Invasive Species and Ecosystem Health, and a growing number of local, state, and federal resource management agencies in the U.S. including the NPS, the U.S. Forest Service, and the USFWS (<http://whatsinvasive.com>, accessed July, 2011). A key element of the app that is downloaded to the smart phone is EDDMaps, or “Early Detection and Distribution Mapping System” that allows for web-based mapping the location of invasive species. EDDMaps was and continues to be developed at the University of Georgia.

The pilot effort of “What’s Invasive!” occurred at the Santa Monica Mountains National Recreational Area (NRA) in California. The Santa Monica Mountains protect one of the largest areas of mountainous, Mediterranean-type ecosystem in North America, let alone the world. However, in addition to the NRA protecting habitat of many plant species of limited range, its proximity to the Los Angeles metropolitan area--the second largest in the U.S.--means that the park is a popular getaway for hikers, birdwatchers, and amateur naturalists.

In addition, it is a park that is struggling with the control of invasive plants since so many non-native species have been introduced to southern California.

With "What's Invasive!", the NPS, which manages the Santa Monica Mountains NRA, went from relying on a small staff of federal employees to locate newly established areas of invasives to the much larger community of visitors to the park. From its beginning at the NRA, "What's Invasive!" projects have been established at more than 40 local, state, and federal parks and recreation areas in the U.S., as well as locations in Canada and Denmark.

Application of "What's Invasive!" has common elements at all the locations where it is in use. First, a login is required for a person to provide data to CENS which manages the databases. At a given park, the application provides users with photos and other information to help identify the most common invasive plant or those for which data is most needed. Besides noting the location, the user can send an image of the plant and make qualitative assessments of the population size (one, few, or many). Beyond providing information on correctly identifying the plant, the application also provides educational information such as where the plant is native, characteristics of its growing patterns, and how it is changing the environment where it has become established as an invasive. The citizen scientist can also look at results, such as maps of all the locations in a park where the plant has been observed.

Rather than just relying on periodic observations from visitors to the park, "What's Invasive!" is also being used in a "campaign mode" where an agency collaborates with a school or other organization to rapidly identify where invasive plants have become established in an area. This mode has been the most effective when the application has been used as an educational tool for schools since a large number of results are generated quickly, are visually available in a short amount of time, and it is an opportunity for students to work in teams to collect the information. Finally, use of "What's Invasive!" is not limited to parks with established programs. At any location, the application automatically picks the invasive plants most associated with the nearest location to the user. Those more experienced can also turn off the automated selection list and manually choose from the list of invasive plants.

3.2.4 The Community Environmental Monitoring Program

The Community Environmental Monitoring Program (CEMP) provides a model for embedded public involvement in a monitoring program, and was designed with the specific intent of fostering better communications between participating communities and the federal agency responsible for monitoring through maximizing the involvement of public stakeholders (Hartwell et al., 2006; Shafer & Hartwell, 2011, in press). The CEMP is a network (Fig. 3) of radiation and weather monitoring stations (Fig. 4) surrounding the Nevada National Security Site (NNSS), formerly known as the Nevada Test Site, where the U.S. tested nuclear devices between 1951 and 1992. It has provided a well-defined hands-on role for members of the public since its inception in 1981. Modelled in part after an independent monitoring network that was implemented around the Three Mile Island nuclear power plant in the U.S. after the accident there in 1979 (Gricar & Baratta, 1983), the CEMP seeks to provide maximum transparency of, and accessibility to, monitoring data both through the participation of public stakeholders and by making data available in near real-time on a public web site.



Fig. 3. The monitoring stations that make up the CEMP are located in communities and ranch sites scattered across a 160,000 km² area of southern Nevada, south-eastern California, and south-western Utah in the U.S.

The CEMP is funded by the U.S. Department of Energy (DOE), National Nuclear Security Administration, and administered by the Desert Research Institute (DRI), a non-profit environmental research arm of the Nevada System of Higher Education. While the DOE has historically been viewed by many in the region with distrust as the agency responsible for radioactive contamination of downwind areas, particularly during the era of above ground nuclear testing, the administration of the program by a state agency associated with the higher education system helps to improve confidence in the monitoring results. However, it is the participation of residents of the local communities that achieves the greatest benefit for the program in terms of public trust, communication, and education.

Two people per community (Fig. 5) are designated as Community Environmental Monitors (CEMs). Their responsibilities include collection of bi-weekly air filter samples, the posting

of monthly summary data at their local monitoring stations, and serving as liaisons between their communities and the DOE and as points-of-contact for local residents who have questions about the monitoring process, results, or ongoing activities at the NNSS.

The original CEMs (a few of whom have participated in the program since its inception in 1981) were nominated by their communities, and largely consisted of school teachers with a general science background. However, many other CEMs are from other walks of life, including clergy, postmasters, volunteer firefighters, and retirees. The only true criteria for selection is that there be a willingness to perform the outlined duties, that they be generally respected members of their communities, and that they have a significant degree of contact with other community members. The tradition of identifying teachers as primary participants has continued throughout the program's existence, with the added benefit of knowledge gained through participation in the program often working its way into the teaching curricula and thus involving the local students.

The public participants in this program are not strictly volunteers, but receive a small monthly stipend for their duties as employees of DRI. The decision to hire them as employees was made in part to stress the importance of their sample collection duties, but also to offer them protection for any injuries that might occur during the discharge of their duties. The amount they are paid (approximately \$150 US per month) is small, so as not to create the public perception that they are "in the pocket" of the DOE sponsors, and simply being given messages to parrot to their communities. On the contrary, CEMs are provided with regular training on the basics of ionizing radiation, and become knowledgeable on subjects ranging from radiation detection to local environmental conditions. Through attendance at these training workshops, the CEMs also become effective liaisons between local and federal entities, helping to identify concerns of people in their communities.



Fig. 4. A typical CEMP environmental monitoring station, with a full suite of meteorological sensors, radiation detection equipment, air sampler, and interpretive display with real-time sensor readouts.

CEMs in participating communities are part of the official chain-of-custody for collected samples, and become trained in the basics of ionizing radiation, including detection and potential health effects. They become knowledgeable points-of-contact for other community members. Although the CEMs are the primary means of interacting with and disseminating information to the public, DRI and DOE personnel actively participate in community events (e.g., producing displays and giving presentations for civic organizations and schools).

In 1999, DRI developed a public web site and upgraded communications at the stations so that most could upload their data every ten minutes (<http://cemp.dri.edu/>, accessed July 2011). In addition, data are archived back to the year 1999 for most stations, and users are able to produce tabular and graphical summary data for multiple parameters in any combination. The advent of the web site ushered in a new era of even greater transparency for the monitoring program, since now the public could access the data in near real-time, and know that they were seeing the data as soon as anyone else, including personnel of the sponsoring federal government. With time, links were developed to multi-level educational information on ionizing radiation, as well as a means to contact and discourse with program personnel.

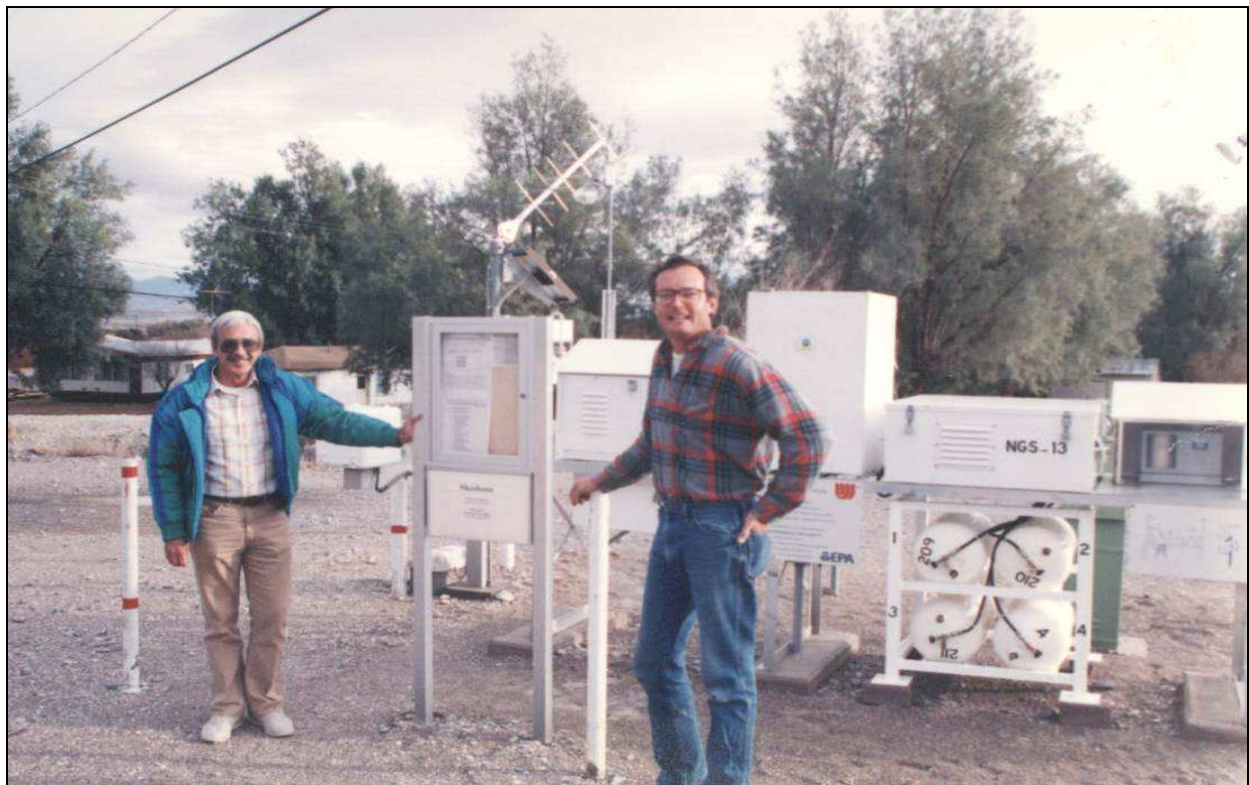


Fig. 5. A photo of a CEMP station and its CEMs in California, taken when nuclear testing was still ongoing at the Nevada National Security Site, then called the Nevada Test Site.

There are undoubtedly some pitfalls associated with significant public transparency that can be provided by a public web site such as the CEMP. The public sees not only the normal data when it is posted, but also is occasionally privy to “bad” data caused by message mistranslation during communication, power outages, or equipment malfunction. While these incidents can cause significant angst for program personnel for short periods of time

(e.g. Hartwell et al., 2008), the overall benefits conveyed by maximum transparency (especially public trust) are much greater than any temporary detriment caused by such an aforementioned incident.

As the CEMP has continued to evolve, it has endeavored to keep pace with the advent of new technologies (you can follow the CEMP on Twitter at @DRICEMP as of May 2011), and has played a significant role in keeping the public informed not only about monitoring results associated with past nuclear weapons testing, but also about other events as well. The CEMP web site reported the program's detection of radionuclides in Nevada in the U.S. resulting from the nuclear accident caused by the earthquake and subsequent tsunami in Japan in March 2011, and responded to hundreds of public inquiries from concerned citizens and requests for media interviews. By reporting data results as they became available, the CEMP was able to keep its network of community citizen scientists (Fig. 6) informed about not only the detection of radioactivity from this incident, but also that levels being measured in the U.S. were not a public health threat. As recognized points-of-contact in their communities, they were able to provide an invaluable service by mitigating much of the concern being expressed by their neighbors over the event.

4. Conclusions

Members of the general public often have a surprising willingness to participate in the process of assisting scientists with the collection of data as well as the dissemination of and communication of results to the public at large. While such public participation is often driven by personal curiosity, in cases where there is either the perception or reality of a potential risk to the personal well-being of an individual, his or her family, or community, many citizens relish the opportunity to become significantly involved when the opportunity is made available.

Most models of public involvement in environmental monitoring or other scientific endeavours have traditionally stopped short of a direct role for public involvement, instead relying solely on practices such as holding public meetings, providing opportunities for written feedback in the form of response to proposals or studies, or the formation of advisory groups to provide input into the decision-making process. While these are all important avenues for public discourse, they are oftentimes regulatory-driven, with little effort or impetus on the part of the agencies or corporations involved to provide additional opportunities for public engagement. The endowment of public stakeholders with a direct role in the process of environmental monitoring (or other scientific research) can convey several potential benefits, both to the stakeholders as well as the entities responsible for conducting monitoring studies. Direct participation by public stakeholders imparts a sense of ownership to those involved as well as to the general community. Careful identification of participating individuals who are in positions of high public trust and who are representative of a broad cross-section of the members of potentially affected communities can be an important contributing factor towards increasing public confidence in monitoring results. A role for direct involvement for the public from the outset (as opposed to in the conduct of damage control following an incident which has caused a loss of public trust) can be seen as a gesture of both good faith and public transparency in the monitoring process. The inclusion of these public stakeholders also helps to engender increased accountability on the part of those conducting the monitoring activities.

Engaging members of the public in a participatory role can actually produce programmatic cost savings, especially in those cases where significant computer resources or data entry is required, or in cases where environmental data must be collected from widely dispersed sites over a large geographic region. Technical tasks that require a minimal amount of training (such as the proper collection and replacement of an air filter sample at a CEMP station) can be accomplished by local residents, often on a voluntary basis, rather than sending technicians out on a regular basis at a significant cost to the monitoring program. Finally, the process of educating and training citizen participants can create a network of informal communicators who live and work within the communities that may have concern about future or past activities that necessitate environmental monitoring. These citizens can be equipped with the knowledge to become “lay-experts” on related issues of community concern, and can serve both as liaisons between their communities and those conducting monitoring activities, as well as points-of-contact for their neighbours, which can help to identify and defuse rumours or public tensions before they reach unmanageable proportions. While there are invariably some pitfalls that will arise as a result of increased public participation and transparency, the authors believe that the overall benefits conveyed by maximizing public involvement to the greatest extent practical generally far outweigh any detrimental factors.



Fig. 6. Residents of 23 communities in southern Nevada, south-eastern California, and south-western Utah in the U.S., most of whom are schoolteachers, come together for regular workshops that train them to become effective communicators on issues related to the monitoring of ionizing radiation in their communities.

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