

Bellefonte Efficiency & Sustainability Team

B.E.S.T.

A local chapter of Blue Ridge Environmental Defense League



BEST RADIATION MONITORING MANUAL

Empowering Communities

Quality Assurance Protocols and Standard Operating Procedures



Modeled after *A Citizens Guide to Monitor Radiation* by Sergey Pashenco and Norm Buske, May, 2005

and BREDL/Shell Bluff - Draft QAPP Advancing Environmental Justice at the Nuclear Crossroads by Lou Zeller, July 3, 2012

BEST/MATRR Garry Morgan and Gretel Johnston October 5, 2012

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CAUTION

CAUTION

Before starting

- Energetic radiation (~~radioactivity~~) is harmful to you.
- If you are monitoring radioactivity, you are looking for hazards.
- Plan ahead. Look ahead, so you can stop or take precautions before you get into trouble.
- Be cautious in sample collecting and handling, sample preparation, sample analysis and sample archiving or disposal. Be cautious rather than adventurous. Be safe rather than regretful.
- Secure copies of this Manual and the Citizens Guide to Monitor Radioactivity, or attain access to them.
- Read all of these procedures and guidelines (and the *Citizens Guide to Monitor Radioactivity*) carefully before beginning citizen-based radiation monitoring around any nuclear facility or any intensive source of radioactivity.
- Take warnings seriously; heed them.
- Be careful and protective of yourself, of your family, friends, co-workers, your neighbors, and your equipment.
- Begin your plan by getting informed about radioactivity and its dangers.
- Take personal responsibility to become well enough informed about radioactivity in the environment and about human health consequences.
- Use good sense.
- Become informed. Consider how what you have learned applies to what you plan to do in your particular situation. Carefully apply what you have learned. Learn more from your experiences. This is good sense. Good sense is uncommon.
- Remember that most exposures to radioactivity are permanent and cumulative. Avoid exposing yourself, others, and your equipment to radioactivity.
- Be consciously aware of and guard against the three main pathways by which radioactivity will harm you:
 - Inhalation.
 - Ingestion.
 - Track off (taking contamination with you: on hands, clothing, and shoe soles).
- Use your Inspector Geiger Counter as your guide, your guard, your backup.
- Use this rule of thumb: Follow high Inspector readings to sampling sites, but STOP before the Inspector reads four times your natural background readings and contact your team captain who will contact the Project Manager; also see the Glossary in the *Citizens Guide to Monitor Radioactivity*.

(continued)

- As you approach a hot-spot, slow down. Be increasingly cautious and careful.
- Avoid getting contaminated. Limit contact with contaminated materials. Prepare in case you might become contaminated. If you might have been contaminated, wash the contamination off with lots of water and change clothes. Until your hands are clean, don't eat anything.
- As you leave a hot-spot, check yourself and others for contamination, using your Inspector. Wash it off or bag it. Do not spread contamination.
- After leaving a contaminated area, check that your Inspector readings return to background levels to be sure your Inspector is not contaminated.

The following Chart is from the National Academy of Sciences **BEIR VII - Phase 2 report**, pg.12:

Unit ^a	Symbol	Conversion Factors
Becquerel (SI)	Bq	1 disintegration/s = 2.7×10^{-11} Ci
Curie	Ci	3.7×10^{10} disintegrations/s = 3.7×10^{10} Bq
Gray (SI)	Gy	1 J/kg = 100 rads
Rad	rad	0.01 Gy = 100 erg/g
Sievert (SI)	Sv	1 J/kg = 100 rem
Rem	rem	0.01 Sv

TABLE 1 Units of Dose

NOTE: Equivalent dose equals absorbed dose times Q (quality factor). Gray is the special name of the unit (J/kg) to be used with absorbed dose; sievert is the special name of the unit (J/kg) to be used with equivalent dose.

4International Units are designated SL

The Chart below is an EPA Radiation Health Effects description of varying doses of radiation sickness:

Exposure (rem)	Health Effect	Time to Onset (without treatment)
5-10	changes in blood chemistry	
50	nausea	hours
55	fatigue	
70	vomiting	
75	hair loss	2-3 weeks
90	diarrhea	
100	hemorrhage	
400	possible death	within 2 months
1,000	destruction of intestinal lining	
	internal bleeding	
	and death	1-2 weeks
2,000	damage to central nervous system	
	loss of consciousness;	minutes
	and death	hours to days

BEST

A

A. Organization, Goals and Objectives

Please write us (either send us an email to <u>BEST@MATRR.org</u> or write Garry Morgan, BEST/MATRR, P.O. Box 241, Scottsboro, AL 35768), and we will either schedule training for your group or help you find an environmental organization in your area that cares about nuclear issues and can help with your project.

_____ A-1

A-1.	Title	and A	pproval	Sheet
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Organization's Name:

[a brief description of your group, your mission, and your location]

Project Title: [example:Advancing Environmental Justice at the Nuclear Crossroads in __ County, State]

Location(s):	Date:
	Date:
Quality Assurance Officer:	_ [a BREDL/BEST/MATRR instructor or qualified local person]
Project Manager(s):	Date:
Team Captain(s):	Date:
	Date:
Sampling Team(s):	

A-2

A-2. Project/Task Organization

***** Key personnel:

- 1) Project Manager: directs the on-the-ground operations throughout the duration of the project in consultation with the Quality Assurance (QA) Officer.
- QA Officer: One of our trainers or the most knowledgable person who can train team captains and sampling teams in the proper procedures: that is, maintenance and use of equipment, survey protocols, chain-of-custody, sampling procedures, data recording, record keeping and reporting.
- Team Captains will direct field investigations, ensure proper procedures and report to the Project Manager.
- 4) Sampling Teams will work together to gather primary data under the direct supervision of Team Captains, and Team Captains will upload data via GeigerGraph to the Radiation Network and report to the Project Manager.





A-3

A-3. Project/Problem Definition/Area of Operations

The local environmental/public health issues that this project seeks to address are the public's safety and health in the communities surrounding nuclear power facilities. We seek to record specific radiation counts using quality portable geiger counters, recording name and type of nuclear power plant (NPP), kind of reactors (boiling water BWR reactors or pressurized water PWR reactors), precise location, weather conditions, dates and times of recorded readings. This project's purpose is to independently document and report radionuclide emissions which may be airborne, in the soil or in the water in communities surrounding nuclear power facilities in a structured process for scientific data collection.

A-3.1

A-3.1 Know Your Nuclear Facility - Record when your plant was built, how many and what kinds of reactors it houses, the purpose of the facility (producing electricity, enriching uranium, etc.), where it is located, what body of water it uses, and events at the site that might effect the health of local residents.

Population: The Nuclear Regulatory Commission defines two emergency planning zones around nuclear power plants: a plume exposure pathway zone with a radius of 10 miles (16 km), concerned primarily with exposure to, and inhalation of, airborne radioactive contamination; and an ingestion pathway zone of about 50 miles (80 km), concerned primarily with ingestion of food and liquid contaminated by radioactivity.¹

Research the population within 10 miles (16 km) and 50 miles (80 km) of your facility. For groups in the USA, we recommend you read the article by Pulitzer Prize winning NBC investigative reporter, Bill Dedman, and refer to the interactive map for information on your community, compiled from an analysis of U.S. Census data for MSNBC News.²

We also recommend reading a Scientific American article about the safety of US reactors, and we suggest you research your local reactors, events that require reporting to the Nuclear Regulatory Commission (NRC) and NRC actions, using their website data.³, ⁴

Our group compiled a Fact Sheet on one of our local nuclear power plants (Browns Ferry), which may be useful as an example for your group.⁵*[5]

¹ NRC Document Collection, <u>http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/emerg-plan-prep-nuc-power-bg.html</u>

² Nuclear neighbors: Population rises near US reactors, msnbc.com, April 14, 2011 <u>http://www.msnbc.msn.com/id/42555888/ns/us_news-life/</u>

³ Scientific American, March 9, 2012 - "How Safe are U.S. Nuclear Reactors? Lessons from Fukushima" <u>http://www.scientificamerican.com/article.cfm?id=how-safe-are-old-nuclear-reactors-lessons-from-fukushima</u>

⁴ Nuclear Regulatory Commission, "Operating Nuclear Power Reactors (by Location or Name), <u>http://www.nrc.gov/info-finder/reactor/#listAlpha</u>

⁵ Horn, Stewart and Morgan, Garry, "Browns Ferry – Three Reactors, Multiple Problems" Fact Sheet on Browns Ferry Nuclear Power Plant, March 2012, <u>http://nuclearvalley.blogspot.com/</u>

A-3.2

A.3.2. Radionuclides - Know Your Local Poisons

All nuclear power reactors produce electricity through the atom-splitting process called fission. Uranium-235 atoms are bombarded with neutrons, producing heat, which drives turbines to produce electricity. Fission also produces over 100 radionuclide isotopes from the breakup of Uranium-235 atoms. These isotopes are not found in nature, but are only created when atomic bombs explode or when nuclear reactors operate. Each of the 100-plus radionuclides released during fission, also known as radionuclide isotopes, are radioactive and poisonous.

The radionuclide isotopes release radiation in three forms and decay at varying rates, called a "Half-life," and generally the correlation is that the isotopes remain radioactive, and therefore dangerous, for about ten times the Half-life. For instance, Cesium-137 with a Half-life of 30 years would remain toxic to humans for about 300 years. The following are some radionuclide decay rate examples (see Appendix 9: Nuclear Poisons):

Iodine-129	15.7 million years	~157 million years	beta & gamma
Iodine-131	8.0 days	~80 days radioactivity	beta & gamma
Cesium-134	2.06 days half-life	\sim 3 weeks radioactivity	beta
Cesium-137	30.1 years	~301 years radioactivity	beta & gamma
Strontium-89	50.5 days	~505 days radioactivity	beta
Strontium-90	28.7 years	~287 years radioactivity	beta
Plutonium-239	24,200 years	~242 thousand years	alpha & beta

Despite efforts by reactor operators to contain these dangerous substances within the reactor buildings, some must be routinely emitted into the air and water during daily plant operations and refueling. The air born particles and gases are returned to the earth through precipitation and gravity; the ground and water emissions contaminate our water. Nuclear poisons enter the human body by breathing, drinking and the food chain, where they kill and injure cells by emitting alpha particles, beta particles, or gamma rays. A damaged cell may or may not repair itself. If it fails to do so, it will replicate into similarly damaged cells, which can lead to mutations and cancer.

Studies of morbidity and mortality statistics compiled by the U.S. Centers for Disease Control and private non-profit organizations indicate a substantial increase after Plant Vogtle Units 1 and 2 went online 26 miles south of Augusta, GA. One study compares cancer deaths during the period 1982-1990 with those occurring during the period 1991-2002. This study demonstrated that Burke County's cancer deaths per 100,000 population rose 24.2% after Nuclear Power Plant Vogtle went online, while statewide the death rate fell 1.4% during the same period. A second study examined deaths among infants under one year old in Burke County. The findings, which compared the periods before and after the startup of Nuclear Power Plant Vogtle's operation, show a 70.1% increase in infant deaths after startup. Statewide, the rate of infant deaths fell 1.7% during the same period. These findings were published in 2005. References: http:// www.radiation.org/reading/pubs/070104Vogtle.pdf and http://pbadupws.nrc.gov/docs/ML0734/ML073440163.pdf

[EPA sets limit of 3 mSv/yr for Iodine radionuclides.]

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A-4

A-4. Project/Task Description

- Lists measurements to be made includes on-site field analysis and off-site laboratory analysis
- Cites applicable or program-specific regulatory standards, criteria, or technical objectives
- Identifies types of personnel, equipment and instruments required to perform field sampling, field analysis and laboratory analysis
- Provides work schedule and data deliverable timelines
- Summarizes required project and QA records/reports

A-4.1

A-4.1. Field Measurements

The Sampling Team(s) will collect samples of air, soil and water for the purpose of detecting the levels of radioactivity in communities, roadways and waterways near the nuclear plant. In addition to sampling, the team, working closely with the Quality Assurance Officer will monitor radiation around the Nuclear Power Facility(s) via a combination of screening methods.

Utilizing a vehicle and a Geiger counter, the Vehicle Forced Air Screen Method (VFAM)*[1] will be utilized to sample the air surrounding the nuclear power facilities. The team will screen large areas surrounding each nuclear power plant and make SAFE STOPS*[2] out of traffic-ways near a distinct landmark such as an intersection. The team will take air, soil, vegetation or a water sample and perform a 10 minute Geiger counter screen test on the sample taken. Each SAFE STOP sampling area and specific 10 minute VFAM interval test point with date, time, location and Geiger counter readings will be recorded on a computer or manual log. Based on the results of the Geiger count per minute readings, the team will perform further screening and actual sampling in areas of concern.

Through training of volunteers, your project will develop Sampling Teams to gather useful, credible scientific data in support of BREDL/BEST/MATRR's longstanding efforts to reduce radioactive emissions into the air, land and water. The training of the Sampling Team volunteers will efficiently and safely accomplish both the collection of scientific data and the empowerment of local residents. Contact us at <u>best@matrr.org</u> to schedule a training session in your area, or for help finding a group to implement training in your country or province.

*Notes for Field Measurements

[1] Vehicle Forced Air Screen Method (VFAM) – A method of directing airflow from a moving vehicle over the monitoring sensor of the Geiger counter from an open vehicle window utilizing funneled air instead of a vehicle mounted detection device.

[2] SAFE STOPS- Always be safe, drive safe, think safety. Do not place yourself into harm's way. We need you to test for radiation safely within our communities, not become a victim of unsafe, dangerous circumstances. Always be conscious of your surroundings. Obey all laws and safety rules, and use common sense to avoid personal confrontations and unsafe stop points and operations of your vehicle. Always ask permission to enter private property, never trespass.

A-4.2

A-4.2. Regulatory Standards

Radiation dose standards are set by both the US Nuclear Regulatory Commission (NRC) and the US Environmental Protection Agency (EPA). EPA standards for air and water are lower than NRC standards. "Ionizing Radiation Dose Ranges" charts are included in the back of this *BEST/MATRR Radiation Monitoring Manual* for both Sievert and Rem dosages.

Sievert is the Standard International (SI) unit of dose equivalent (the biological effect of ionizing radiation), equal to an effective dose of a joule of energy per kilogram of recipient mass.

REM is a unit of effective absorbed dose of ionizing radiation in human tissue, equivalent to one roentgen of X-rays. Roentgen is a unit of charge in one square centimeter of air.

The different standard units can be confusing. We suggest using the Counts Per Minute (CPM) setting on your geiger counter for recording data, then CPM can be translated into mSv or mrem. If you use the CPM setting rather than the milliSievert setting (mSv) on the Navigator Geiger, then 1,000 CPM = 1 mrem = .01 mSv. *[1]

RADIATION DOSE LIMITS for GENERAL PUBLIC:

- NRC Annual Dose Limit is 100 mrem/yr = 1 mSv/yr = 100,000 CPM/yr *[1]
- EPA Annual Air Limit = 10 mrem/yr = 0.1 mSv/yr = 10,000 CPM/yr *[2]
- EPA Annual Water Limit = 4 mrem/yr = 0.04 mSv/yr = 4,000 CPM/yr (drinking water)
- NRC PER HOUR DOSE LIMIT for the General Public is 0.002 rem/hr = 0.02 mSv/hr *[3]
- In CPM, NRC limits = 100,000 CPM per year and 2,000 CPM per hour DOSE LIMITS

Federal regulations at 10 CFR § 20.1301 Subpart D, "Radiation Dose limits for individual members of the public," states: (a) Each licensee shall conduct operations so that (1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation, from any administration the individual has received, from exposure to individuals administered radioactive material and released under § 35.75, from voluntary participation in medical research programs, and from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.2003. See 56 FR 23398, May 21, 1991.

Radionuclide contamination from nuclear power plants can range from undetectable to background levels or in some cases much higher. Our technical objective is to find such Hotspots and measure the radiation levels without jeopardizing the Sampling Team. A rule of thumb for personnel protection is to avoid contamination levels above 4X background levels by withdrawing from the area until further measurements can be done with protective equipment.

References:

[1] DOE Office of Science, "Ionizing Radiation Dose Ranges," - <u>http://lowdose.energy.gov/pdf/</u> DoseRanges.pdf

[2] EPA "National Emissions Standards for Emissions of Radionuclides from Facilities Licensed by NRC Not Covered by Subpart H, 40CFR Part 61: Subpart I" <u>http://www.epa.gov/radiation/docs/</u> <u>neshaps/40cfr61subpart-i.pdf</u>

[3] NRC §20.1301, "Subpart D - Radiation Dose Limits for Members of the Public" - <u>http://</u> www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1301.html

A-4.3







A-4.3. Personnel, Equipment and Instruments required for Sampling and Analysis

The principal sampling device is a Geiger Counter (a Geiger-Müller particle detector) that measures ionizing radiation. Although you can simply write all your findings in a notebook, as noted in Appendix 3, a portable laptop computer can be linked to the detector and during preliminary field surveys can generate a graphic readout and map.

Our selected model of Geiger Counter, the U.S. made SE International INSPECTORTM (<u>http://</u><u>seintl.com/products/inspectorplus.html</u>), has a data cable to interface with a computer or data logger. We use the Geiger-Graph Network Mineralab software, which uploads to the online real-time (national and international) Radiation Network database at <u>www.radiationnetwork.com</u>.

A count from the Geiger Counter is transmitted through the data cable to the computer and the software displays and graphs those Counts-per-minute (CPM) in terms of the Current reading, an Average, and Minimum and Maximum Counts-per-minute (CPM) over the test period. For safety, the software issues an audible and visual alert whenever the CPM exceeds a user-set level. The count data for each minute is recorded on an internal spreadsheet to which the user can add notes for each minute of analysis. The program also saves the radiation count data every minute to a text file that can be exported to an external spreadsheet program (like Excel) for further analysis.

We recommend at least two members per team for each sampling mission, so that one member can handle the Geiger Counter and computer while the other member assists, records the data in the log-book and is a general look-out for hazards.

SAFETY FIRST - Sampling team mission and safety briefings will be conducted by the Project Manager prior to each sampling team mission. No sampling team collection missions will be conducted without a safety and collections briefing.

BEST

A-5

A-5. Objectives and Criteria for Data Measurement

- State project objectives qualitatively and quantitatively
- Links measurement quality objectives to applicable action limits, criteria

A-5.1

A-5.1. Project Objectives

The objectives of the project are threefold: (1) to investigate radioactive air, water and soil pollution in the vicinity of commercial nuclear power facilities; (2) involve community residents living in the vicinity of the three sources of radioactive pollution in scientific investigations of their environment; (3) assist community residents in seeking solutions to the disproportionate environmental burdens they bear as neighbors of TVA's nuclear power facilities.

In 2006, the National Academy of Sciences published their latest study of the biological effects of ionizing radiation, *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII-Phase 2* report. In addition to comprehensive risk estimates for cancer incidence and mortality and other health effects from exposure to low-level ionizing radiation, the report listed a series of research needs, gaps in knowledge requiring additional data. BEIR VII "Research Need 12" states, "Data from the [Life Span Study] LSS [cohort of 120,000 Japan A-bomb survivors] should be supplemented with data on populations exposed to low doses and/or dose rates, especially those with large enough doses to allow risks to be estimated with reasonable precision."*[1] To help meet this need, Advancing Environmental Justice at the Nuclear Crossroads in the Tennessee River Valley will provide new data on low-dose sources of radiation in the communities surrounding TVA's nuclear power facilities.

In order to assess radioactive contamination in a scientific manner, we will gather data from as many points as possible around the three radionuclide emission sources. Preliminary surveys will require the taking of mobile Geiger counter readings over hundreds of miles of paved and unpaved roads. Further data gathering on foot will be based on high reading areas detected in the preliminary survey. Scores of samples will be gathered of soil, sediment, water and biota for testing. Always remember the "Safe Stops" rule.

Reference: [1] National Research Council, National Academies of Science, *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII-Phase 2*, National Academies Press, 2006, page 323. <u>http://www.nap.edu/catalog.php?record_id=11340</u>

A-5.2

A-5.2. Linking measurement quality objectives to action criteria

Geiger counters typically measure radiation in Counts-per-minute (CPM) or millirems (mrem) or milliSieverts (mSv). To convert radiation in units of CPM to radiation in units of mrem, one can use a conversion ratio of 1,000 CPM = 1 mrem. This conversion ratio is not exact due to the definition of the rem, but it provides a good benchmark for this study. One can convert from one radiation unit to another with the conversion factors compiled in the tables below:

A-5.2

Units of Radiation Doses and Unit Symbol Conversion Factors

100.0000 rem = 1	00000.0 mrem = 1 Sv	= 1.000000 Sv $= 1$	000.000 mSv = 3	1000000 µSv
1.0000 rem =	1000.0 mrem = 1 rem	= 0.010000 Sv =	10.000 mSv =	10000 µSv
0.1000 rem =	100.0 mrem = 1 mSv	= 0.001000 Sv =	1.000 mSv =	1000 µSv
0.0010 rem =	1.0 mrem = 1 mrem	= 0.000010 Sv =	0.010 mSv =	10 µSv
0.0001 rem =	0.1 mrem = $1 \mu Sv$	= 0.000001 Sv =	0.001 mSv =	1 µSv

Unit	Symbol	Conversion Factors
Becquerel	Bq	1 disintegration/s = $2.7 \times 10-11$ Ci
Curie	Ci	3.7×1010 disintegrations/s = 3.7×1010 Bq
Gray	Gy	1 J/kg = 100 rads
Rad	rad	0.01 Gy = 100 erg/g
Sievert	Sv	1 J/kg = 100 rem
Rem	rem	0.01 Sv
Millirem	mrem	$0.001 \text{ rem} = 1 \times 10-5 \text{ Sv}$
For example:		
.1 $Gy = 0.1$	J/kg = 10 rads = 0	$1 \text{ Sv} = 10 \text{ rem} = 10,000 \text{ mrem} = 1 \times 10(7 \text{thpower}) \text{ CP}$

The Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation of the National Research Council publishes data on the health risks of low-level ionizing radiation. These data were published in the National Academy of Sciences 2006 BEIR VII, Phase 2 report. A summary of cancer data is in Table ES-1 from that report:

Lifetime Risk for All Solid Cancers and for Leukemia

TABLE ES-1 The Committee's Preferred Estimates of the Lifetime Attributable Risk of Incidence and Mortality for All Solid Cancers and for Leukemia

	All Solid Cancers		Leukemia	
	Males	Females	Males	Females
Excess cases (including nonfatal cases) from exposure to 0.1 Gy	800 (400, 1600)	1300 (690, 2500)	100 (30, 300)	70 (20, 250)
Excess deaths from exposure to 0.1 Gy	410 (200, 830)	610 (300, 1200)	70 (20, 220)	50 (10, 100)
Number of deaths in the absence of exposure	22,100	17,500	710	530

NOTE: Number of cases or deaths per 100,000 exposed persons.

#95% subjective confidence intervals.

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Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2, pg 15. http://www.nap.edu/catalog/11340.html

A-6

A-6. Special Training Requirements/Certified Listed

• States how training is provided, documented and assured

How training is provided, documented and assured

Training of the Sampling Teams will take place in your community conducted by the Project Manager and QA Officer, who will receive their training from BREDL/BEST/MATRR or a recommended trainer. Using a combination of lecture, reading materials, fact sheets, PowerPoint presentations and hands-on practice, instructors will guide team members through a series of exercises to familiarize them with data gathering procedures and QA. Attendance at training sessions will be documented by sign-up sheets and these will become part of the project record. Also, significant parts of the trainings will be photographed both to make a record of the session and to provide guidance to others. The QA Officer will ensure that these documents are compiled and preserved.

SAFETY FIRST - Sampling team mission and safety briefings will be conducted by the Project Manager prior to each sampling team mission. No sampling team collection missions will be conducted without a safety and collections briefing.

A-7. Documentation and Records

• Lists information and records to be included in data report (e.g., raw data, field logs, results of QC checks, problems encountered

In addition to training and instruction materials cited above, the Sampling Teams will compile test data including graphs and charts of Geiger counter readings, tests of samples, field logs, Project Manager and QA Officer notes.

During the first phase of data gathering with the Geiger counter utilizing the Vehicle Forced Air Screen Method (VFAM), the Team Captains and their respective Sampling Teams under the guidance of the Project Manager and QA Officer will record raw information in Counts-per-minute (CPM) which is fed into the Inspector software installed in the laptop computer. Also, photographs and video of the route will be taken during the data gathering, field logs will be used to record observations of date, time, wind direction, weather, vehicle speed and route information.

In the second phase of data gathering, Sampling Teams will travel on foot to points of interest identified by the first phase. Walking with the same Geiger counter, computer and software, team members will again record raw information in Counts-per-minute (CPM) with the Inspector software installed in the laptop computer. Again, photographs and video of the route will be taken during the data gathering, field logs will be used to record observations of date, time, wind direction, weather and route information. For the third phase, actual samples will be gathered by the teams and the date, time, location, sampling conditions, sample identification and weight and any other observations will be recorded in field logs. Tracking numbers will also be assigned and recorded.

B

B. Sampling Process Design (Rationale for Design)

- Specifies the type, number and matrix of samples slated for collection
- Discusses the rationale for the proposed sampling design
- Specifies sample locations and frequency of sample collection at each location

B-1. Rationale for the sample collection

The collection of samples—the number, distribution and type—will be based on Phase One and Phase Two surveys of the area. At minimum, the Teams will attempt to collect samples from as many areas around the TVA nuclear facilities as safety, geography and private property considerations will allow.

The first choice for sampling design will be systematic grid sampling, a probability-based methodology allowing quantitative conclusions to me made about the resident population.

Where this is not possible, judgmental sampling based on knowledge of the terrain, site history and other factors will be employed. Consequently, because variability of the data may be high, the economical methods of testing selected for Advancing Environmental Justice at the Nuclear Crossroads in the Tennessee River Valley will allow large numbers of samples to be collected. This will augment sampling design accuracy and reduce overall potential for error.

There are three fundamental types of radiation alpha (a), beta (b) and gamma (g). Alpha radiation are particles of high energy in the million electron volt MeV) range. Because of their large mass, alpha particles are stopped by a few inches of air or a piece of paper. Beta radiation is electrons with energy in a range of a few hundred keV to several MeV. Electrons are much lighter than helium atoms and can penetrate several feet of air, several millimeters of plastic or very light metal. Gamma radiation is photons, like light, but of high energy, typically from several keV to several MeV. Gamma is an electromagnetic phenomenon similar to X-rays. Depending on the source and level of energy, gamma can be stopped by aluminum foil or can penetrate several inches of lead.

Normal background radiation is below 50 CPM. Some areas in North Alabama will average 30 CPM. The highest levels above background detected by Phase One and Phase Two surveys will be the sites for sample gathering.

B-2. Sampling Methods Requirements

- Describes sample collection procedures and methods
- Lists equipment needs
- Identifies support facilities
- Identifies individuals responsible for corrective actions in the field
- Describes the process for preparation and decontamination of sampling equipment
- Describes selection and preparation of sample containers and specifies sample volumes
- Describes sample container, volume, preservation and holding time requirements per each chemical, physical or biological parameter

B-2.1

B-2.1. Phase One Data Collection Procedure: Vehicle Forced Air Screen Method (VFAM)

REMEMBER, ALWAYS BE SAFE

The initial field survey will utilize the laptop computer and the VFAM notating all areas of increased radiation readings. SAFE STOP radiation data collection screening points will also be utilized depending on wind direction during initial survey period. All data collection screening points will be entered on data and/or manual logs. The Project Director and Team Captains will select daily routes of travel and screening points to be communicated to the sampling teams during the Phase One data collection. The teams will make at least two passes on each roadway. Based on these surveys, we will identify trends which point to areas requiring further investigation. Background radiation varies with concentrations of natural potassium-40 and other radionuclides. Since background radioactivity differs from location to location, random variations will be minimized by longer periods of data gathering.

During this phase, data gathering is done with the Geiger counter utilizing the VFAM and SAFE STOP screening methodology. The Team Captains and their respective Sampling Teams, under the guidance of the Project Manager and QA Officer, will record raw information in Counts-perminute (CPM) which is fed directly from the Inspector into the RadiationNetwork software installed in the laptop computer. Also, photographs and video of the route will be taken during the data gathering, field logs will be used to record observations of date, time, wind direction, weather, vehicle speed and route information.

B-2.2

B-2.2 Phase Two Data Collection Procedure: Walking Survey

REMEMBER, ALWAYS BE SAFE

In the second phase of data gathering, Sampling Teams will travel on foot to points of interest identified by the first phase. Walking with the same Geiger counter and computer, team members will again record raw information in Counts-per-minute (CPM) with the GeigerGraph® software in the laptop computer. Again, photographs and video of the route will be taken during the data gathering, field logs will be used to record observations of date, time, wind direction, weather and route information.

B-2.3

B-2.3. Phase Three Data Collection Procedure: Sample Gathering

REMEMBER, ALWAYS BE SAFE

For the third phase, actual physical samples will be gathered. Collected samples are placed in plastic bags and labeled with an identifying number. Sampling Teams record the date, time, location, sampling conditions, sample identification and weight and any other observations on field logs. Tracking numbers are assigned and recorded. The samples to collect will be determined by identifying pathways carrying radioactive substances from a source and the first two phases of data collection. Pathways may include wind direction, surface water groundwater, animal tracks, and uptake by vegetation.

For data collection from samples, the Geiger Counter will be set to "total count" (instead of Counts-per-minute or CPM) and measured for a period of three (3) hours. After waiting one day and at the same time of day and location, a second reading is taken again for a period of three hours. The results of the two tests are compared. If the second value is higher than the first, radioactive in-growth has occurred; if the second value is lower, radioactive decay has occurred.

If necessary, a final testing stage, using the *Nfoils-jigTM is performed. It is similar to the previous tests but allows one to distinguish one radioactive source from another. The duration of the test is longer—23 hours duration, beginning at the same time of day and proceeding for five (5) days.*Note: See pg. 27 in *A Citizens Guide to Monitor Radioactivity* relating to the Nfoils-jig.

B-2.4

B-2.4. EQUIPMENT LIST

Concerned team members who maintain sensible, safe operations through attitude and behavior

FIELD KIT CHECKLIST:

- Radiation Detection Procedures Manual and the Citizens Guide to Monitor Radioactivity
- Geiger Counter (Geiger-Müller particle detector) and users manual
- · Laptop PC computer with installed software
- GPS device (and users manual) and county map
- Camera (and users manual)
- Field notebook
- Pencils & Pens
- Zip-loc® bags & garden spade
- Back-up Battery(s)

LABORATORY CHECKLIST:

- Laboratory notebook
- Rechargeable Cordless Handheld Vacuum
- Specimen drying oven
- Nfoils-jig[™]
- Weight scales
- Timepiece
- Aluminum foil
- Filters and lab ware
- Potassium chloride, 500 grams
- Potassium-40 for Geiger Counter calibrations
- Individual and Equipment protective gear-as needed

B-2.5

B-2.5. Support Facilities

Norm Buske, co-author of *A Citizen's Guide to Monitor Radioactivity* is advising Blue Ridge Environmental Defense League (BREDL) on this project. Mr. Buske's experience and technical expertise provide practical guidance in equipment preparation, sample collection, field work and laboratory testing.

Lou Zeller of BREDL is the Quality Assurance Officer providing guidance on methodologies, techniques and procedures for this BEST/MATRR radiation monitoring project in the Tennessee River Valley. Each Sampling Team Captain will report to the Project Manager who can appeal to the Quality Assurance Officer for additional technical assistance.

B-2.6. Corrective Action

All field work will be done by Sampling Teams under the guidance of trained Team Captains. Any corrective action needed will be taken by the captains to ensure sampling and information gathering is done correctly and recorded in field notebooks and/or computers. These data will also be reviewed by the Quality Assurance Manager.

B-2.7. Preparation of Sampling Equipment

In addition to calibration of the Geiger counter, ensure that all units have fresh batteries and that they are fully charged to prevent loss of data.

Always go through the complete FIELD EQUIPMENT CHECKLIST before leaving your home for field data collection.

FIELD KIT CHECKLIST:

- Concerned team members who maintain sensible, safe operations in attitude and behavior
- Radiation Detection Procedures Manual and the A Citizens Guide to Monitor Radioactivity
- Geiger Counter (Geiger-Müller particle detector) and users manual
- Laptop PC computer with installed software
- GPS device (and users manual) and county map
- Camera (and users manual)
- Field notebook
- Pencils & Pens
- Zip-loc® bags & garden spade
- Back-up Battery (s)

B-3

B-3. Sample Handling and Custody Requirements

- Summarizes sample handling requirements
- Summarizes chain-of-custody procedures

B-3.1. Sample handing requirements

Vegetation, soil or dust samples are gathered, put into a plastic Zip-loc® bags, dried and measured for radioactivity with the Geiger counter. Once physical samples are collected and bagged, Radioactive decay and ingrowth require that the sample drying process begin as soon as possible, within two hours, and proceed for a period of 24 hours at a temperature <200°F (95°C). Sample geometry—weight, volume and shape—are standardized.

B-3.2. Chain of custody

To ensure samples collected are transported, treated and tested within the time frames necessary for quality assurance. Since there is no outside laboratory required, the QA Officer will review all chain of custody procedures and records to ensure best practices are followed. The Project Manager will insure chain of custody is maintained locally.

B-4

B-4. Analytical Methods Requirements

- Identifies the analytical methods to be followed (including method number and sample preparation method such as digestion/extraction method where applicable)
- Provides validation information for non-standard methods
- Identifies individuals responsible for corrective action
- Specifies the laboratory turnaround time for analysis and data deliverables

B-4.1. Analytical methods

The project will use methods which were developed by Dr. Do Lee, Dr. Norm Buske and Dr. Sergey Pashenko respectively. In 2005 this group published a methodology entitled *A Citizen's Guide to Monitor Radioactivity* (attached)*[1] upon which Blue Ridge Environmental Defense League has based its investigations and training program. The project's Quality Assurance Officer is responsible for any corrective action.

[1] Sergey Pachencko (SSGR), Norm Buske (TRAC), Lucy Henry and Do Lee (ISAR), *A Citizens Guide to Monitor Radioactivity Around the Energy Department's Nuclear Facilities*, May 2005. (included in Sampling Team field kit)

BEST

B-5

B-5. Quality Control Requirements

- Identifies QC procedures and frequency for each sampling event, analysis, or measurement technique, as well as associated acceptance criteria and corrective actions
- References procedures and provides equations for calculating QC statistics including bias/ accuracy, precision - specifies acceptance criteria for completeness, comparability and representativeness.

The frequency of sampling events and respective analyses, bias/accuracy, criteria for completeness, comparability and representativeness are to be determined after the initial data survey is completed and under the guidance of the Project Manager and Quality Assurance Officer.

B-6

B-6. Instrument/Equipment Testing, Inspection and Maintenance Requirements

- Identifies acceptance testing of sampling and measurement systems
- Describes equipment preventive and corrective maintenance
- Summarizes availability and location of spare parts

The testing of sampling and measurement equipment and corrective and preventive maintenance will be done by Team Captains at the outset of each data gathering event. Maintenance will include inspection and cleaning of the Geiger counter and calibration with a known source.

B-7

B-7. Instrument Calibration and Frequency

- Identifies equipment needing calibration and frequency for such calibration
- Summarizes required calibration standards for equipment
- Cites calibration records and the manner traceable to equipment

To make accurate and reliable readings, the Geiger counter must be calibrated monthly and whenever there is a high result or any unusual reading. (It is not the Geiger-Muller tube that needs calibration, but the circuits around it.) Using known source potassium-40, for which the exact level of radioactivity is known, place the Geiger counter near the source making sure the Geiger-Muller tube window is facing the material directly. Read and record the result of the measurement on the Geiger counter. Compare the reading with the number for the known source. If they match, the Geiger counter is calibrated. If not, adjust the Geiger counter's circuit until the exact reading for the known source is reached to ensure the Geiger counter is calibrated and ready.

B-8

B-8. Inspection/Acceptance Requirements for Supplies and Consumables

- Provides a list of the supplies and consumables
- Identifies the individuals responsible for inspecting supplies and consumables to ensure compliance with requirements

Consumable supplies include paper towels, aluminum foil, Ziploc® bags, filters and potassium chloride; The Project Manager will ensure these materials are in good supply.

B-9. Data Acquisition Requirements for Non-Direct Measurements

- Identifies type of data needed from non-measurement sources (e.g., computer databases, literature searches, models, etc.) and provides the acceptance criteria for using this information
- Describes the limitations of this information and specifies where and when it cannot be used
- Documents the rationale for original collection of data and its relevance to the project

The need for any non-direct measurements will be determined after the initial data gathering surveys are completed.

B-10

B-10. Data Management

- Describes record/data keeping, storage and retrieval policies/requirements for organization/project
- Provides attachments to this Quality Assurance Protocols and Procedures (QAPP) manual containing SOPs, Checklists, Analytical Methodologies, etc.
- Describes data handling equipment and procedures used to process, compile and analyze data (e.g., computer hardware and software) identifies the type of software used, such as GeigerGraph®, Observer, Excel, Statistical, Data Validation, etc.

B-10.1. Data keeping, storage and retrieval

The records compiled during field data collection will be the responsibility of each team Captain. It is important that all log entries and data collected be accurate. All data and records will be turned over to the Project Manager upon completion of testing in an area. Questions concerning logs, data accumulation and assimilation will be addressed to the Project Manager. Any problems or questions concerning data collection or procedures that cannot be resolved by the Project Manager must be referred to the BREDL Quality Assurance Officer, Lou Zeller.

BEST

B-10.2. Standard Operating Procedures (SOP)

Attached to this QAPP manual is the *Citizen's Guide to Monitor Radioactivity*, which provides basic analytical methodology and other guidance for the project. In addition to the Citizen's Guide, this "BEST/MATRR Procedures Manual" also serves as part the Standard Operating Procedures (SOP).

B-10.3

B-10.3. Data handling equipment and processors

The information collected with the Geiger counter during the project surveying and sampling will be compiled using GeigerGraph® software for Windows. A data cable with a 3.5mm stereo plug connects the Geiger counter via a USB-adapted PC laptop computer. The count data is recorded on an internal spreadsheet along with notes for analysis. Also, radiation data may be monitored with radiation maps and graphs.

Manual hand written data log information is to be maintained by Team Captains and converted to informational spreadsheets where applicable. Project Managers are responsible for the completeness of this data. It is crucial that a free flowing line of communications exists between Team Captains and Project Manager(s).

С

C. Assessments, Response Actions, Reports and Audits

Assessments, Audits, Reports and Response Actions are to be determined by the Quality Assurance (QA) Officer and the Project Manager. Problems in the testing program are to be conveyed to the Project Manager. The Project Manager is responsible for communicating problems to the Quality Assurance Officer if there is a problem which cannot be resolved by the Project Manager.

Reports and data are to be submitted to the Project Manager from the Team Captain weekly. After review, final area reports are to be submitted to the BREDL QA Officer by the Project Manager.

Audits of testing methodology and data collection are to be performed per instruction from the BREDL QA Manager.

Appendix-1

Appendix

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Appendix-2

2. Data Log Requirements

DATE /TIME

AREA LOCATION - Nuclear Facility

- GPS Info
- Specifics of location
- Notable landmarks
- DATA
- NOTES Team Name
 - Team Members Present

- CPM or Sievert Count

- Weather conditions

DATE	LOCHTON TIME	NUCLEAR	GASINFO	Count	Notes,
2012	AL TEAM	FACILITY	MAP IA fo	CPM etc	Weather, Wind
10-12	Derne Crass 11:10 mm	Beaus Freeze			Rain-inast W-SWLOE-NE
C	Mis Johnston - W. Horgan Gerenbergia Ro + I-565 MAdow, AL 12:30		\bigcirc	860- = 37CPM HI = 66 CPM	LIGHT RAIN
2	TANNER, AL 12:55 4531 Y BEAND RELY RD		2	HI = 196 CM	STRINKLE
0	ROUND ISLAND BAPTOT CHOREH		Ì	866= 42000 HI = 128000	RAIN ward Walt-SE
Ð	Shaw Rd @ Carling Towers 230	lon	Ø	HI 118	Partly llory
Ø	SE OF DOWERS DE NOU JENN THENT THWAR REMOVE 274 1471	.	E .	0K0 36 14 68	DRIZZLE
6	Aucune Punto lot Lucos FEREY		6	8KG 28 HI 60	Author Coney
	~ Inte E of BFN (7.5mile	(6FR)			

Appendix-3

3. Equipment List

• A concerned BEST member who maintains a sensible, safe operations attitude and behavior

FIELD KIT CHECKLIST:

- Radiation Monitoring Procedures Manual and the Citizens Guide to Monitor Radioactivity
- Geiger Counter (Geiger-Müller particle detector) and users manual
- Laptop PC computer with installed software (if no computer available, then manual Log only)
- GPS device (and users manual) and county map (if no GPS available, use detailed maps)
- Camera (and users manual)
- Field notebook
- Pencils & Pens
- Zip-loc® bags & garden spade
- Back-up Battery(s)



Appendix-4

4. VFAM Broad Surveillance Method

The Vehicle Forced Air Method is used to survey large areas around the nuclear facility, to identify 'hot spots' or places with higher than background radiation readings for more on the ground readings. First you make a funnel from two paper plates and duct tape, next attach to passenger side window, then the passenger takes readings by holding the geiger counter mesh area next to the small funnel end inside the vehicle (going less than 35 mph).





Appendix-5

5. Units of Radiation Dose Examples and Unit Symbol Conversion Factors

100.0000 rem =	100000.0 mrem = 1 Sv = 1.000000 Sv =	1000.000 mSv =	1000000 µSv
1.0000 rem =	1000.0 mrem = 1 rem = 0.010000 Sv =	10.000 mSv =	10000 µSv
0.1000 rem =	100.0 mrem = 1 mSv = 0.001000 Sv =	1.000 mSv =	$1000 \; \mu Sv$
0.0010 rem =	1.0 mrem =1 mrem = 0.000010 Sv =	0.010 mSv =	10 µSv
0.0001 rem =	$0.1 \text{ mrem} = 1 \mu S v = 0.000001 \text{ Sv} =$	0.001 mSy =	I μSv

Appendix-6

6. Radiation Dose Limits

Radiation dose standards are set by both the US Nuclear Regulatory Commission and the US Environmental Protection Agency. The U.S. Nuclear Regulatory Commission standard for offsite radiation exposure is 25 millirem; EPA standards for air and water are lower. The standards are:

General Public - 100 mrem	(NRC, member of the public)
General Public - 25 mrem	(NRC)
General Public - 10 mrem	(EPA, air pathway)
General Public - 4 mrem	(EPA, drinking water pathway)

7. Radiation Units of Dose

TABLE 1 Units of Dose

Unit ^a	Symbol	Conversion Factors
Becquerel (SI)	Bq	1 disintegration/s = 2.7×10^{-11} Ci
Curie	Ci	3.7×10^{10} disintegrations/s = 3.7×10^{10} Bq
Gray (SI)	Gy	1 J/kg = 100 rads
Rad	rad	0.01 Gy = 100 erg/g
Sievert (SI)	Sv	1 J/kg = 100 rem
Rem	rem	0.01 Sv

NOTE: Equivalent dose equals absorbed dose times Q (quality factor). Gray is the special name of the unit (J/kg) to be used with absorbed dose; sievert is the special name of the unit (J/kg) to be used with equivalent dose.

^aInternational Units are designated SL

8. EPA Dose / Radiation Sickness Symptoms

Exposure (rem)	Health Effect	Time to Onset (without treatment)
5-10	changes in blood chemistry	
50	nausea	hours
55	fatigue	
70	vomiting	
75	hair loss	2-3 weeks
90	diarrhea	1 million
100	hemorrhage	
400	possible death	within 2 months
1,000	destruction of intestinal lining	
	internal bleeding	
	and death	1-2 weeks
2,000	damage to central nervous system	
	loss of consciousness;	minutes
	and death	hours to days

9. Radionuclide Poisons

Man-made nuclear fission creates about 200 radioactive isotopes that do not exist in nature. Nuclear power plants routinely release these radionuclides into the environment. Living organisms try to make sense of these unnatural isotopes, so they identify them as the elements they most closely resemble and treat them as those analogs. Some nuclear reactor released isotopes burn out very quickly, but others remain radioactive for millions of years.

Radiation poisoning is invisible and insidious. There is no safe dose. Some people appear more resistant than others, but radiation poisoning is cumulative and children are extremely vulnerable because their cells are dividing rapidly. Studies show childhood leukemia rates double near nuclear power plants. Women and the unborn are also at high risk. Birth defects include downs syndrome, cleft palate or lip, congenital malformations, spinal defects, kidney, liver damage and more.

IODINE 131 is a very volatile radioactive isotope with a half-life of 8 days, which means its radioactive for about 23 weeks. It is a beta and a high-energy gamma emitter, and as such is very carcinogenic. It enters the blood stream through the alveoli in the lungs or can be ingested by eating contaminated foods or milk. It is avidly absorbed by the thyroid gland at the base of the neck, and children are at very high risk of exposure. Potassium iodide cannot prevent this absorption, but it can slow it.

CESIUM 137 is a POTASSIUM analog and mimics potassium in every cell of the human body. It deposits in human muscles where it irradiates muscle cells and nearby organs. Cesium 137 is a dangerous beta and high-energy gamma emitter and is highly carcinogenic.

STRONTIUM is a CALCIUM analog (which means the body mis-identifies it as calcium and absorbs it as such). Strontium 90 is a beta and gamma emitter with a half-life of 28 years, which means it is radioactively dangerous for about 300 YEARS. Strontium 90 released from nuclear power plants lands on the soil and is taken up by grass and concentrated in cows and goats milk and in the breasts of lactating women. Caution should be taken to protect babies from drinking this milk, as it can induce bone cancer and leukemia in the child's body years later.

PLUTONIUM, named after the Greek god of hell, is considered the most dangerous substance on earth. It is so toxic and carcinogenic that inhaling one-millionth of a gram will cause lung cancer. It enters lymph glands via white blood cells and can mutate regulatory genes causing lymphoma or leukemia. An IRON analog, it enters bone marrow and hemoglobin in red blood cells. It irradiates bone cells causing bone cancer and white blood cells in bone marrow causing leukemia. It is stored in the liver, causing liver cancer, and crosses the placenta into a developing embryo. Plutonium is also stored in the testicles, adjacent to spermatocytes, causing mutations in reproductive genes, increasing genetic diseases in future generations, and causing testicular cancer in men.

TRITIUM is a radioactive form of hydrogen, (H3), and a gas produced in reactors as a waste product. If ingested, Tritium is extremely dangerous as it behaves like water passing throughout the body and is incorporated in organic molecules capable of irradiating large numbers of cells. Tritium is a beta emitter and has a half-life of 12.5 years, remaining dangerous for more than 125 years. There are three potential health effects from the ingestion of Tritium: cancer; genetic mutations; and damage to fetuses as it crosses the placenta.

For more information on nuclear power and radiation poisoning visit the <u>MATTR.org</u> website. .

NOTES