PRESCO, Inc.
Gas Well Drilling Monitoring Report
Battlement Mesa Area, Garfield County, Colorado

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LIST OF ACRONYMS AND TERMS

AEC	Acronym for the Atomic Energy Commission, a forerunner of the DOE
ALARA	Acronym for "As Low as Reasonably Achievable"
ALI	Annual Limit on Intake for occupational exposures to radionuclides established by the United States Nuclear Regulatory Commission. The ALI is the derived limit for the amount radioactive material taken into the body of an adult worker by inhalation or ingestion over a period of a year
Alpha Particles (α)	Radioactive particles consisting of two protons and two neutrons, the same as a helium nucleus. These particles can be shielded by a piece of paper and cannot penetrate the outer layer of dead skin cells, but pose a hazard if inhaled
Analyte	A substance or chemical constituent undergoing analysis or the substance being measured by an analytical procedure. Any chemical, parameter, or radionuclide in a water sample with a concentration or activity capable of be measured by a laboratory
Aquifer	A body of rock that is sufficiently permeable to conduct groundwater and yield significant quantities of potable water to wells and springs
Background	Naturally occurring ionizing radiation from sources including cosmic radiation, terrestrial radiation, internal radiation from potassium in our bodies, and indoor radon concentrations
Becquerel (Bq)	The SI derived unit of radioactivity, defined as the activity of a quantity of radioactive material in which one nucleus decays per second. It is therefore equivalent to s^{-1}. The older unit of radioactivity was the curie (Ci), defined as $3.7x10^{10}$ becquerels or 37 gigabecquerels (GBq);
Beta Particles (β)	Radioactive particles consisting of electrons. Beta particles can travel no more than 10 meters in air or about 1 centimeter in tissue, and can be shielded by a pad of paper. Beta particles can cause damage to skin cells in high doses outside the body and can cause damage to cells and critical organs when emitted inside the body through ingestion or inhalation
CDPHE	Acronym for the Colorado Department of Public Health and Environment
COGCC	Acronym for the Colorado Oil and Gas Conservation Commission

Connate Water	Water that is trapped inside a bedrock formation and was present at the time that the sediments were deposited, as opposed to meteoric water that has fallen as precipitation and percolated into the ground
Confining Unit	A body of impermeable or distinctly less permeable material stratigraphically above or below one or more aquifers
CPM	Counts per minute. A measure of radioactive disintegration
Curie (Ci)	A unit of radioactivity measurement. One curie equals 3.7×10^{10} disintegrations per second. One becquerel (Bq) is the International System of Units (SI) unit and equals 1 disintegration per second
DAC	Derived Air Concentration. The DAC is the concentration of a radionuclide in air as the occupational exposure limit to that radionuclide in hours established by the United States Nuclear Regulatory Commission.
Darcy	A standard unit of measurement of permeability, equivalent to the passage of one cubic centimeter of fluid of one centipoises viscosity flowing in one second under a pressure differential of one atmosphere through a porous medium having an area of cross section of one square centimeter and a length of one centimeter
Decay Mode	In physics describes the way a radioactive atom decays
DOE	United States Department of Energy (formerly the AEC)
DRI	Desert Research Institute of Nevada
EIC	Eberline Instrument Corporation
EPA	United States Environmental Protection Agency
EPA Method	A specific method required by the EPA for laboratory analysis of specific parameter or analyte and is followed by the method number
Fission Products	Radionuclides created in the process of nuclear fission of uranium or plutonium.
Gamma (γ)	gamma radiation is electromagnetic radiation with high energy, similar to x-rays. Gamma radiation is given off by the nucleus of radionuclides, while x-rays come from outside the nucleus. Gamma rays and x-rays can travel long distances and penetrate through the human body. Gamma

	radiation is a hazard to all organs from both inside and outside the body. Gamma radiation can be shielded by heavy materials such as lead and concrete.
gpm	gallons per minute
Half-life	The time it takes for half of the radioactive atoms of a radionuclide present to decay. The half-life is dependent on the radionuclide, some having half lives measured in seconds, days, years, or in millions of years
LANL	Los Alamos National Laboratory located in Los Alamos, New Mexico
MCi	A mega curie equals one million (10^6) curies
MCL	Maximum Contaminant Limit(s) set by the EPA as the maximum concentration or activity concentration allowed in a municipal drinking water supply
MDA	Minimum detectable activity is the minimum activity of a particular radionuclide that the laboratory can detect
MDC	Minimum detectable concentration
MDL	Method Detection Limit is the same as the laboratory reporting limit or the minimum concentration of an analyte that the laboratory can accurately quantify using a particular laboratory method
MeV	Mega electron volts, a unit of the energy given off during radioactive decay of a radionuclide, one million (10^6) electron volts (eV)
mg/L	milligrams per liter One milligram equals one thousandth (10^{-3}) of a gram per liter of water, and is approximately equivalent to parts per million
millidarcies	The customary unit of measurement of fluid permeability, equivalent to 0.001 darcy, abbreviated md.
MMCF	a million cubic feet of gas
mrem	millirem (See “rem”)
NERC	National Environmental Research Center – Las Vegas, Nevada
NORM	Naturally occurring radioactive materials

NRC	Nuclear Regulatory Commission, is an independent agency established by the Energy Reorganization Act of 1974 to regulate civilian use of nuclear materials, and is headed by a five member Commission
ppb	parts per billion, approximately equivalent to micrograms per liter
ppm	parts per million, approximately equivalent to milligrams per liter
pCi	picocuries. A unit of radioactivity measurement. One picocurie equals one trillionth of a curie (see definition of a curie)
pCi/cc	picocuries per cubic centimeter as a measure of radioactivity per volume
pCi/g	picocuries per gram as a measure of radioactivity per unit weight
pCi/L	picocuries per liter is a measurement of radioactivity in a volume of liquid, usually used for water concentrations
pCi/m^3	picocuries per cubic meter is a measure of radioactivity in a volume of air
pMC	percent modern carbon, a unit of measurement for carbon-14
Project Rulison	An experiment conducted by the AEC and Austral Oil, a private oil company, on September 10, 1969 involving the detonation of a nuclear device to stimulate natural gas production from low permeability sandstone at a depth of 8,426 feet
QA/QC	Quality Assurance/Quality Control is an evaluation of the accuracy and precision of laboratory analytical results
RAMS	Remote Area Monitoring Systems
Radioactivity	the random decay of unstable atomic nuclei (nuclides) emitting subatomic particles and energy (radiation) to create a new daughter product nucleus
Radionuclide	a radioactive isotope of a particular chemical element
Radionuclides of Interest	Radionuclides which could possibly be entrained in the natural gas or have the remote possibility of being encountered during drilling activities. Concentrations of radionuclides related to Project Rulison are not expected to be encountered in the drilling area.
rem	A measurement of radioactivity dose. A radiation dose is a measure of the amount of energy absorbed by body tissues. One mrem is one thousandth (10^{-3}) of a rem.

roentgen (R)	Measure of radiation exposure, or the amount of ionization produced by gamma radiation or x-rays in the air. An exposure of one milliroentgen (mR) would result in a dose of approximately one millirem (mrem)
Shielding	The use of a physical barrier, such as a lead apron, as protection from radiation
Sievert (Sv)	The international system (SI) unit for dose equivalent equal to 1 joule/kilogram. 1 sievert = 100 rem. Named for physicist Rolf Sievert.
TENORM	Technologically enhanced naturally occurring radioactive materials. Concentrations of NORM at the surface that have been enhanced or concentrated due to human activities such as mining and milling wastes; or pipe scale
TLD	Thermoluminescent dosimeter, a device used to measure whole body beta or gamma doses to onsite personnel. A TLD can contain a variety of different materials. When these materials are exposed to radiation, the absorbed energy is "trapped" and held indefinitely. When the materials are heated at a later date in a device known as a TLD reader, the trapped energy is released in the form of light, and the amount of light released is related to the radiation dose received.
Tritium	A radioactive form of hydrogen, H-3, forms naturally by reactions in the upper atmosphere with cosmic rays, and also by the detonation of nuclear devices. Tritium is a weak beta particle emitter.
TU	Tritium Units, an older unit of measurement of tritium equal to 3.21 pCi/L of tritium
µg/L	micrograms per liter, or one millionth (10^{-6}) of a gram per liter of water, approximately equivalent to parts per billion
µCi/L	microcuries per liter, or one millionth (10^{-6}) of a curie, a measurement of radionuclide activity concentration per liter of water
Unconsolidated	A sediment that is loosely arranged, unstratified, or whose particles are not cemented together, or "lithified"as a sedimentary rock, occurring either at the surface or at depth. Soil material that is in a loosely aggregated form.
USGS	Acronym for the United States Geological Survey

1.0 Introduction

PRESCO, Inc. (PRESCO) is developing natural gas resources on the north side of Battlement Mesa in Garfield County, Colorado. PRESCO owns both the surface land and the mineral rights in the vicinity of Battlement Mesa, Rulison Field, Colorado. These resources are in proximity to where Austral Oil, a private company, and the United States Atomic Energy Commission (AEC), a predecessor agency to the United States Department of Energy (DOE), conducted Project Rulison, an experiment involving the detonation of an underground nuclear device designed to stimulate natural gas production from tight gas, or natural gas in dense, low permeability sandstone reservoir rock.

This report presents a summary of the historic monitoring that was conducted at the time of the Project Rulison experiment, and the current monitoring efforts that PRESCO has conducted in conjunction with the conventional natural gas well drilling in the area.

1.1 Project Rulison Location and History

The Project Rulison site is located in Garfield County about six miles southeast of the town of Parachute, formerly known as Grand Valley, Colorado, on the north side of Battlement Mesa, and within the Battlement Creek drainage valley. The emplacement well, the Hayward #25-95, or R-E well, was located in the Northeast Quarter of the Southeast Quarter of Section 25, Township 7 South, Range 95 West of the Sixth Principal Meridian at an elevation of 8,154 feet above sea level. Figure 1 presents the general site location, and Figure 2 shows the location of Project Rulison site and the locations of PRESCO's natural gas wells drilled in 2005. The following information was obtained from the Project Rulison Manager's Report, April 1973 (AEC, 1973).

Project Rulison involved the detonation of a 43 ± 8 kiloton yield nuclear device on September 10, 1969. The device was emplaced inside a 10 ¾ -inch steel casing in the Mesaverde Formation at a depth of 8,426 feet. No radioactivity was detected on the surface either onsite or offsite as a result of the detonation (AEC, 1973, p. 53). The Mesaverde Formation, reservoir rock, was estimated to contain eight trillion cubic feet of natural gas at depths ranging from 6,200 feet to 8,700 feet beneath 60,000 acres; however, the permeability of this rock is very low. At the time of the experiment the conventional production stimulation methods were not economic to produce the tightly held gas from low permeability reservoir rock.

1.2 Battlement Mesa Geology

Battlement Mesa is located in central Garfield County, Colorado on the Colorado Plateau along the south-central part of the Piceance Basin, an irregularly shaped, geologic

structural depression in the earth's crust created as a result of tectonic forces associated with the uplift of the Colorado Rocky Mountains and the Colorado Plateau. Rocks ranging from Precambrian to Cenozoic in age and having a total thickness of 15,000 feet are present within the central part of Garfield County; however, only rocks of the Cenozoic Era are exposed in the Rulison area as mapped on the Geologic Map of the Rulison Quadrangle (Yeend et al, 1988). Figure 3 presents a cross section of the geology of the area, and Figure 4 presents the generalized stratigraphic column of the Rulison area.

The oldest exposed rock units in the Rifle – Rulison area consist of a sequence of red beds composed dominantly of shale and sandstone of the Maroon Formation and Weber Sandstone deposited during the Pennsylvania geologic period and crop out near the Grand Hogback northeast of Rifle, Colorado. These formations are overlain, in ascending order, by the Triassic age Chinle Formation; the Jurassic age Navajo Sandstone, Entrada Sandstone, and Morrison Formation; and the Cretaceous age Dakota sandstone, and Mancos Shale (Fischer, 1960). The Jurassic sedimentary rocks are known regionally to contain ore deposits of uranium and vanadium, including some historically mined deposits near Rifle, Colorado as the only known occurrence in Garfield County.

The Jurassic sediments are overlain by the Creatceous Dakota Group and Mancos Shale confining unit. The non-water yielding Mancos confining unit typically ranges from 1,000 feet to 6,000 feet thick, and is composed of marine shale, mudstone, and claystone, interbedded with minor sandstone, siltstone, and limestone (Robson and Banta, 1995).

The Mancos confining unit is overlain by upper Cretaceous MesaverdeGroup, composed of the Iles Formation and the Williams Fork Formation. The Mesaverde Group is not an aquifer in the Battlement Mesa area. The Mesaverde Group under the test site consists mainly of sandstone and interbedded shale approximately 2,500 feet thick (Voegeli, West, and Cordes, 1970). The Williams Fork Formation that comprises the upper part of the Mesaverde Group, is of special interest because it contains natural gas resources, and the Project Rulison nuclear device was detonated within this group, as an experiment to stimulate natural gas production from tight gas sands.

Core samples of unfractured rock at the base of the Mesaverde Group have been tested and found to have very little ability to transmit groundwater. Core samples that have been analyzed are nearly incapable of vertically transmitting groundwater with permeability of less than 10^{-4} darcy and most samples have a matrix of less than 10^{-3} darcy (Mayo and Kuntz, 2000). Porosity and permeability in the coal bearing sequences are variable with porosities ranging from less than 4% to greater than 12%, and permeabilities ranging from less than 0.1 millidarcy to 2.2 millidarcy. Much of the original porosity was reduced by compaction during burial of these sediments (Pitman et al, 1996).

The Mesaverde Group is also overlain by impermeable sedimentary rock including the Tertiary Wasatch Formation and Green River Formation. These thick sedimentary rock strata limit the downward migration of surface water. These units are not considered to be aquifers since they do not yield sufficient water volume to wells, and are considered confining units since they limit the migration of water. The Wasatch Formation consists of brightly colored clay and shale, interbedded with sandstone lenses. The Wasatch Formation is approximately 3,900 feet thick at the Project Rulison site. The Wasatch Formation generally is not a source of ground water in the Rulison area (Voegeli, West, and Cordes, 1970).

The Green River Formation is known for its oil shale, and also for deposits of sodium and calcium bicarbonate. In the central part of the Piceance Basin, a saline zone in the lower part of the Green River Formation, limits the thickness of the freshwater found in the overlying Unita-Animas Aquifer (Robson and Banta, 1995).

The sedimentary bedrock units are covered by younger, Quaternary, unconsolidated sediments and boulders of basalt eroded from the top of Battlement Mesa. These Quaternary age deposits range in size from clay and silt all the way up to boulder size particles and represent alluvium, terrace deposits, fan deposits, and slump blocks, and debris flows derived from the bedrock units and basalt transported from higher elevations to the south. Water resources are utilized within this relatively thin layer of sediments.

1.3 Ionizing Radiation

Radiation is a form of kinetic energy, or energy in motion. Ionizing radiation has enough kinetic energy to strip electrons from atoms. Radioactive decay is the process by which a radioactive atom, or radionuclide, releases energy in the form of radiation to become more stable. A half-life is the time that it takes for half of the radioactive atoms present to decay. The half-life is dependent on the radionuclide and may be seconds, days, years, or even millions of years.

Not all ionizing radiation released during radioactive decay has the same amount of energy. The amount of energy released per decay is also dependent on the radionuclide. The three principal types of radiation include:

- alpha particles (α) which consists of 2 protons and 2 neutrons, the same as a helium nucleus;
- beta particles (β) which are electrons; and
- gamma (γ) radiation and x-rays which are electromagnetic radiation, similar to light, ultraviolet light, and microwaves, but have more kinetic energy.

Exposure to these types of radiation may be from natural sources or may be the result of human activity. Radiation used in medical and dental procedures, such as x-rays,

magnetic resonance imaging (MRI), and chemotherapy are examples of beneficial exposures.

Control of radiation dose to the human body from direct exposure depends on the following factors:

1. Minimize the time of exposure to the source of radiation;
2. Maximize the distance to the source of radiation; and
3. Use shielding, or a physical barrier, to reduce the exposure to the human body.

Alpha radiation has the least amount of energy, traveling only about five centimeters in air, or 0.01 centimeters in tissue. Alpha particles can be shielded by a piece of paper and are not a hazard outside the body since they cannot penetrate the outer layer of skin cells. If inhaled, alpha particles can be a high hazard inside the body because they can cause a lot of damage to cells in a small volume of tissue.

Beta particles, as electrons, are much smaller in size, and will travel no more than 10 meters in air or about 1 centimeter in tissue. Beta particles can be shielded by a pad of paper, and can cause skin damage at high dose levels from outside the body. They can cause damage to cells and critical organs when the beta particles are emitted inside the body when ingested or inhaled.

Gamma rays and x-rays are electromagnetic radiation with high energy. Gamma radiation is given off by the nucleus; whereas x-rays come from outside the nucleus. Gamma radiation can travel long distances and can penetrate through the body. Gamma radiation is a hazard to all organs from both inside and outside the body. Gamma rays can be shielded by heavy materials such as the cab of a vehicle, lead apron, barium compounds, concrete, or thick sedimentary rock sequences.

1.4 Background Radiation

Background radiation is ionizing radiation from natural sources including cosmic radiation and sources within the earth, and radionuclides incorporated in food and water, and in the human body tissues. This radiation affects all living things on a daily basis and is omni present. Natural background radiation dose originates from three primary sources: cosmic radiation, terrestrial sources, and the human body itself.

Cosmic Radiation

All living things on the earth are constantly bombarded by radiation from outside our solar system. This radiation interacts in the atmosphere to create secondary radiation that rains down. The dose rate from cosmic radiation varies in different parts of the world based largely on the geomagnetic field and land elevation. The amount of cosmic

radiation to which people are exposed depends on altitude and location. At sea level, the amount of cosmic radiation is about 26 millirem (mrem) per year. The cosmic background radiation levels on the Colorado western slope range from 50 mrem to 100 mrem per year. During commercial air travel passengers are exposed to about 0.5 mrem per hour of cosmic radiation.

Terrestrial Radiation

Naturally occurring radioactive material is found throughout nature in the soil, rocks, water, air, and vegetation. The primary radionuclides responsible for terrestrial radiation are potassium, uranium, and thorium, and their decay products. These radionuclides undergo a well documented radioactive decay process which yield naturally occurring daughter products. Fission products released during the detonation of a nuclear device, such as the one used for the Project Rulison experiment, are not naturally occurring and are distinct from background radionuclides.

1.5 Naturally Occurring Radioactive Materials

The primary radionuclides responsible for terrestrial radiation are potassium, uranium, and thorium. Naturally occurring radioactive materials (NORM), as the name implies, include naturally occurring terrestrial radiation at background levels ranging to the elevated levels of radioactivity found in some rocks and soils as concentrated by geologic and chemical processes. The amount of terrestrial radiation to which people are exposed depends on the geology of the area.

Some oil and gas fields have elevated NORM associated with the produced petroleum hydrocarbons and produced water (connate water). This NORM precipitates out as a radioactive scale on the walls of pipe, production tubing, production equipment, vessels, and settles out in tank bottoms.

Some industrial processes, such as production, treatment, and separation of oil and saltwater in the oil and gas industry, may concentrate radionuclides increasing the level of radioactivity. These radionuclides can become concentrated enough that they could pose a human health risk or a risk to the environment if not controlled. Such technologically-enhanced naturally occurring radioactive materials are referred to as TENORM.

The NORM radionuclides of most concern in the oil and gas industry are radium 226, radium 228, and radon 222. The most abundant of these is radium 226. Radium is very soluble in connate water, or the produced water/brine that accompanies oil and natural gas resources, but radium is not soluble in oil. Radium deposition occurs during changes in temperature and pressure and precipitated radium can be found in scale, sludge, produced waters, and produced sands. Radium is of concern not only because it is

radioactive, but it is also toxic to the human body. Radium is carcinogenic and has been linked to leukemia and bone cancer. Radium 226 and radium 228 are the parent radionuclides of radioactive decay chains that include radioactive daughter products. The activation and fission products created by the Project Rulison experiment are unique and distinct from radionuclides that are the daughter products of NORM decay chains.

The Rulison natural gas field, and other natural gas fields within the Piceance Basin, are not known to have a significant NORM problem. Elevated concentrations of NORM are present in parts of the Gulf Coast region of Louisiana and Texas. The natural gas in the Rulison field is reportedly dry, with relatively little produced water generated.

1.6 Evaluation of NORM in the Rulison Area

In order to evaluate NORM in Garfield County, Cordilleran obtained a copy of the Colorado Geological Survey's Bulletin 40, Radioactive Mineral Occurrences of Colorado "A Complete Listing with Locations, Production, Geologic Setting and Bibliography" (Nelson-Moore et al, 1978, 2005). The Bulletin 40 is available on a compact disk, and a review of the documents indicate that the only occurrences of radioactive minerals in Garfield County are associated with uranium and vanadium deposits in the Wingate Sandstone, Entrada Sandstone, and the Chinle Formation near the town of Rifle, Colorado. These units lie stratigraphically below the Mesaverde Group, at significant depth, and will not be encountered in PRESCO's drilling activities.

An interesting occurrence, different from any of the other known occurrences in Garfield County, was discovered in a test well drilled for oil. The Schulte 1 occurrence is a highly radioactive black shale horizon in a one-foot thick alternating shale-quartzite zone near the base of the Cambrian Sawatch Quartzite. Although this deposit was reportedly encountered at a depth of 8,455 feet; based on a review of the COGCC database information and boring logs, the Schulte-Govt #1 well was located near Douglas Pass in western Garfield County. This is in an area that is geologically dissimilar from that of Battlement Mesa, consisting of older Paleozoic rocks at this depth, and stratigraphically much lower than the formations PRESCO will encountered during drilling.

Cordilleran contacted Dr. James Otton with the USGS Energy Resource Surveys Program to inquire about NORM in Garfield County. According to Dr. Otton, the Green River Formation locally contains some uranium; however, he was not aware of any elevated radioactivity levels in the Wasatch Formation or the Mesaverde Group in the area (Otton, personal communication).

The Green River Formation is present near the surface of some of PRESCO's well sites; however, it is not a zone of production. Published geochemistry information also indicates that there are local zones within the Tertiary Green River Formation. Elemental uranium concentrations associated with organic materials in oil shale are reported at 4.5

ppm, as compared to petroleum with 0.06 ppm, and coal 1.6 ppm (Fish, 1983). PRESCO's drilling activities will go through part of the Green River Formation at some well locations, but this interval will be cased and cemented off and therefore will be isolated from the wells where it is present. The Wasatch Formation will be cased and cemented off from the gas wells. There are some uranium deposits in the Wasatch Formation in Wyoming, but a search at the USGS Library revealed none in Colorado.

The USGS and Colorado Geological Survey have evaluated coal resources in northwestern Colorado including the collection of samples for geochemical analysis. Chemical analyses of 100 coal samples and 17 coal-associated rock samples from the Williams Fork Formation were collected from parts of Garfield, Moffat, Pitkin, Rio Blanco, and Routt Counties (Hildebrand et al, 1981). The following tables present the statistical analysis of the data for potassium, reported in percent, and for uranium and thorium, reported parts per million (ppm) obtained for coal samples from the Williams Fork Formation in Northwestern Colorado, as adapted from USGS Open-File Report 81-1348.

Element	Arithmetic Mean	Minimum (%)	Maximum (%)	Geometric Mean	Geometric Deviation
Yampa Coal Field, Moffat and Routt County, Colorado – Sixty-three Coal Samples					
Potassium (K)	0.11	0.003	0.72	0.061	2.9
Danforth Hills Coal Field, Rio Blanco County, Colorado – Twenty-two Coal Samples					
Potassium (K)	0.22	0.009	0.65	0.089	3.9
Grand Hog Back Coal Field, Garfield County, Colorado – Six Coal Samples					
Potassium (K)	0.038	0.022	0.071	0.034	1.6
Carbondale Coal Field – Garfield and Pitkin County, Colorado - Nine Coal Samples					
Potassium (K)	0.027	0.01	0.048	0.024	1.6

(Adapted from Hildebrand et al, 1981) Potassium analyzed by x-ray fluorescence analysis.

It should be noted that the potassium values, reported as percentages, represent total potassium concentrations in the coal samples. Since the natural abundance of stable potassium isotopes is 99.99% (^{39}K is 93.26%, and ^{41}K is 6.73%) and the radioactive isotope potassium-40 (^{40}K) has a natural abundance of 0.012%, the amount of activity from radioactive potassium-40 in the Williams Fork coal is expected to be low, based on the low percentages of total potassium.

All rocks contain some minerals with naturally occurring radioactive isotopes, the source for terrestrial NORM, the most common of these isotopes being potassium-40, found in potassium containing minerals. Because clay minerals, such as illite and smectite,

generally contain significant amounts of potassium, rocks such as shale or claystone tend to emit gamma rays at relatively high rates. Gamma-ray logs are used in oil and gas drilling to detect this gamma radiation (Brenner and McHargeue, 1988).

In contrast to potassium, uranium and thorium do not have stable isotopes. Thorium and uranium and their daughter products also emit gamma rays and are more common in argillaceous rocks than in sandstones or limestone. These radionuclides tend to reinforce the gamma-radiation distribution results from the presence of the potassium.

Coal is largely composed of organic matter, but also contains inorganic matter, as minerals and trace elements, including potassium, uranium, and thorium, and their decay products. Shales and other argillaceous rocks are usually associated with coals, occurring either stratigraphically above or below the coal.

Sandstone lenses containing the natural gas within the Williams Fork Formation pinch out and grade into finer-grained sediments due the fluvial environment in which they were deposited. Rulison is considered an unconventional gas reservoir due to the extremely low permeabilties (5 to 30 microdarcies (µD)) considerable evidence indicates that natural fractures are the primary conduits for gas movement in the Piceance Basin and the Mesaverde Group gas production. The fractures pinch out in the upper part of the Mesaverde Group. Fractures propogate through the sandstone, which are brittle and laterally discontinuous but the more ductile shales and claystone units, will accommodate a certain amount of strain (Jansen, 2005).

According to USGS Open-File Report 81-1348 the Geology and Chemical Analyses of Coal and Coal-Assoicated Rock Samples, Williams Fork Formation, (Upper Cretaceous) Northwestern Colorado (Hildebrand et al, 1981), statistical comparisons of the same means and variance of 35 elements (whole coal basis) for 100 Williams Fork Formation coal samples with 295 coal samples from the Rocky Mountain province show that the Williams Fork Formation samples have significant higher content of potassium, but that the contents of uranium were not significantly different. The report did not provide a comparison of thorium content between the Williams Fork coal samples and Rocky Mountain province coal samples, but did present thorium data for the Williams Fork samples collected in northwestern Colorado. The values represent naturally occurring concentrations of these elements reported in parts per million (ppm). The following table presents the uranium and thorium data for the Williams Fork from the USGS Open-File Report 81-1348.

Element	Arithmetic Mean	Minimum (ppm)	Maximum (ppm)	Geometric Mean	Geometric Deviation
Yampa Coal Field, Moffat and Routt County, Colorado – Sixty-three Coal Samples					
Thorium (Th)	3.2	0.7	15	1.5	3.6
Uranium (U)	1.2	< 0.2	4.9	1.0	1.8
Danforth Hills Coal Field, Rio Blanco County, Colorado – Twenty-two Coal Samples					
Thorium (Th)	3.0	0.3	10	2.1	2.3
Uranium (U)	1.9	< 0.2	6.3	1.4	2.2
Grand Hog Back Coal Field, Garfield County, Colorado – Six Coal Samples					
Thorium (Th)	2.4	1.0	4.6	1.8	2.1
Uranium (U)	1.0	0.4	2.3	0.8	2.0
Carbondale Coal Field – Garfield and Pitkin County, Colorado - Nine Coal Samples					
Thorium (Th)	2.0	0.7	3.8	1.8	1.7
Uranium (U)	0.6	< 0.2	1.2	0.2	4.0

(Adapted from Hildebrand et al, 1981) Uranium and Thorium were analyzed by delayed neutron activation.

According to the Health Physics Society to convert becquerels per gram (Bq/g) to ppm for uranium (U), thorium (Th), and potassium (K) in rocks, you use the following conversions:

Uranium (^{238}U): 1 ppm = 0.33 pCi/g
1 pCi/g = 3 ppm;
Thorium (232Th): 1 ppm = 0.11 pCi/g;
1 pCi/g = 9.1 ppm; and
Potassium (^{40}K) 1 ppm = 0.000817 pCi/g;
1 pCi/g = 1,224 ppm.

One Becquerel (Bq) = 27 picocuries (pCi)

One picocurie (pCi) = 0.037 becquerels

0.1 percent = 1,000 ppm

1 percent = 10,000 ppm

2.0 PROJECT RULISON

The following section describes the objectives of the Project Rulison experiment, the historic monitoring and sampling efforts that were undertaken, and the results of the monitoring and sampling during the detonation, reentry drilling, and flaring operations from 1969 to 1972.

2.1 Project Rulison Objectives and Chronology

Prior to conducting the Project Rulison experiment, the USGS collected water samples from wells, springs, and surface water sources in the area to evaluate baseline conditions. The USGS logged the emplacement well and evaluated the bedrock formations encountered in the boring for the presence of groundwater, and found that the formations did not yield water. Project Rulison occurred on September 10, 1969, with the detonation of a 43 ± 8 kiloton yield nuclear device. The technical objectives of the experiment were:

1) to measure changes in gas production caused by a nuclear explosion;
2) to measure effective flow capacity to the nuclear fracture zone with time and decreasing reservoir pressure;
3) to determine the gas quality with regard to contamination by radioactivity and techniques utilized in reducing this contamination;
4) to identify the effective height and volume of the chimney and the effective fracture zone radius as determined by volumetric measurements during production testing; and
5) to evaluate seismic effects produced by the detonation, to provide information on appropriate yields for any future development.

Austral Oil and the AEC waited seven months before commencing reentry drilling occurred where a second borehole, R-EX, was drilled into the underground cavity created by the blast. Austral Oil and the AEC waited to allow the radioactivity to decrease to less than one thousandth of that present 12 hours after the detonation occurred, before beginning reentry drilling.

Postshot re-entry site preparations began in April 1970. Directional drilling started toward the chimney of the cavity on June 29, 1970, and also involved cementing a 5½ inch diameter casing in place to a depth of 7,624 feet. Directional drilling was completed to a total measured drill string depth of 8,354 feet, or 192 feet above the detonation point, on July 28, 1970.

Approximately 456 million cubic feet (MMCF) of gas were produced in 108 days of flow testing. At the time, this was the equivalent of approximately 10 years of production

from a conventionally stimulated well drilled in the Rulison Field (AEC 1973, p.20) Calibration flaring was scheduled to start August 18, 1970; however, the hole plugged after initial flow tests were made on August 18 and August 22, 1970. A drill rig was brought back on site to cleanout the borehole and operations were initiated on September 11, 1970 and completed September 29, 1970. Calibration flaring resumed October 4, 1970, and was completed on October 7, 1970 with the flaring of 12.9 million cubic feet (MMCF) of gas during this period.

High flow-rated production testing began October 26, 1970, and continued to November 3, 1970, when the well was shut in for a short term buildup period. A total of 109.5 MMCF was flared during this test. Intermediate production flow testing began December 1, 1970, and was completed on December 20, 1970. A total of 99.9 MMCF of natural gas was flared to the atmosphere. The third, and final, flow test began on February 2, 1971, and ended on April 23, 1971, with a total of 233 MMCF of gas having been flared to the atmosphere.

2.2 Project Rulison Radionuclides of Interest

According to the Project Rulison Manager's Report (AEC 1973), the detonation created an oblate to elliptical shaped cavity where the surrounding sandstone and shale were vaporized and the melted rock cooled to form a glass, lining the cavity. The Project Rulison experiment also resulted in a zone of fractured rock surrounding the cavity, and a "chimney" of rock rubble above and surrounding the shot point. The DOE calculated the chimney cavity radius at 75 feet, and the outer radius of the fracture zone calculated at 220 feet. Most of the radionuclides, or residual radioactive elements from the detonation of the Rulison device, are trapped within the glass slag, and are immobile (AEC, 1973, p.25).

Radionuclides possibly entrained in natural gas present within the cavity or in the surrounding fracture zone include tritium, carbon-14, and krypton-85. Table 1 presents radionuclides of interest, or those fission products that remotely could be encountered in the natural gas resources during exploration and production.

The following section provides a description of the radionuclides that could possibly be entrained in the natural gas stream. These radionuclides are those identified in the AEC Project Manager's Report, April 1973, and also in the DOE Project Rulison End State Vision Document, January 2006.

Tritium

The primary radionuclide analyzed by the EPA at underground nuclear test sites is tritium. As a product of underground nuclear testing, high levels of tritium are found in the test cavities. Some of the tritium is expected to be in the form of free water in the

cavity, and also as water vapor. Since tritium may be incorporated into water molecules, it is expected to be the first radionuclide to migrate from a test cavity. Therefore, tritium serves as an indicator of radionuclide migration. Tritium has a half-life of 12.3 years.

Most hydrogen is made up of one proton, and an orbital electron, but tritium has two extra neutrons in the nucleus. In nature, tritium is produced when cosmic rays interact with nitrogen (^{14}N) or oxygen (^{16}O), causing spallation from the nuclei, and forming tritium (^{3}H) and carbon (^{12}C), or when cosmic rays interact with deuterium (^{2}H). These interactions primarily occur in the upper atmosphere and the resulting tritium falls to earth as precipitation, as rain or snow. The USGS and EPA data indicate the presence of naturally occurring, atmospheric tritium in surface water samples and samples from shallow aquifers, and springs closely connected to shallow aquifers.

Prior to atmospheric nuclear weapons testing, the global equilibrium tritium inventory was estimated at 80 megacuries (MCi). Surface waters such as lakes and streams are estimated to have had a concentration of 5 to 10 pCi/L. Post World War II atmospheric testing caused an increase in atmospheric input rate of about 6 to 7 MCi per megaton yield. The United States and former Soviet Union stopped their above-ground tests in the early 1960s; however, China did not stop until much later. With rapid hydrosphere mixing, a half-life of 12 years, greater than natural level concentrations of man-made tritium can now be found in surface and shallow groundwaters. These tritium levels have been declining back to the natural background levels with the reduction in aboveground nuclear weapons testing.

Drinking water supply wells and springs in the area produce water from shallow, unconsolidated aquifers, and consequently, do not represent groundwater from the bedrock formations, known as connate water. Connate water is trapped in the pore spaces and fractures within the sedimentary rock, which lacks sufficient permeability to allow this water to be produced in useful quantities. Connate water typically has much higher total dissolved solids (TDS), as salts, may contain dissolved petroleum hydrocarbons, or elevated metals concentrations.

Project Rulison was conducted at a depth of 8,425 feet, more than a mile and half below ground surface, a depth near sea level. The Project Rulison test cavity is well below the depth of shallow water resources used for drinking water in the area. Connate water trapped in the Mesaverde Group is largely immobile, and dates to the late Cretaceous when these sediments were deposited, millions of years before the present. Since tritium has a half-life of 12.3 years, naturally occurring tritium is not present in the Mesaverde Group, and if tritium were found within the Mesaverde Group could only be from a man-made source such as the Rulison cavity, or as naturally occurring background concentrations introduced in PRESCO's drilling fluids. Due to the time lapsed since the test in September 1969, any tritium remaining is approximately one-eighth of the original

amount generated during the Project Rulison test, and the extremely low permeability of the formation inhibits migration of the tritium away from the cavity.

The concentrations of tritium are measured in picocuries, or one-trillionth of a curie, in a liter of water. The laboratory is capable of measuring extremely low levels of tritium radioactivity. The EPA has established a drinking water standard for tritium of 20,000 pCi/L, expected to result in a total body dose of 4 millirems (mrem) per year. The derived air concentration (DAC) is 0.00002 microcuries per cubic centimeter ($\mu Ci/cm^3$), or 20 pCi/cm^3, and the annual limit intake (ALI) for tritium is 80 millicuries (mCi) or 80,000,000,000 pCi (Idaho State University and NRC website). The maximum permissible body burden for tritium to the whole body is 1 mCi, or 1,000,000,000 pCi (Worcester Polytechnic Institute, Radiation Safety Office website).

Tritium is one of the weakest beta particle emitter known with a maximum beta decay energy of 0.019 mega electron volts (MeV), forming helium-3 as the decay product. The range of the most energetic tritium beta particles is only about 5 millimeters in air or 0.005 millimeters in water or soft tissue, making it nonhazardous outside the body, but its lack of energy presents a detection problem. Where other radionuclides can be detected by their penetrating radiation, tritium has to be introduced directly inside the detector or counter in order to be measured. Therefore, water samples must be sent to a laboratory to be able to detect the presence of tritium using a liquid scintillation counter.

Tritium is almost always found as water, or "tritiated" water. Once tritium enters the body it disperses quickly and is uniformly distributed throughout the body. Since tritium is in the form of water and disperses through the body, therefore, the entire body is of concern rather than target organs as is the case with other radionuclides. However, tritium is excreted through urine within a month or so after ingestion. Organically bound tritium can remain in the body for a longer period. While not impossible, ingesting a large enough dose of tritium to cause any significant harm to a person is unlikely (Idaho State University, physics department website, 2005).

Krypton 85

Krypton is a chemical element with the symbol Kr, atomic number 36. Krypton is a colorless gas that occurs in trace amounts in the atmosphere with a concentration of about one part per million (ppm). Krypton is isolated by fractionating liquefied air and is often used with other rare gases in fluorescent lamps. Krypton is referred to as a noble gas, similar to helium, argon, neon, xenon, and radon, so called because of their low chemical reactivity. Due to this limited interaction with other elements, krypton is considered chemically inert; however, krypton can form clathrates with water when atoms of krypton-85 are trapped in a lattice of water molecules (Wikipedia, 2006).

Naturally occurring krypton is composed of five stable isotopes and one radioactive isotope. Krypton 85 (^{85}Kr) is an inert, radioactive noble gas with a half-life of 10.76 years, that is produced by fission of uranium and plutonium. Sources have included nuclear bomb testing, nuclear reactors, and the release of Krypton-85 during reprocessing of fuel rods from nuclear reactors (Wikipedia, 2006). Krypton-85 has a decay energy of 0.687 MeV, and decays through beta decay to form rubidium 85 (^{85}Rb) which is stable with 48 neutrons. Since krypton-85 is a beta particle emitter, the EPA drinking water standard is 4 mrem/year. The NRC has not established an ALI for Krypton, but has established a DAC of 0.0001 µCi/ml, which is equivalent to 100 pCi/ml, or 100 pCi/cc.

Carbon 14

Carbon is a chemical element, with the symbol C, and atomic number of 6. Carbon-14, ^{14}C, or radiocarbon, is a naturally occurring radioactive isotope of carbon that was originally discovered by Martin Kamen and Sam Ruben on February 27, 1940 (Wikipedia, 2006). Its nucleus contains 6 protons and 8 neutrons. Its presence in organic materials is used extensively as a radiocarbon dating method to date archaeological and relatively recent paleontological organic samples. Radiocarbon dating can be used to determine the age of carbonaceous materials up to ca 60,000 years.

Carbon-14 is produced naturally in the upper layers of the atmosphere (troposphere and stratosphere) by thermal neutrons absorbed by nitrogen atoms. When cosmic rays enter the atmosphere, they undergo transformations, including the production of neutrons.

The natural relative abundance of carbon-14 is one part per trillion (0.0000000001%) of all naturally-occurring carbon on Earth. The half-life of carbon-14 is 5,730 years, and it decays to stable nitrogen-14 (^{14}N) through beta decay, with a decay energy of 0.156 MeV. The NRC has established an ALI for compounds containing carbon-14 of 2,000 µCi/ml, or (2,000,000,000 pCi/ml), and a DAC for compounds containing carbon-14 of 0.000001 µCi/ml, (1 pCi/ml or 1 pCi/cc).

Gamma Emitting Radionuclides

Gamma radiation is produced in association with the release of alpha particles and beta particles during decay of certain radionuclides; therefore, gamma emitting radionuclides are also of interest.

In the absence of nuclear testing, ambient gamma radiation rates naturally differ among locations since rates vary with altitude (cosmic radiation) and with radioactivity in the soil (terrestrial radiation). Ambient gamma radiation will also vary slightly at a location due to changes in solar radiation, weather patterns, and other environmental factors.

Project Rulison Radionuclide Estimated Activities

According to the Project Rulison Manager's Report, the following radionuclide activities were created as a result of the detonation:

- Tritium: A theoretical 10,000 curies of tritium were estimated to have been created, of which 2,824 curies of tritium were produced during the flow tests. Most of the gaseous tritium was removed from the cavity by the end of the testing (AEC, 1973 p. 25-26). An accounting of all of the tritium created could not be made because of the large quantity of tritiated water that was recovered at the conclusion of the testing, and an unknown volume of tritiated water remaining in the cavity. A significant portion of the tritium remains in the solidified melt zone. A boron carbide shield surrounding the nuclear explosive may have been effective in reducing the tritium produced by the explosion to less than 10,000 curies, but a lack of tritium balance made it difficult to evaluate the actual quantity.
- Krypton-85: A theoretical 800 curies of krypton-85 were estimated to have been produced as a result of the explosion. However, the volume of the cavity was calculated based on an observed release of 1,064 curies of krypton-85 as well as the observed reservoir pressure and temperature which indicated a radius of 78 feet. The yield of the device was subsequently calculated at 43 ± 8 kilotons based on the creation of approximately 1,113 curies of krypton-85 (AEC, 1973 p.25)
- Carbon-14: The estimated inventory of carbon-14 is 2.2 curies (DOE End State Vision, 2006) produced by the Project Rulison detonation. The carbon-14 is likely to be incorporated in the carbon dioxide (CO_2) molecule. Most of the carbon dioxide was initially formed at the time of the detonation and possibly some generated from the heat of the rock melt. Carbon dioxide concentrations were found to increase as the well produced, and the hydrogen concentration in the gas declined (AEC, 1973 p. 28).

These radionuclides are also identified as being the most mobile and therefore most likely to be present in the gas in the DOE Project Rulison End State Vision document dated January 2006. Table 2 presents

1) A list of the "estimated inventory" of other radionuclides present within the cavity, including the radionuclides of interest and those trapped in the glass within the cavity based on Rulison data and data from the Nevada Test Site;
2) the half-lives of these radionuclides;
3) the primary type of radioactive decay mode,
4) the natural abundance of each radionuclide; and

5) the radiation energy and daughter products produced by each of the radionuclides adapted from the End State Vision Document. A copy of the DOE End State Vision Document is included as Appendix A.

2.3 Project Rulison Environmental Surveillance

Samples of water, soil and vegetation were collected prior to the detonation to establish background radiological conditions of the site. Preshot and postshot precipitation samples were collected by the USGS. Samples of water, soil, and vegetation, were also collected prior to, during, and after completion of the drilling operations, and prior to the start of flaring, during calibration flaring, and periodically during and after each production test. Continuous air samples were collected during the drilling operations. Precipitation samples were collected during both the calibration flaring and production testing.

2.4 Project Rulison Monitoring

The AEC oversight included onsite radiological safety monitoring conducted during the Project Rulison detonation phase, reentry drilling, and the flaring operations. Several different methods were employed to monitor for the presence of radionuclides. The AEC contracted the Eberline Instrument Company (EIC) to provide onsite radiological safety support for Project Rulison which included;

1) Installation and operation of Remote Area Monitoring Systems (RAMS) around the site for effluent documentation and hazards evaluation (during the detonation phase only);
2) Around the clock site surveillance by certified radiation monitors;
3) Environmental sampling;
4) Operation of onsite sample preparation and radiological measurement trailers;
5) Installation and operation of continuous effluent monitoring systems during post detonation activities;
6) Radiation area access control;
7) Personnel dosimeters;
8) Instrument maintenance and calibration;
9) Control of radioactive and contaminated materials and equipment;
10) Report Preparation, including daily reports to open file during postshot activities; and
11) Maintaining the capability to respond to radiation incidents in case of an emergency (AEC, 1973, p.85).

Beginning with the detonation phase, and during all operations through completion of the production testing, one or more AEC representatives were present at the Rulison location.

Radiological monitoring and sampling programs were conducted both onsite and offsite. No fresh fission products attributable to Project Rulison were found in any of the air, water, milk and feed, soil, vegetation, animal, precipitation, or natural gas samples analyzed following the detonation phase (AEC, 1973, p. 106).

Detonation Phase Monitoring

During the detonation phase, eight RAMS detectors were installed in a circular array around the Project Rulison test site at a distance of approximately 300 feet, and one placed on the R-E wellhead unit. All of the RAMS units, including the one on the wellhead reportedly survived the ground shock, and no radiation above normal background was detected by any of these units.

Weekly readings were recorded by a gamma scintillation detection system equipped with a strip chart readout installed on the wellhead prior to the site being placed in a caretaker status. Action guidelines were established for indicated radiation levels of 3 milliroetgen per hour (mR/hr) above background (AEC, 1973, p.85).

Reentry Drilling Monitoring

EIC installed monitoring systems and analyzed drilling fluids for radioactivity during reentry drilling of the R-EX borehole. EIC installed and calibrated systems to continuously monitor all drilling mud, chips, and gas prior to the start of drilling. Remote monitors for explosive gas mixtures around the drill rig, tanks, and exhaust air ventilation system were installed and operated continuously by EIC personnel.

Radiological analyses were performed in an onsite laboratory trailer equipped with gamma scintillation detectors with a multichannel analyzer, a gas flow proportional alpha and beta counter, and a liquid scintillation spectrometer. Sample preparation was conducted in a separate trailer onsite. An oxidizer was used to combust samples of organic materials and natural gas from which the water of combustion was collected and analyzed for tritium (AEC, 1973, p.86).

Portable radiation detectors and industrial hygiene hazard detection equipment for toxic and explosive gases were also provided by EIC. Detection of contaminated fluids, consisting of oily rig wash water, rain or snow melt, diesel oil, and mud, was accomplished by:

1) periodically checking mud samples for tritium and gross gamma activity,
2) continuously analyzing off gas for tritium and krypton-85; and
3) using a gamma detector over the shaker table capable of detecting krypton-85.

As an added precaution, all water was assayed and contained in two 500-gallon capacity tanks and one 9,000-gallon capacity tank. Samples, swipes, and air and vapor samples in the work area were analyzed and all found to be at background levels. No detectable activity was found in the mud or water displaced from the borehole annulus between the production tubing and the casing (AEC, 1973, p.87).

Calibration Flaring Monitoring

During calibration flaring radiological data were collected from samples obtained in the downwind trajectory of the plume, as well as from rain-out data, plume rise data, and actual concentrations of tritium and krypoton-85 in the effluent plume. Concentrations obtained with onsite instruments were compared with actual isotopic concentrations found in the downwind samples. After the drill rig was removed, remote monitors were deactivated or were moved to different locations such as the flare line to monitor effluent flow. A fraction of the gas was diverted, dried, and passed through a special chamber known as a STALLKAT where tritium and krypton-85 were measured and the results were recorded. Liquids, including water and hydrocarbons, were separated from the sampled gas and were analyzed for tritium and fission products to document the condition of the gas going to the flare stack. The larger portion of these liquids was removed by a separator and stored in steel tanks, and was sampled and analyzed for tritium, gross beta, and gamma emitters before being re-injected into the flare. A gross gamma scintillation detector was also mounted on the flare line and set to alarm if any unexpected release of fission products occurred (AEC, 1973 p.87-90).

No air samples taken in work areas showed activities above background, except for tritium water vapor during flaring periods. The highest air concentration observed was 100,000 (10^5) times less than the level established by the AEC Manual 0524 for occupational workers. Analysis of onsite vegetation and soil samples showed only worldwide fallout and natural activity, except for areas with known spills, and the close-in area contaminated with fallout or snow out from the flare stack (AEC, 1974, p.76).

During the first production test, or high-rate flaring, approximately 420 curies of krypton-85, 620 curies of tritium, 0.9 curies of carbon-14, and 0.00004 curies of mercury-203 were released to the environment (AEC, 1973, p. 95). Radioactivity concentrations in the natural gas sampled after the separator are included in the following table.

Flaring at 2 MMCF per day was conducted on October 4, 1970. Of the numerous samples collected, only four atmospheric moisture (tritium) samples were significantly above background: 1) 50 picocuries per cubic meter (pCi/m^3) on Morrisania Mesa and 2) 12 pCi/m^3, 46 pCi/m^3, and 170 pCi/m^3 on Holmes Mesa. Radioactivity concentrations guides in air for the general offsite population were 67,000 pCi/m^3 for tritium and 100,000 pCi/m^3 for krypton-85 (AEC, 1973 p. 106). The EPA and NERC failed to detect

any offsite levels significantly above background following the October 5, 1970 flaring at 10 MMCF per day. The EPA/NERC samples indicated tritium levels in the offsite area ranged from background, 5 to 10 pCi/m^3, to a maximum of 290 pCi/m^3 at a sampling location about ½ mile from the flare stack (AEC, 1973 p. 107). All of the Colorado Department of Health samples were within the range of background.

Project Rulison Gas Testing Monitoring Results

Radionuclide	**Testing Event**	**Initial Flaring Concentration In the Gas (pCi/cc)**	**Final Flaring Concentration In the Gas (pCi/cc)**
Tritium	First Production	185	160
	Second Test	150	100
	Third Test	90	3.3
Krypton-85	First Production	145	125
	Second Test	125	90
	Third Test	80	2.8
Carbon-14	First Production	0.35	0.30
	Second Test	0.28	0.23
	Third Test	0.19	0.07

pCi/cc – picocurie per cubic centimeter (about the volume of a sugar cube) equivalent to picocurie per milliliter (pCi/ml)

The isotope mercury-203 was also detected in the Rulison gas. Chemical analysis of the formation rock near the point of detonation indicated that sufficient mercury was present naturally to produce the minute concentrations of mercury-203 observed in the Rulison gas (AEC, 1973, p.25). Approximately 0.00003 curies of mercury 203 were observed in the Rulison gas following the third production test.

Snow samples collected at the time of production flaring were analyzed for tritium concentrations. They indicated tritium levels ranging from background to a maximum of 1,800 picocuries per milliliter (pCi/ml) during the first production test, and a maximum of 5,100 pCi/ml of moisture, during the second production test, both collected as single day samples 20 yards from the flare stack. The maximum readings resulted from short term rainout of tritiated water from the flare, after accidental extinguishing of the flame (AEC, 1973, p. 95). At no time during the entire production testing did onsite radiation surveillance detect any Rulison-related radioactivity in the environment, other than tritium (AEC, 1973, p. 96).

During site cleanup conducted and completed in July 1972, soil and vegetation samples were collected to determine the distribution and concentration of residual tritium impacts. All soil samples were below the tritium cleanup concentration guide of 30,000 picocuries per gram (pCi/g). The maximum concentration observed in soil was 20,000 pCi/g. The maximum tritium concentration in vegetation was 150 pCi/g (wet). Tritium concentrations were not detected above background levels in samples of site spring water and site air moisture. The concentrations of tritium in the produced water remained essentially constant throughout the flow testing indicating no influx of new water from the producing formation (AEC, 1973, p. 27).

2.5 Project Rulison Personnel Dosimetry

Film badges were issued to personnel involved during the initial reentry drilling. Urine samples were also collected from ten EIC personnel prior to detonation to establish individual background levels. No urine samples were collected after the detonation, since there was no release of radioactivity.

During the reentry drilling, calibration flaring, and production testing all personnel entering controlled areas at the Rulison site were issued thermoluminescent dosimeters (TLDs). No onsite personnel received whole body beta or gamma doses during the report period as measured by TLDs. Urine assays for tritium showed no positive results (AEC, 1973, p.75-76, and 96).

3.0 PRESCO MONITORING ACTIVITES

PRESCO conducted the following monitoring activities during the drilling of natural gas wells on Battlement Mesa in the proximity of Project Rulison, during 2005, as part of the first phase of natural gas well development:

1) Screening drill cuttings using a Ludlum Model 3 Survey Meter and Pancake probe;
2) Recording the Model 3 Survey Meter drill cutting screening results for several wells outside the ½ mile radius of Project Rulison to evaluate background radioactivity levels for each of the geologic formations;
3) Using Landauer® Environmental TLD badges on personnel and posted on location to continuously evaluate potential radiation exposures;
4) Collecting samples of natural gas for isotopic analysis including tritium and carbon-14; and
5) Collecting samples of produced water for radionuclide analysis including tritium and gamma emitters.

PRESCO and Cordilleran developed a Work Plan in October 2004, and finalized the Work Plan on May 26, 2005. The Work Plan included protocols for the collection of water samples from area wells, springs, and surface water (creeks). The data obtained from these activities was presented in a report dated March 2006 that was sent to PRESCO and copies were also provided to the COGCC.

The Work Plan also outlined monitoring activities during gas well drilling activities. These monitoring activities were based on what the AEC had done during the Project Rulison experiment. The Work Plan took into consideration that

1. PRESCO's activities are located outside the 40 acres surrounding the Project Rulison, as set aside by the AEC/DOE, also described as Lot 11 located in the Northeast Quarter of the Southwest Quarter of Section 25, Township 7 South, Range 95 West, of the Sixth Principal Meridian;
2. PRESCO's activities during 2005 were conducted outside the ½ mile radius set by the COGCC;
3. the impermeable nature of the Mesaverde Group and overlying sediments; and
4. the estimated inventories of the radionuclides produced by the explosion, their chemical and radiological properties, and the half-lives of the radionuclides possibly entrained in the gas in developing the monitoring activities employed.

The individual monitoring and sampling activities PRESCO has conducted are described in the following sections.

3.1 Ludlum Model 3 Survey Meter Screening

PRESCO retained Pason Systems USA (Pason) of Golden, Colorado to provide a well-site geologist and mudlogging services for the gas wells drilled in the fall 2005. PRESCO purchased a Ludlum Model 3 Survey Meter and Pancake probe capable of detecting alpha, beta, and gamma radiation. The Pason geologist was trained to operate the Ludlum meter and was instructed to screen the cuttings obtained from the gas wells on 30 foot intervals and record the readings in conjunction with the mudlogging activities.

Originally, the readings were recorded in milliroetgens per hour (mR/hr); however, after reviewing the protocols with Janet Johnson, Ph.D, Senior Scientist Health Risk Assessment with MFG, Inc., the Ludlum Model 3 meter does not provide an accurate exposure rate in mR/hr, only a relative reading using this scale. Dr. Johnson suggested that using the counts per minute (CPM) would be more meaningful.

The pancake probe is a Geiger Mueller (GM) detector. It detects beta radiation with high efficiency, gamma radiation with low efficiency, and barely detects alpha radiation. The cut off values that Cordilleran had originally proposed in the Work Plan were reasonable for a NORM survey for pipe scale, but not for soil evaluations. True normal background for this area is 0.015 mR/hr (Jan Johnson, personal communication). Cordilleran revised the Work Plan and had the Pason geologist record the readings of subsequent wells in CPM. The readings reported in mR/hr for the first two wells were converted to CPM by comparing the instrument scales.

The Pason geologist screened drill cuttings from the PRESCO BM 26-42 and the BM 36-13 gas wells from the surface to the total depth drilled, which included readings from the Green River Formation, the Wasatch Formation, and from the Mesaverde Group. The Pason geologist screened drill cuttings from the PRESCO BM 36-23 and the BM 34-24 only from the Mesaverde Group since this is the production interval, and the interval in which Project Rulison was conducted. Copies of the screening logs, statistical analysis, and calibration records are provided in Appendix B.

3.2 Landauer® Dosimetry Badges

Environmental, low-level dosimetry badges were obtained from Landauer® of Glenwood, Illinois to evaluate personnel dosimety and area environmental monitoring. These type of Landauer® badges were selected since they are rugged enough to be used outdoors and tolerate environmental extremes, and are sensitive enough to provide accurate reporting to 0.1 millirem (mrem) or 1 microSievert (μSv).

Landauer® designed these thermoluminescent dosimetry (TLD) badges for environmental and low level dosimetry applications which are significantly improved over previous dosimeters. The environmental/low level dosimeter can be used indoors or outdoors, and are designed to withstand extremes in temperature, humidity, precipitation, and other environmental conditions. The holder is constructed of opaque, matte black polypropylene plastic, sealed within a heavy-duty vinyl tamper resistant pouch with multiple slots to permit several methods of attachment for easy deployment.

Since the drilling for each gas well was completed within a month or less, Cordilleran requested that Landauer® provide monthly TLD service. PRESCO had two drill rigs operating during the fall 2005, the GTS rig on the west side of PRESCO's acreage, and the Union rig on the east side of PRESCO's acreage. Eight TLD badges were deployed with each of the rigs. Four of the badges were used as area monitors, attached to locations with the greatest potential for exposure on the rig platform, above the shale shaker(s), over the mud mixing tanks, and one near the reserve pit. Figure 5 shows a typical drill rig layout and the site locations where the TLD badges were deployed. The other four were issued to site personnel, including the driller or assistant driller, company man, tool pusher, and the mudlogger. The TLD badge issued to the mudlogger was placed over the table where the cuttings were logged.

Annual drilling activities had concluded by November 2005 due to winter weather conditions and access issues, so Cordilleran posted badges on the three well pads outside the ½ mile radius, that were closest to Project Rulison. These gas wells included the BM 26-42 to the west, and the BM 36-13 and BM 36-23, to the south-southeast of the Project Rulison site.

Two controls were provided with each shipment; one for field deployment and retrieval, used to measure exposures during shipment for placement and collection, and the other for transit used to measure exposure during shipment to and from Landauer® only. The deployment/retrieval control is used to calculate the net exposure. The deployment/ retrieval control was stored either in the mudlogger's trailer onsite, or in the company man's trailer onsite. The shipment control was kept in a desk drawer in Cordilleran's Arvada, Colorado office until it was time to ship the TLD badges back to Landauer®.

The technical Specifications for the TLD badges are as follows:

- Fully meets ANSI N545 performance, testing, and procedural specifications;
- Thermoluminescent element is aluminum oxide (Al_2O_3:C);
- Favorable atomic number (10.2) compared to calcium based TL materials (14-16);
- Two TLDs per dosimeter;

- Minimum detectable dose is nominally 0.1 mrem (1 µSv); reporting to tenths of a mrem ambient dose equivalent;
- Maximum Dose (linear range) 100 mrem (1 Sv); if exposure at a level of 25 rem (0.25 Sv) or higher is suspected, Landauer® can specially process the TLD; and
- Fade – during a full year of deployment, fade is negligible under normal indoor conditions and less than 10% for most extreme environmental conditions over a three month use period.

Landauer® suggests the following applications for the Environmental/low-level TLD badges:

- Environmental monitoring including site characterization, site boundaries, off-site, and compliance with administrative and regulatory requirements;
- Low level exposure studies, including area monitoring, shielding studies, special studies. Low minimum detectable dose permits shorter exposure period and faster study; and
- Determining exposure to members of the public by ensuring compliance with current guidelines and 10 CFR 20 limiting dose for non-occupationally exposed persons to 100 mrem annually.

Copies of the Landauer® TLD badge results are presented in Appendix C. Sets of Landauer® TLD badges were deployed to the field in August, September, October, and November, 2005 during PRESCO's drilling and well completion activities.

3.3 Natural Gas Sampling

The following section describes the natural gas sampling activities that have been performed to evaluate potential radionuclide impacted natural gas.

Desert Research Institute Samples

On May 5, 2005, the Desert Research Institute (DRI), under contract to the DOE, sampled five commercial gas wells producing from near the site of the Project Rulison gas stimulation test site were sampled and analyzed for tritium. Four of the wells sampled were located just within the three-mile notification radius to the northwest of the Project Rulison site, and the fifth well was located approximately five miles to the northeast of the Project Rulison site. The gas wells sampled included,

- The 28-31 South Parachute Federal;
- The 15-34 Clem-Warren;
- The 11-43 Bentley;
- The 11-34 Bentley; and
- The 10-11 Savage.

The samples were collected and contained in five new 20-pound steel propane bottles, filled with wellhead gas, and were purged three times to ensure representative samples.

The samples were obtained directly at the wellheads with pressures limited to less than 30 pounds per square inch (psi), as specified by the analytical facility. The samples were sent to Isotech Laboratories, Inc. (Isotech) in Champaign, Illinois, for compositional analysis, δ^{13} carbon analysis of methane, carbon-14 (^{14}C), and tritium (^{3}H) by beta spectrometry. Tritium and carbon-14 were not detected in any of the five samples. A copy of the DRI report is included as Appendix D.

PRESCO Gas Well Samples

PRESCO collected natural gas samples from PRESCO's gas wells that have been completed and are currently in production outside the ½ mile radius of Project Rulison. Samples were collected when the well was first brought into production in the fall of 2005, and PRESCO plans to samples the four closest gas wells for every 60 million cubic feet (MMCF) of gas that is produced. The gas samples were analyzed for tritium and carbon-14. Isotech is not able to analyze the samples for krypton-85.

PRESCO established the sampling interval of 60 MMCF based on production data for other gas wells producing from the Williams Fork Formation in the Mesaverde Group. Approximately 80% of wells drilled on ten-acre spacing show no production interference with one another, and wells drilled on 40-acre spacing show no interference with one another (PRESCO, 2005). Gas production drainage curves were plotted based on a uniform drainage model, and anisotropic drainage models, the latter expected to be more representative of natural conditions.

The gas samples collected from PRESCO's wells were collected in 20-pound steel propane tanks that were under vacuum and provide by Isotech. Since the tanks were purged by Isotech and were received under vacuum, it was not necessary to purge the tanks three times. Since samples were collected soon after the well was brought into production, and periodically when production records indicated that the wells have produced 60 MMCF, the gas samples are representative of the natural gas in the well.

Samples were collected from the PRESCO BM 26-42 and the BM 27-44 on December 7, 2005. The BM 26-42 was sampled again on January 27, 2006, because when the December sample arrived at Isotech, it was still under partial vacuum, and the tritium and carbon-14 analysis could not be run with the limited sample amount. The initial gas sample was collected from the BM 36-13 well on January 27, 2006 when the BM 26-42 well was re-sampled. The results for all three samples were provided in a report on March 3, 2006.

Cordilleran personnel sampled the BM 26-42 on April 5, 2006 after the well had produced 60 MMCF, and sampled the BM 36-13 well soon after production records indicated it had produced 60 MMCF on May 17, 2006. The analytical results have not been received for the May 17, 2006 gas sample. Copies of the Isotech analytical results are presented as Appendix E.

3.4 Produced Water Sampling

An initial produced water sample was collected from the BM 26-42 on December 7, 2005 and was submitted to Paragon Analytics (Paragon) in Fort Collins, Colorado for analysis of tritium using the conventional method and gamma emitters. The sample was collected from the discharge pipe into the reserve pit using a gallon capacity plastic bucket. The sample was contained in one 250-milliliter amber bottle for conventional tritium analysis, and one liter poly bottle preserved with a ten percent nitric acid solution for the gamma emitters. The only other well, the BM 36-13, that had been completed at that time was still flowing back, and the water was not deemed to be representative. Due to the time of year access to the site became difficult due to snow, and therefore, no initial produced water sample was collected from the BM 36-13.

A produced water sample was collected from the base valve on a production tank at the BM 36-13 on May 17, 2006 and was submitted to Paragon for analysis of tritium and for gamma emitting radionuclides. According to Brian Evers, PRESCO, the BM 26-42 is on a plunger and the produced water is discharged to the reserve pit only at certain times. For this reason, Brian collected a produced water sample from the BM 26-42 on May 18, 2006. Analytical results for these two samples have not been received at the writing of this report. Analytical results for the initial sample collected from the BM 26-42 are included in Appendix F. Copies of subsequent analytical results for produced water samples will be provided once they are received.

3.5 Gamma-Ray Logs

PRESCO is running gamma-ray logs on the wells that they are drilling. The gamma-ray log measures natural radiation emitted by a rock formation as a scintillometer-containing sonde is lifted up the borehole. The scintillometer detects natural gamma rays emitted by radioactive isotopes within rock units. Measurements are recorded in standard American Petroleum Institute (API) units, or in grams per ton, on a strip chart (Brenner and McHargue, 1988). These readings plot out as “curves” or “tracks” with the amount of gamma radiation increasing from left to right. Since the printouts are normalized, it is difficult to correlate the readings to other units of radioactivity measurement. However, if a significant source of gamma radiation were encountered in the subsurface, it would be logged. Cordilleran has not been provided with copies of the gamma logs.

3.6 Work Plan Deviations

The drilling activities PRESCO conducted in 2005 were all outside the ½ mile radius from Project Rulison, and the monitoring activities performed were voluntary. Therefore, since these wells were not in close proximity to the Project Rulison test site, and the Ludlum Meter readings did not indicate the presence of radioactivity above background levels, no drilling mud or drill cutting samples were submitted for laboratory analysis.

Ludlum Meter Screening

The drill cuttings were generally screened on 30 foot intervals; however, for wells BM 36-23 and the BM 34-24, only drill cuttings from the Mesaverde Group were screened, whereas drill cuttings from the entire borings of the BM 26-42 and BM 36-13 were screened. The work plan stated that Ludlum meter screening of drill cuttings were to be recorded as millirem per hour (mR/hr). However, following discussions with MFG, it is more accurate to report the readings in counts per minute (CPM) using the model 3 survey meter and pancake probe. Earlier readings were converted to CPM by reading them off the corresponding meter scale. These readings establish site specific background values.

Wipe Samples

Wipe samples for tritium were not collected from the drill rig surfaces or other structures and equipment onsite. Since PRESCO's 2005 drilling activities were outside the ½ mile and PRESCO is not flaring any natural gas, wipe samples to be analyzed for tritium were not collected. PRESCO is not flaring natural gas there is no pathway for tritium in the form of water vapor to be released to the atmosphere. Samples of the natural gas and a sample of produced water were collected and submitted for laboratory analysis. Produced water samples and natural gas samples will be collected in the future as the gas wells are brought into production and/or for each 60 MMCF volume of gas produced from the four wells closest to Project Rulison.

Gas Samples and Produced Water Samples

The gas samples are submitted to Isotech for the same analysis as performed on natural gas samples collected from area gas wells by the DOE/EPA. The work plan originally stated that the gas samples would be analyzed for krypton-85; however, Isotech is not able to perform this analysis on the gas samples, and the work plan was revised.

A produced water sample was collected from the BM 26-42 well located approximately one mile west-southwest of the Project Rulison site. The produced water sample was submitted to Paragon Analytics for analysis of tritium and gamma emitters, but was not

analyzed for the presence of carbon-14 or krypton-85. The tritium analysis and gamma spectroscopy analysis that was conducted is consistent with what the DOE/EPA have been conducting for samples collected from area water wells, springs, and surface water locations, and is consistent with the analysis PRESCO has been conducting for their baseline and ongoing water monitoring.

Tritium has only been analyzed using the conventional method, which typically has a method minimum detectable activity (MDA) of 300 pCi/L to 400 pCi/L. The DOE/EPA has used an enriched method for tritium analysis on a few of their annual well and spring groundwater samples. The enriched method uses an electrolysis concentrate and distillation process to achieve a lower detection limit of 5 pCi/L. The EPA currently analyses all of the water samples by the conventional method and then selects 25% to be analyzed by the enriched method in areas where migration is possible. Tritium analysis performed by the enriched method is only performed by a few laboratories nationwide, is more expensive, and requires a long time to receive the results. The MDA for the conventional method are well below the EPA drinking water standard of 20,000 pCi/L.

4.0 MONITORING ACTIVITY RESULTS

The following section provides the results of each of PRESCO's monitoring activities conducted during the natural gas well drilling activities for wells in close proximity to the Project Rulison site.

4.1 Ludlum Model 3 Survey Meter Screening Results

The Ludlum model 3 survey meter and Geiger Mueller pancake probe do not detect tritium, but were used to screen for radioactivity since the instrument is able to detect alpha, beta, and gamma radiation. The instrument detects beta radiation with high efficiency; however, since tritium is a weak beta radiation emitter the instrument is not sensitive enough to detect tritium. Field detection of tritium is difficult because of the low beta particle energy, potential interference from other radionuclides, the need for large equipment, such as a liquid scintillation counter, and a clean work area free of dust and equipment exhaust is necessary to be able to prepare and analyze the samples and obtain accurate results.

The Ludlum model 3 survey meter was used to screen the drill cuttings from the gas wells for radiation. Initially, the readings were recorded as mR/hr on the first couple of wells; however, these results were later converted to counts per minute (CPM) since this is more meaningful for this equipment. Subsequent drill cuttings screening data was recorded in CPM.

Cordilleran performed a statistical evaluation of the data to establish site specific background levels of radioactivity. The results indicate that the majority of readings were reported around 100 CPM, and that relatively few readings exceed 200 CPM to 260 CPM for each of the wells. This is consistent with surface survey readings that Cordilleran has observed at the well pad sites. Since these wells were drilled outside the half-mile radius surrounding Project Rulison as established by the COGCC, and the readings are generally consistent from the top of each hole to the total depth drilled, these readings are assumed to represent background conditions. The background range has been established at four standard deviations, with a maximum of 260 CPM using the model 3 meter and pancake probe on the 0.1x setting.

Cordilleran evaluated data for each bedrock formation based on the expected top of formation elevations PRESCO reported for each well. All of the formation show very consistent results, as do the readings for each well. Cumulative frequencies and histograms showing the cumulative percentages of readings, as well as the data for each of the four wells, are presented in Appendix B.

4.2 Landauer Dosimetry Badge Results

The Landauer environmental dosimetry badge results indicate radiation exposures consistent with background radiation. The transit control badges, stored in Cordilleran's Arvada, Colorado office away from radiation sources, have similar gross readings to those badges that were deployed in the field for each monthly batch which it accompanied. The deploy controls were kept onsite either in the company man's trailer or the mud logger's trailer, and were stored away from potential radiation sources. The results for the deploy badges are also consistent with the badges that were deployed in the field. The highest gross reading was 21.8 mrem.

The TLD badges were used to monitor drilling activities from August, September, October, and November 2005. The October TLD badge results for monitoring conducted from the October 15 to November 15, 2005 interval, were elevated as compared with the previous and later results. The transit control and deploy control also indicated elevated readings. These badges were collected from the field on November 17, 2005, and were shipped back to Landauer® on November 22, 2005 via Federal Express priority overnight. The lag time in collecting and shipping the badges back to Landauer® is believed to be the reason that these results were higher.

Dose limits to workers should be no greater than 5,000 mrem/year above background. Dose limits to members of the public should be no more than 100 mrem/year above background (10 CFR 20.1201 Subpart C). The average person is exposed to 294 mrem/year from natural background radiation; however, the dosage range from background is from 75 mrem to 5,000 mrem due to geographic and other factors (University of Florida, Environmental Health and Safety website).

The TLD dosimeter badge ID numbers that were issued to site personnel were kept consistent to the extent possible, due to employee turnover and time-off schedules. Landauer® provided cumulative exposure results in mrem for these location ID numbers for the calendar quarter, year to date, and permanent. The highest net result was 3.6 mrem, the highest calendar quarter result was 4 mrem, and the highest cumulative year-to-date and permanent reading recorded was 5.0 mrem. The TLD badge results are presented in Table 3 and, copies of the Landauer® reports are presented in Appendix C. A diagram of the drill rig and equipment on which the TLD badges were placed is shown as Figure 5.

4.3 Natural Gas Sampling Results

The results of the natural gas samples that DRI collected from area gas wells at a distance of approximately 3 miles from the Project Rulison site indicated that activities for carbon-14 and tritium were not detected in any of the five gas samples. These samples were collected from wells owned by EnCana Oil & Gas (USA) Inc., with one gas well

located to the southwest, three gas wells located to the north-northwest, and one gas well located to the northeast of the Project Rulison site. A copy of the DRI Rulison: Gas Sampling of Proximate Producing Wells Report is presented as Appendix D.

Isotech reported that concentrations of carbon-14 were not detected with a detection limit of 0.6 percent modern carbon (pMC) to 0.7 pMC. Isotech reported that concentrations of tritium were not detected in any of the five gas samples with a detection limit of 10 TU, or approximately 32.1 pCi/L.

Concentrations of tritium and carbon-14 have not been detected in gas samples collected from PRESCO's wells. The results of the natural gas samples collected from PRESCO's wells included three samples from the BM 26-42 gas well, the first of which was not able to be analyzed due to insufficient sample volume, a sample from the BM 27-44, and a sample from the BM-36-13. An additional sample was collected from the BM 36-13 on May 17, 2006; however, analytical results will not be received until late June-July, 2006.

Isotech reported that concentrations of carbon-14 were not detected with detection limits ranging from 0.4 pMC to 0.6 pMC. Concentrations of tritium were not detected above detection limits of 10 TU to 12 TU, or approximately 32.1 pCi/L to 38 pCi/L.

Copies of the Isotech laboratory analytical results are included on Table 4 and copies of the Isotech laboratory reports are included as Appendix E. Gas samples will be collected from the four closest gas wells to the Project Rulison site with gas samples analyzed for tritium and carbon-14, every 60 MMCF production volume.

4.4 Produced Water Sampling Results

A produced water sample was collected from the flowline off the BM 26-42 separator on December 7, 2005. The sample was collected in a plastic bucket and was contained in a 5-gallon collapsible carboy. The sample was transferred to a 1 liter poly bottle preserved with a 10 percent nitric acid solution for analysis of gamma emitters, and one 250-milliter amber bottle for analysis of tritium.

The sample was submitted to Paragon Analytics in Fort Collins, Colorado for laboratory analysis of tritium and gamma emitters. According to the Paragon Analytics Condition of Sample Upon Receipt Form, the sample had an external reading of 13 µR/hr and a background reading of 12 µR/hr. These screening results indicate that the level of radioactivity was less than two times background and was within Department of Transportation (DOT) acceptance criteria.

The laboratory analytical results indicate that concentrations of tritium were not detected, with a minimum detectable concentration (MDC) of 340 pCi/L. According to the Paragon Analytics Radiochemistry case narrative for tritium:

"Three reagent blanks were prepared with batch 3H051227-1. Reagent Blank 3H051227-1CB1, had a "window 2" count rate above the upper control limit. Due to being quenched for the method of standard addition for a sample in another work order within this prep batch, this sample is unable to be recounted. In lieu of recounting, this sample will be rejected and only two reagent blanks will be used to determine the background and "window 2" rates for this sample. Data quality is not believed to be significantly affected and is submitted without further qualification."

"For this analysis, "Window 2" is monitored for high-energy beta contamination. Sample BM2642W (Paragon ID 0512143-1) has a "Window 2" count rate of 43.39, above the upper control limit of 43.50. This sample has measured activity less than the achieved MDC. Data quality is not believed to be significantly affected. Data is submitted without further qualification."

"No further anomalous situations were encountered during the preparation of this sample. All remaining quality control criteria were met."

The laboratory analytical results for the gamma spectroscopy analysis indicated that no gamma emitters were detected above the MDC, with the exception of potassium-40 detected at 152 ± 96 pCi/L, and a MDC of 146 pCi/L. Potassium-40 is a common, naturally occurring radionuclide found in food, human muscle tissue, and has been reported in coal samples and coal-associated rock samples collected from the Williams Fork Formation from around the region. Concentrations of bismuth-214 (^{214}Bi) and Lead-214 (^{214}Pb) were estimated at concentrations below the MDC.

"Paragon Analytics has found there to be a significant low bias to ^{214}Pb and ^{214}Bi results when using a mixed nuclide gamma source for efficiency calibrations. The magnitude of this bias has been determined to be approximately 32% for ^{214}Bi, and 23% for ^{214}Pb. Therefore, any reported results for ^{214}Pb and ^{214}Bi are flagged with a "J" qualifier, indicating the activity values to be an estimated value. Results are reported without further qualification."

The results for the produced water sample collected from the BM 26-42 well do not suggest the presence of radionuclides associated with Project Rulison. This gas well is located at higher surface elevation to the west of the Project Rulison site. A copy of the Paragon Analytics laboratory report is included as Appendix F.

Cordilleran collected a produced water sample from the BM 36-13 well on May 17, 2006, and Brian Evers with PRESCO, collected a produced water sample from BM 26-42 separator unit discharge pipe on May 20, 2006 at 12:15 pm. According to Mr. Evers, the BM 26-42 is on a plunger system and produced water discharge to the reserve pit is cyclic. Sample results will be presented as an addendum.

5.0 SUMMARY

The results from PRESCO's monitoring and sampling activities do not indicate the presence of elevated radiation levels associated with NORM or with fission products related to Project Rulison. Based on the information contained in the Project Rulison Manager's Report, April 1973, the End State Vision Document, (January 2005) and discussions with Los Alamos and MFG, Inc. it is very unlikely that any radionuclides related to Project Rulison would be present in natural gas or produced water from PRESCO's gas wells. It is even less likely that radionuclides would be able to contaminate drill cuttings, given the impermeable nature of the Mesaverde Group and overlying bedrock formations, and based on the observations and results of the re-entry drilling and natural gas flaring performed as part of the Project Rulison experiment.

PRESCO and Cordilleran developed a Work Plan that is based on the monitoring activities performed by the AEC at the time of the Project Rulison experiment, and on the DOE/EPA monitoring activities that have been conducted since that time. The radionuclides of interest are those that were identified by these agencies relating to Project Rulison and similar underground test sites. PRESCO's voluntary monitoring and sampling activities conducted in 2005 are reasonable considering the distance from the Project Rulison site, the findings obtained by the AEC during the re-entry drilling into the cavity chimney, and the time lapsed since the Project Rulison was conducted.

Approximately 28 percent of the tritium estimated to have been produced by the detonation of the Rulison device was consumed during the flaring activities (AEC, 1973 p. 25). Most of the gaseous tritium was removed from the cavity by the end of the testing. The remaining tritium is expected to be in the form of tritiated water in the cavity, or incorporated within the vitrified rock, or glass, lining the cavity. The tritiated water is immobile because of the impermeable characteristics of the Williams Fork Formation, and the Mesaverde Group in general. Thirty-seven years, or three tritium half-lives have lapsed since Project Rulison was conducted; therefore, the concentration of tritium remaining is one-eighth of that produced.

Krypton-85 has a half-life of 10.76 years and the yield of the Rulison explosive was calculated based on the measured concentrations of krypton-85 in the gas. The concentrations of tritium and krypton-85 were shown to decrease over time with the amount of cumulative gas produced as based on the Project Rulison radiochemcial data. Most of the krypton-85 was removed from the cavity by the end of the Project Rulison production testing.

Carbon-14 was present in low levels in the gas tested during the Project Rulison production testing, and based on the estimated inventory of 2.2 curies from the End State Vision document, it is theoretically possible to be present in natural gas. Carbon-14 also

was observed to decrease over time during Project Rulison production testing. Therefore, it is unlikely that carbon-14 would be found outside the cavity in significant concentrations. Natural gas samples are analyzed for the presence of tritium and carbon-14.

The Ludlum model 3 survey meter and Geiger Mueller pancake probe screening of drill cuttings evaluated site specific background levels of radioactivity for wells drilled outside the half-mile radius of Project Rulison. The Ludlum model 3 survey meter readings indicate that the majority of readings on the 0.1x setting typically fall around 100 CPM, with maximum readings of 240 CPM to 260 CPM. These background readings are consistent for drill cuttings from the Green River Formation, Wasatch Formation, and Mesaverde Group.

The Landauer® TLD badge results do not indicate elevated levels radioactivity were encountered during the drilling of the BM 26-42, BM 36-13, BM 35-12, or the BM 36-23 gas wells located outside the half-mile radius from the Project Rulison site. The badges were worn by key personnel, such as the driller, assistant driller, company man, and tool pusher, and other badges were posted in locations where radioactivity would likely be detected if it were present. These locations included badges posted on the shale shaker, mud mixing tanks near the reserve pit, and also on the rig platform. Readings were consistent with the transit and deploy control TLD badges. Drilling activities took approximately one month to complete a well; Landauer® provided a monthly badge service. Therefore, the badge readings correspond to individual well sites.

The Isotech results from the natural gas samples collected from the wells sampled by DRI in May 2005, and the samples from PRESCO's gas wells (BM 27-44, BM 26-42, and the BM 36-13) indicate that concentrations of tritium and carbon-14 were not detected in any of the samples. The analytical results for the produced water sample collected from BM 26-42 in December 2005 and analyzed by Paragon indicated that tritium and gamma emitters were not detected, with the exception of potassium-40 detected at 152 ± 96 pCi/L. Potassium-40 is a common, naturally occurring radionuclide found in foods, human tissue, and has been found in coal samples and coal-associated rock samples collected from the Williams Fork Formation at various locations in the region.

PRESCO will continue to perform monitoring activities associated with its natural gas well drilling in proximity to Project Rulison on Battlement Mesa. Gas samples will be collected once the well is brought on line and for every 60 MMCF of gas volume produced from the four closest wells to the Project Rulison site. Currently, this includes wells that have been drilled outside the half-mile radius to the west and south-southeast of the Project Rulison site. Produced water samples will be collected and analyzed for tritium and gamma emitters from other wells once they are brought online into production. Produced water samples from these wells will be collected on a production interval of 60 MMCF. The drill holes/gas wells that PRESCO plans to monitor for radiation are shown on Figure 6.

If future monitoring indicates elevated radioactivity significantly above background, the radionuclides will be speciated to determine the source. An evaluation of additional monitoring and response activities would include the following:

- Assessment of migration pathways and/or routes of exposure;
- Making sure that radiation exposure to onsite personnel, the public, and environment is as low as reasonably achievable (ALARA);
- Confirming elevated results through the collection of additional gas samples and/or additional produced water samples;
- Temporarily shutting down operations until the source is determined;
- Collecting wipe samples from onsite equipment for tritium analysis if field screening, natural gas sample analysis, or produced water sample analysis indicate elevated radioactivity; and
- Collecting drill cuttings/drilling mud samples for radiochemical analysis if the Ludlum meter or dosimetry badges indicate levels of radiation significantly above background.

If the source of the radioactivity is determined to be from Project Rulison, the wastes will be removed from the site and disposed by a DOE contractor. This would presumably be conducted in a manner similar to the 1972 cleanup activities that followed completion of Project Rulison, with removal of impacted materials and/or produced water. Due to the distance from the Project Rulison site, it is unlikely that levels of radioactivity (tritium) seen in the re-entry drilling program and production flaring activities conducted in the early 1970s would be encountered.

If necessary, the affected production interval of the well could be plugged off and sealed, or in an extreme case, the gas well could be plugged and abandoned as the AEC did for the RE and the RE-X wells at the Project Rulison site. The gas well would be abandoned in accordance with the COGCC rules and regulations. Based on a 9 5/8-inch well bore and an interval of 500 feet, (Williams Fork Formation: 8,000 feet to 8,500 feet) a maximum of 10 cubic yards of impacted materials could hypothetically be encountered.

If the radioactivity is determined to be from a NORM source, PRESCO will work with CDPHE – Radiation Control to remove the materials from the site and dispose of the materials. The materials may be disposed at the Clean Harbors' Highway 36 Deer Trail, Colorado facility, Waste Management's Bennett Facility, or at an out of state disposal facility licensed to accept NORM wastes. This may involve solidification of the wastes and special packaging and handling prior to removing the materials offsite. The materials will be stored and transported in accordance with applicable CDPHE, NRC, and Department of Transportation regulations.

6.0 REFERENCES

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Online Resources

Aragonne National Laboratory, EVS
www.ead.anl.gov/

Colorado Department of Public Health and Environment – Radiation Services
http://www.cdphe.state.co.us/hm/rad/radiationservices.asp

Health Physics Society – Paul W. Frame, CHP, PhD
http://hps.org/publicinformation/ate/q2345.html

Idaho State University
www.physics.isu.edu/radinf/tritium.htm

United States Department of Energy
www.doe.gov/

United States Environmental Protection Agency
www.**epa**.gov/

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www.usgs.gov/

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www.**nrc**.gov/

University of Florida, Environmental Health and Safety – Radiation Control Guide
www.ehs.ufl.edu/Rad/RCGuide/att2.htm

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FIGURES AND TABLES

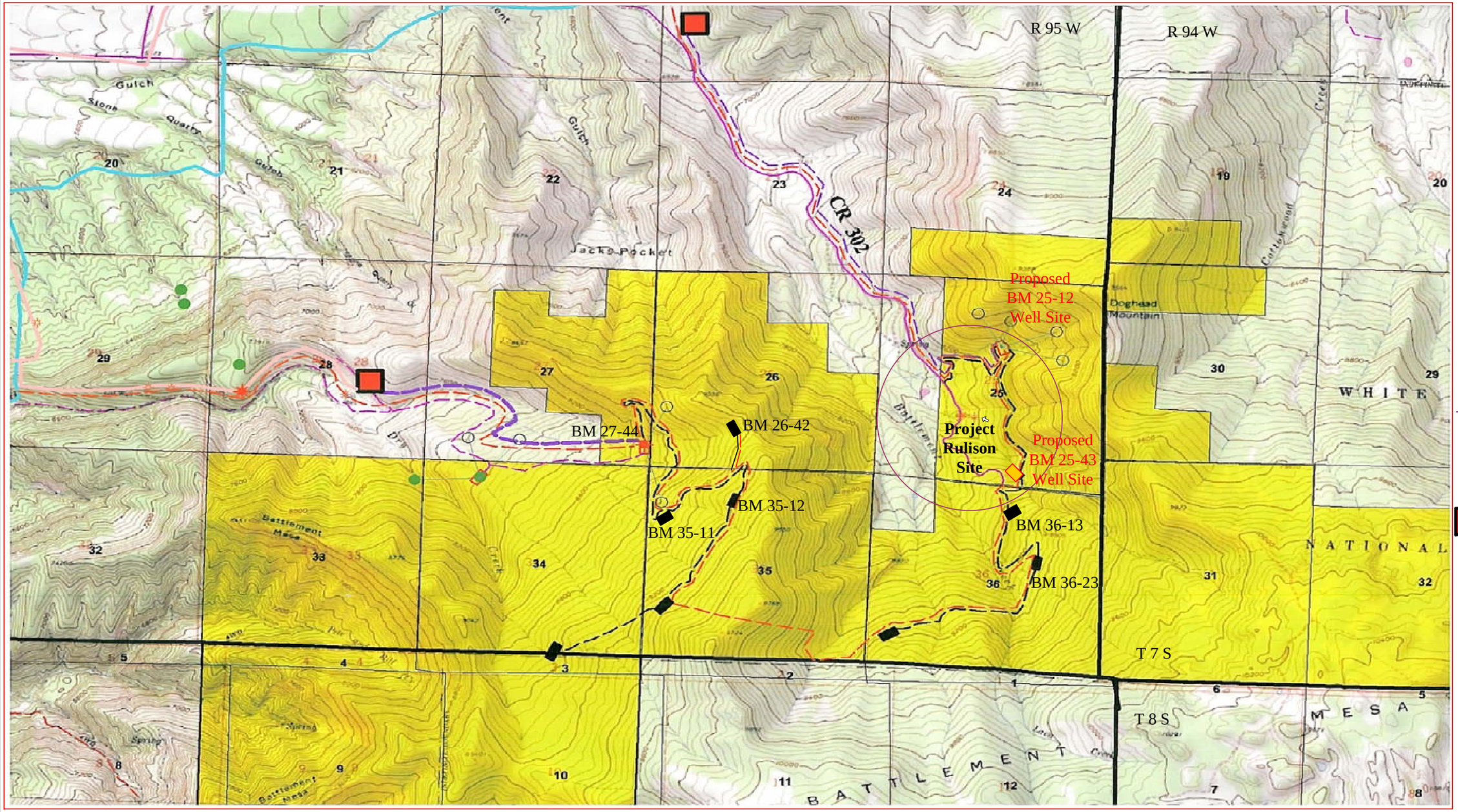


Figure 1
General Site Location Map

PRESCO Inc.
Gas Well Drilling Monitoring
August - November 2005
Battlement Mesa, Garfield County, Colorado

Revision Date:	06/01/06
Revision Number	
Revised by:	JWH
Approved by:	
Project Number:	E04243
Scale:	As Shown

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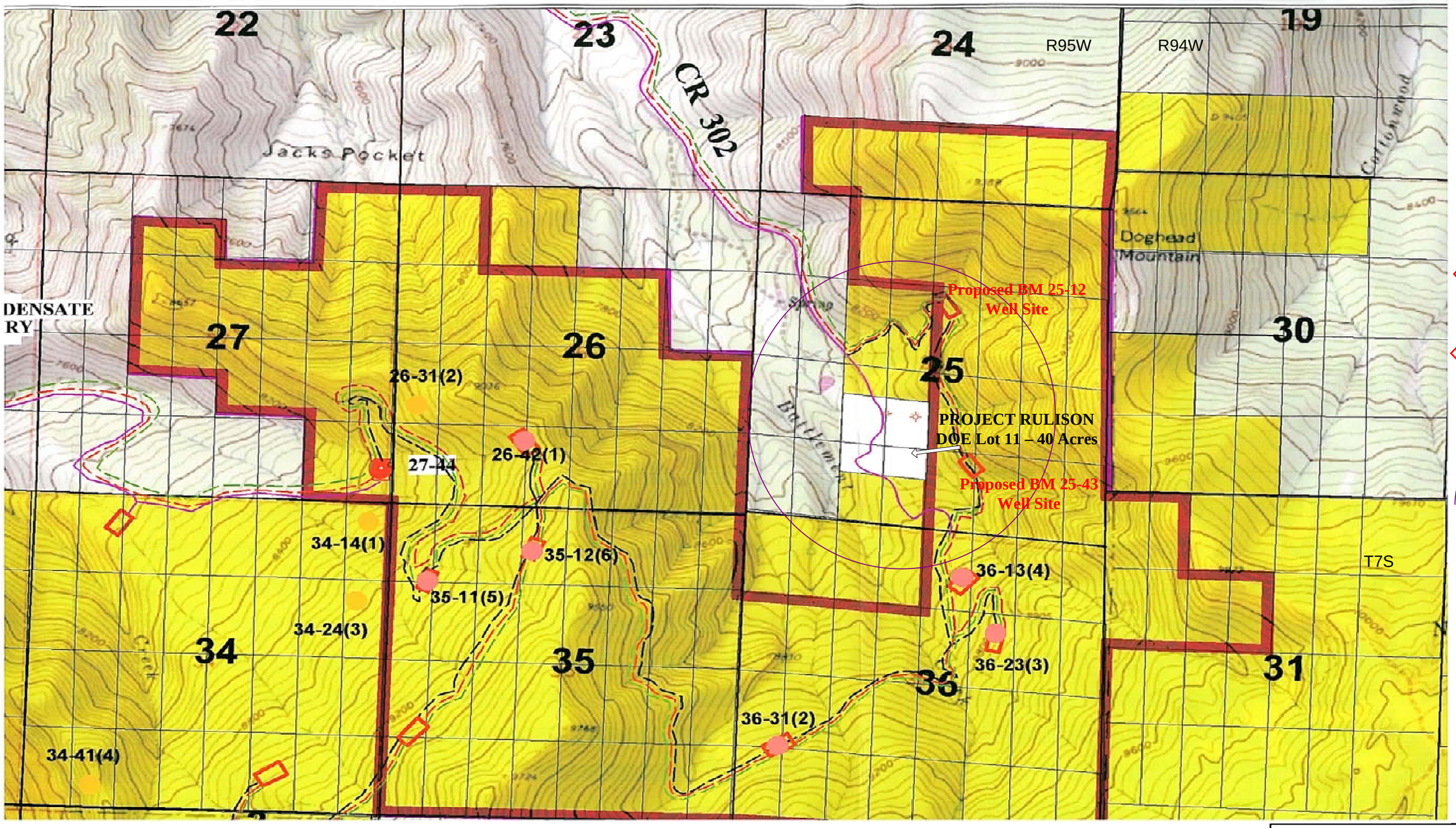


Figure 2
PROJECT RULISON SITE & PROXIMATE GAS WELLS

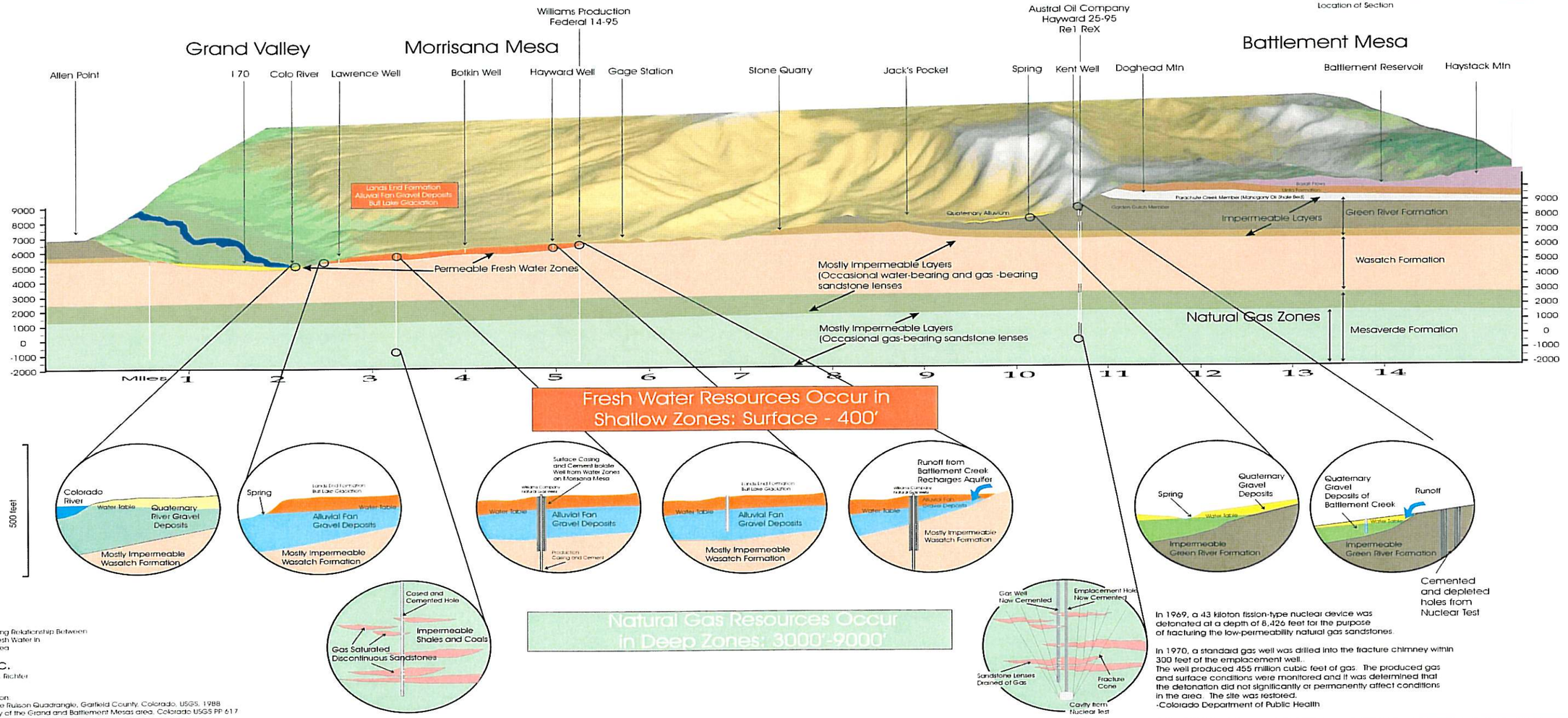
PRESCO Inc.
Gas Well Drilling Monitoring
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Cross Section Showing Relationship Between Natural Gas and Fresh Water in Battlement Mesa Area


Location of Section



In 1969, a 43 kiloton fission-type nuclear device was detonated at a depth of 8,426 feet for the purpose of fracturing the low-permeability natural gas sandstones.

In 1970, a standard gas well was drilled into the fracture chimney within 300 feet of the emplacement well.. The well produced 455 million cubic feet of gas. The produced gas and surface conditions were monitored and it was determined that the detonation did not significantly or permanently affect conditions in the area. The site was restored.
-Colorado Department of Public Health

Cross Section Showing Relationship Between Natural Gas and Fresh Water in Battlement Mesa Area

Presco, Inc.

Prepared by Brian E. Richter
2-15-2005

Sources of Information:
Geologic Map of the Rulison Quadrangle, Garfield County, Colorado, USGS, 1988
Quaternary Geology of the Grand and Battlement Mesas area, Colorado USGS PP 617

Cross Section Showing Relationship Between Natural Gas and Fresh Water in Battlement Mesa Area Prepared by Brian E. Richter – PRESCO, Inc. 02/15/2005

Figure 3
Geologic Cross-Section

PRESCO Inc.
Gas Well Drilling Monitoring
August - November 2005
Battlement Mesa, Garfield County, Colorado

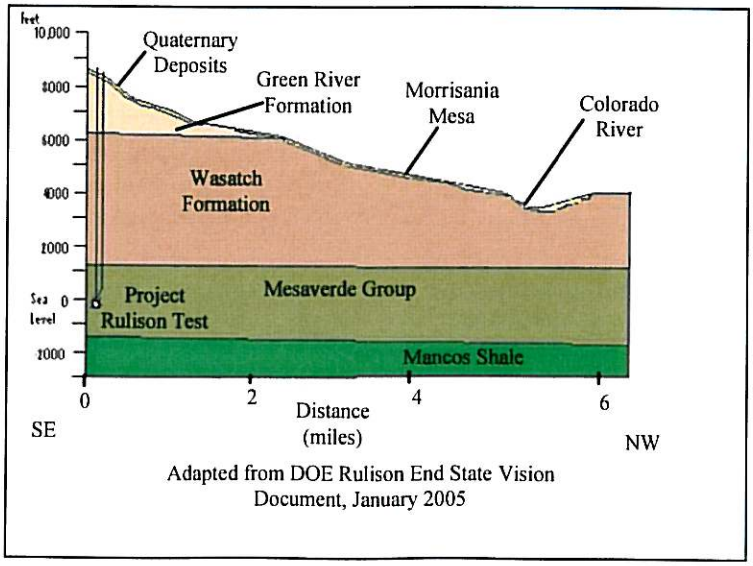
Revision Date:	06/01/06
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RULISON – BATTLEMENT MESA AREA STRATIGRAPHY
GARFIELD COUNTY, COLORADO

Geologic Era	System and Geologic Period	Stratigraphic Unit Name	Appoximate Thickness	Description
Cenozoic	Quaternary "Recent" Quaternary "Pleistocene"	Alluvium/Terrace Deposits (Qal, Qes)	0 ft to 100 ft	Unconsolidated clay, silt, sand, gravel, boulders, deposited by streams
		Terrace, Fan, Landslide deposits (Qga, Qla)	0 ft – 250 ft	Unconsolidated clay, silt, sand, gravel, boulders, deposited by streams
	Tertiary	Uinta Formation (Tu)	0 ft to 1,000 ft	Basalt flows and variegated claystone and gravels
		Green River Formation	2,100 ft total	Lacustrine "oil shale", dark to light colored marlstone, and sandstone
		(Tgr) Evacuation Creek Member	(0-1,250 ft)	
		Parachute Creek Member	(500-1,800 ft)	
		Garden Gulch Member	(0-900 ft)	
		Douglas Creek Member	(0-800 ft)	
		Anvil Points Member	(0-1,870 ft)	
		Wasatch Formation (Tw)	5,000 ft total	Varigated purple, red, gray, brown claystone, siltstone, and shale with minor lenticular, fine- to coarse grained sandstone
		Shire Member		
		Molina Member		
		Atwood Gulch Member		
		Ohio Creek	50 ft	Sandstone and Conglomerate
Mesozoic	Cretaceous	Mesaverde Group (Kmv)	2,500 ft total	
		Lewis Shale-Lance Fm	(200 to 650 ft)	Shale – sandstone
		Williams Fork Formation		Shale – alt beds shale and sandstone
		Paonia Shale Member	(600 to 700 ft)	Shale – alt, coal seams, siltstone, and sandstone lenses containing natural gas (Project Rulison test *)
		Bowie Shale Member	(750 to 1000 ft)	
		Isles Formation		
		Rollins Sand Member	(80 to 200 ft)	Sandstone (Rollins) - Shale
		Mancos Shale (Km)	1,700 ft	Gray marine shale
		Naturitia Formation	600 ft	Shale and sandstone
		Dakota Group (Kd)	80 ft	Sandstone and shale
	Jurassic	Morrison Formation (Jm)	500 ft	Gray to red mudstone, gray sandstone
		Entrada Sandstone (Je)	75 – 125 ft	Light gray fine-grained sanstone
		Navajo Sandstone	30 – 75 ft	Light-brown fine-grained sandstone
	Triassic	Kayenta Sandstone	600 ft total	Red to orange arkosic sandstone
		Chinle Formation		Red siltstone and sandstone
		State Bridge Formation		Red to orange siltstone and sandstone
Paleozoic	Permian	Schoolhouse Formation	60 ft	Sandstone
		Minturn Formation	1,000 ft	Terrestrial red beds w/ white sandstone
		Maroon Formation		Buff-red sandstone
	Pennsylvanian	Eagle Valley Formation	2,800 ft	Evaporites, primarily anhydrite
		Belden Shale		Gray to blk shale w/ basal conglomerate
	Mississippian to Cambrian	Lower Paleozoic Rocks Undifferentiated	Approx 700 ft	Limestone, dolomite, quartzite, and shale (Cambrian Sawatch quartzite)
Precambrian		Basement Complex		Metamorphic rocks and plutonic igneous rocks

Geological Stratigraphy compiled from Yeend et al, 1988; Fischer, 1960; AEC Project Manager's Report, 1973, and Hildebrand et al, 1981.



Adapted from DOE Rulison End State Vision Document, January 2005

Figure 4
Rulison – Battlement Mesa Area Stratigraphy

PRESCO, Inc.
Rulison, Battlement Mesa
Garfield County, Colorado

Revision Date:	06/08/06
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Scale:	N/A

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Illustrated Glossary

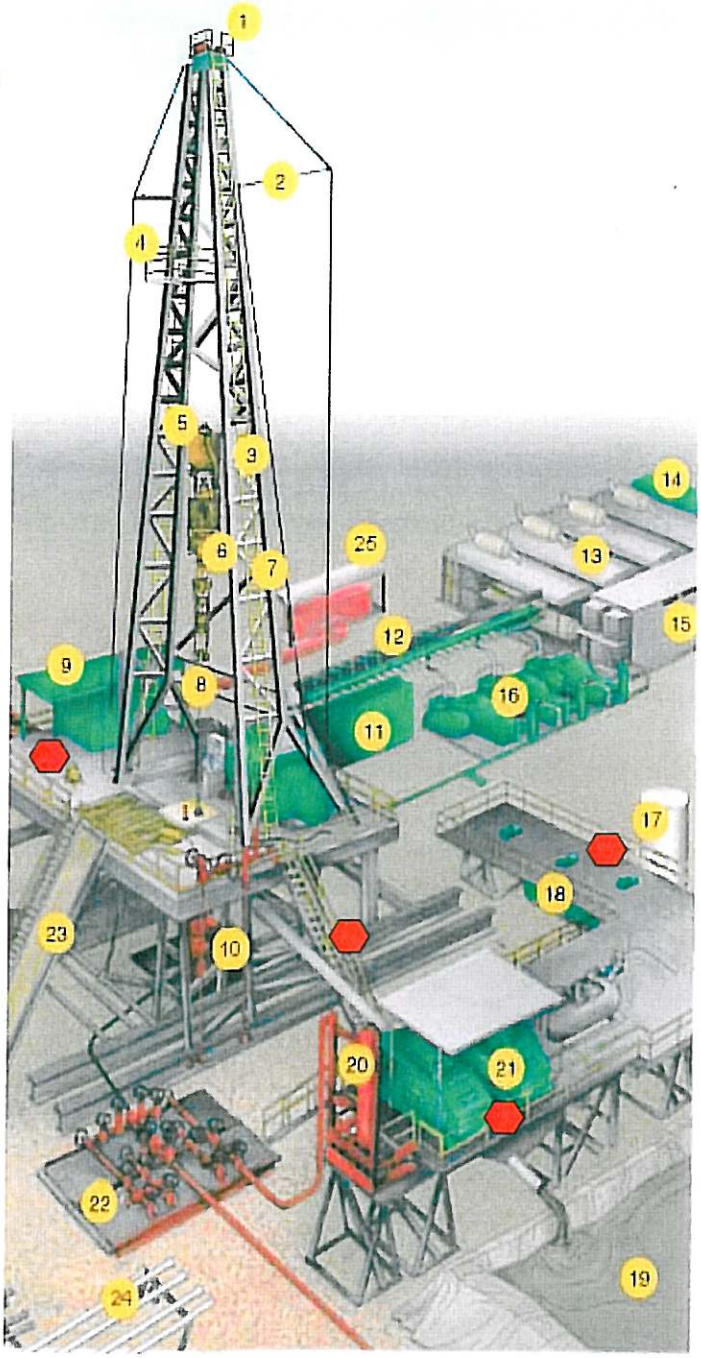
Drilling Rig Components

Click on the name below or a number on the graphic to see a definition and a more detailed photo of the object.

1. Crown Block and Water Table
2. Catline Boom and Hoist Line
3. Drilling Line
4. Monkeyboard
5. Traveling Block
6. Top Drive
7. Mast
8. Drill Pipe
9. Doghouse
10. Blowout Preventer
11. Water Tank
12. Electric Cable Tray
13. Engine Generator Sets
14. Fuel Tank
15. Electrical Control House
16. Mud Pumps
17. Bulk Mud Component Tanks
18. Mud Tanks (Pits)
19. Reserve Pit
20. Mud-Gas Separator
21. Shale Shakers
22. Choke Manifold
23. Pipe Ramp
24. Pipe Racks
25. Accumulator

Additional rig components not illustrated at right.

26. Annulus
27. Brake
28. Casing Head
29. Cathead
30. Catwalk
31. Cellar



Equipment used in drilling

LEGEND:

Landauer® Badge Location

Environmental Thermoluminescent Dosimeter Badges (TLD) were placed on drill equipment as well as being worn by keep site personnel (driller, driller's assistant, company man, mudlogger, tool pusher, etc.)

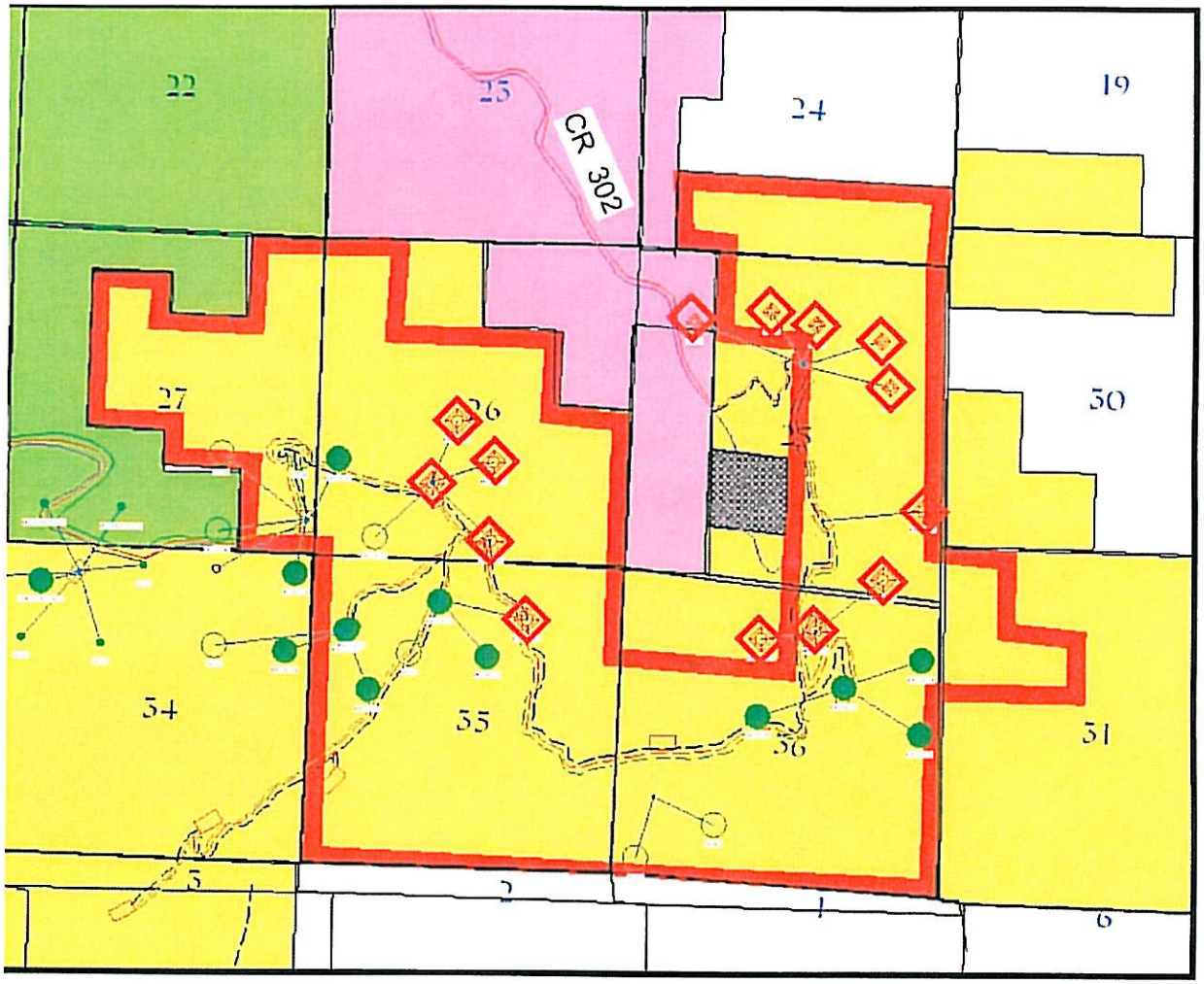
Figure 5
Typical Drilling Site and Equipment
Landauer Badge Location Map

PRESCO, Inc.
Rulison, Battlement Mesa
Garfield County, Colorado

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Adapted from the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) Oil and Gas Well Drilling and Servicing eTool, http://www.osha.gov/SLTC/etools/oilandgas/illustrated_glossary.html



Drill Holes/Gas Wells on which PRESCO Plans to Conduct Radiation Monitoring

Drill Hole/Gas Well – Not Monitored

Designated 40 Acres Surrounding Project Rulison – Set Aside by AEC/DOE Prohibiting Drilling Below 6,000 feet

Figure 6
PRESCO Inc.
Drill Holes Planned for Radiation Monitoring
In Proximity to Project Rulison
Rulison, Battlement Mesa
Garfield County, Colorado

Revision Date:	06/08/06
Revision Number	
Revised by:	
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Scale:	N/A

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TABLE 1

Battlement Mesa Natural Gas
Radionuclides of Interest Occupational Limits

					Inhalation						Ingestion	
Radionuclide	**Class/f1**	**Half Life (Years)**	**Radiation Type**	**Energy (MeV)**	**ALI (MBq)**	**ALI (µCi)**	**ALI (pCi)**	**DAC (MBq/m^3)**	**DAC (µCi/ml)**	**DAC (pCi/ml)**	**ALI (MBq)**	**ALI (pCi)**
Hydrogen Tritium (H-3)	Water Vapor	12.35	Beta (b)	0.019	3,000	80,000	80,000,000,000	0.8	0.00002	20	3,000	80,000,000,000
	Elemental											
Carbon-14 (C-14)	Compounds*	5,730	Beta (b)	0.16	90	2,000	2,000,000,000	0.04	1.00E-06	1	90	2,000,000,000
	CO				60,000	2,000,000	2,000,000,000,000	30	7.00E-04	700	--	
	CO_2				8,000	200,000	200,000,000,000	3	9.00E-05	90	--	
Krypton-85 (Kr-85)	Submersion	10.72	Beta (b)	0.25								
			Gamma (g)	0.0022	--	--	--	5	0.0001	--	--	--

ALI - Annual Limits on Intake
DAC - Derived Air Concentrations
MeV - mega electron volt
MBq - mega becquerel
µCi - microcuries
pCi - picocures
"--" none established
* Labelled Organic Compounds

ALIs and DACs are not available for other tritiated compounds. Under normal conditions, hydrogen gas may rapidly convert to water vapor form.
Submersion denotes situations in which exposure is submersion-limited. Elements in ' vapor' form deposited in lung are assumed to be totally taken up by blood.
Since all three are beta emitters, the EPA drinking water standard is 4 mrem/year.

"Submersion" means that values give are for submersion in a hemispherical , semi-infinite cloud of airborne material.
For Hydrogen as Tritium in water the DAC includes skin absorption. Gas (HT or T_2) Submersion uses above values as tritium oxidizes in the air and in the body.

Sources: U.S. Nuclear Regulatory Commission
Colorado Department of Public Health and Environment

TABLE 2
Project Rulison Radionuclide Estimated Inventories

Radionuclide	Isotope Symbol	Natural Abundance	Half-Life (t1/2 yr)	Estimated Inventory (Ci)[a]	Primary Decay Mode	Decay Energy (MeV)	Daughter Products	Associated Radiation Types	Energy of Associated Radiation Types (MeV)
Tritium	H-3	Trace	12.35	10000[b]	β	0.019	^{3}He		
Carbon-14	C-14	Trace	5,730	2.2[c]	β	0.156	^{14}N		
Aluminum-26	Al-26	Synthetic	730,000	0.000118	β+, é	1.17	^{26}Mg	γ	1.81
Chlorine-36	Cl-36	Synthetic	301,000	2.82	β	0.709	^{36}Ar, ^{36}S		
Argon-39	Ar-39	Synthetic	269	24.30	β	0.565	^{39}K		
Potassium-40	K-40	Synthetic	1,280,000,000	6.17	β	1.31	^{40}Ca, ^{40}Ar	γ	1.46
Calcium-41	Ca-41	Synthetic	103,000	21.60	é		^{41}K		
Nickle-59	Ni-59	Synthetic	76,000	0.53	é		^{59}Co		
Nickle-63	Ni-63	Synthetic	100	55.40	β	0.0069	^{63}Cu		
Krypton-85	Kr-85	Synthetic	10.7	1110[b]	β	0.687	^{85}Rb		
Strontium-90	Sr-90	Synthetic	29	15,700	β	0.2	^{90}Y		^{90}Y: β = 0.94
Zirconium-93	Zr-93	Synthetic	1,500,000	0.55	β	0.06	^{93}Nb		
Niobium-93m	Nb-93m	Synthetic	16	99.9	IT	0.031	^{93}Nb		
Niobium-94	Nb-94	Synthetic	20,000	2.28	β	0.471	^{94}Mo	γ	0.702; 0.87
Technetium-99	Tc-99	Trace	213,000	4.04	β	0.294	^{99}Ru	γ	0.14 Tc99m
Palladium-107	Pd-107	Synthetic	6,500,000	0.021	β	0.033	^{107}Ag		
Cadmium-113m	Cd-113m	Synthetic	14	15.3	β	0.58	^{113}In		
Tin-121m	Sn-121m	Synthetic	55	56.7	β, IT	0.035		γ	0.005
Tin-126	Sn-126	Synthetic	100,000	0.65	β	0.17	^{126}Sb	γ	0.057
Iodine-129	I-129	Synthetic	15,700,000	0.012	β, é	0.194	^{129}Xe		
Cesium-135	Cs-135	Trace	2,300,000	0.42	β	0.269	^{135}Ba		
Cesium-137	Cs-137	Synthetic	30	19,900	β	1.176	^{137}Ba	γ	662 KeV
Samarium-151	Sm-151	Synthetic	90	751	β	0.02			
Europium-150	Eu-150	Synthetic	36	14.6	β+, é	2.26	^{150}Sm	β, γ	0.044, 1.5
Europium-152	Eu-152	Synthetic	13.5	433	β, é	1.87, 1.82	^{152}Sm, ^{152}Gd	β, γ	0.14, 1.2
Europium-154	Eu-154	Synthetic	8.59	240	β, é	0.29	^{154}Gd	β, γ	0.29, 1.2
Holmium-166m	Hm-166m	Synthetic	1,200	0.59	β	65 KeV	^{166m}Er		
Thorium-232	Th-232	100%	14,000,000,000	0.00077	α	4.08	^{228}Ra	β, γ	0.012, 0.0013
Uranium-232	U-232	Synthetic	70	3.36	α	5.41	^{228}Th	β, γ	0.017, 0.0022
Uranium-233	U-233	Synthetic	159,000	2.25	α	4.91	^{229}Th	β, γ	0.0061, 0.0013
Uranium-234	U-234	0.0060%	246,000	1.62	α	4.86	^{230}Th	β, γ	0.013, 0.0017
Uranium-235	U-235	0.72%	704,000,000	0.022	α	4.68	^{231}Th	β, γ	0.049, 0.16
Uranium-236	U-236	Synthetic	23,400,000	0.062	α	4.57	^{232}Th	β, γ	0.011, 0.0016
Uranium-238	U-238	99.30%	4,470,000,000	0.029	α	4.27	^{234}Th	β, γ	0.010, 0.0014
Neptunium-237	Np-237	Synthetic	2,140,000	0.48	α	4.96	^{233}Pa	β, γ	0.07, 0.035
Plutonium-238	Pu-238	Synthetic	87.7	94.2	α	5.5	^{234}U	β, γ	0.011, 0.0018
Plutonium-239	Pu-239	Trace	24,100	254	α	5.25	^{235}U	β, γ	0.0067, < 0.001
Plutonium-240	Pu-240	Synthetic	6,560	81.6	α	5.2	^{240}Am	β, γ	0.011, 0.0017
Plutonium-241	Pu-241	Synthetic	14.4	1,180	β	0.0052	Am	α, γ	< 0.001, < 0.001
Plutonium-242	Pu-242	Synthetic	375,000	0.044	α	4.98	^{238}U	β, γ	0.0087, 0.0014
Americium-241	Am-241	Synthetic	433	61.4	α	5.64	^{237}Np	β, γ	0.052, 0.033
Americium-243	Am-243	Synthetic	7,370	0.0024	α	5.44	^{239}Np	β, γ	0.022, 0.055
Curium-244	Cm-244	Synthetic	18	39.1	α	5.9	^{240}Pu	β, γ	0.086, 0.0017

List of radionuclides, Symbol, half-life, and estimated inventory from the DOE Project Rulison End State Document - January 2005
Natural Abundance, Decay Mode, and Decay Energy from http://en.wikipedia.org and Argonne National Laboratory

[a] Except where noted, value is from the mean unclassified radionuclide inventory for 76 nuclear tests detonated below or within 328 ft of the water table in Areas 19 and 20 of the Nevada Test Site

[b] Value is an unclassified estimate for the Rulison test specifically, from Reynolds (1971)

[c] Value is an unclassified estimate for the Rulison test specifically, and is the total of gaseous species only, from Smith (1971).

α: alpha decay
β: beta decay
β+: positron
é: electron capture
IT: Isomeric transition
γ: gamma radiation

t 1/2 yr: half-life is the time required for half the material present to decay Daughter products shown in blue are stable, and those shown in red are radioactive.
Ci: curies, unit of measure for radioactivity MeV: million electron volts, unit of measure of decay energy

TABLE 3

Landauer Enviornmental Dosimeter Badge - 2005 Results
PRESCO, Inc. Battlement Mesa Gas Well Development
Garfield County, Colorado

Location ID Number	Identifier (Client Supplied)	Note Code	Exposure of Dosimeter (Millirems Ambient Dose Equivalent)		Net Cumulative Totals (millirems)			X9 Badge Series No.	Number of Dosimeters Reported	Badge Series Deployment Date	Badge Deployment Date	Badge Retrieval Date	Inception Date of Permanent Total	Dosimeter Badge Location/Personnel Description
			Gross (mrem)	Net (mrem)	Calendar Quarter	Year to Date	Permanent							
00000	Transit Control		13.7	-1.6				0551927V		8/15/2005				Transit Control - Cordilleran Arvada, CO office
000X9	Deploy Control		15.3	0.0				0553881V		8/15/2005				Deploy Control - GTS Rig BM26-42 site Company Man Trailer/Alex - Driller
00001			16.0	0.7	0.7	0.7	0.7	0469637V	1	8/15/2005	8/4/2005	9/14/2005	8/15/2005	GTS Rig - Company Man (Ed Pilcher) BM26-42
00002		A						0467995V		8/15/2005	8/4/2005			GTS Rig- Absent, Worn by crew (Tool Pusher) BM26-42
00003		A						0413201V		8/15/2005	8/4/2005			GTS Rig - Absent, Worn by crew BM26-42
00004			17.2	1.9	1.9	1.9	1.9	0554940V	1	8/15/2005	8/4/2005	9/14/2005	8/15/2005	GTS Rig - Worn by Crew - Saqib (Assistant Driller) BM26-42
00005	GTS - Shale Shaker		15.2	-0.1	-0.1	-0.1	-0.1	0610416V	1	8/15/2005	8/4/2005	9/14/2005	8/15/2005	GTS Rig BM26-42 - Walkway Next to Middle Shale Shaker (39°24.27N; 107°58.03W)
00006	GTS - Rig Floor		15.3	0.0	0.0	0.0	0.0	0554920V	1	8/15/2005	8/4/2005	9/14/2005	8/15/2005	GTS Rig BM26-42 - Next to Doghouse SW corner of Rig Floor
00007	GTS - Mud Tank		15.5	0.2	0.2	0.2	0.2	0606124V	1	8/15/2005	8/4/2005	9/14/2005	8/15/2005	GTS Rig BM26-42 - Mud Tank (39°24.28N; 107°58.03W)
00008	GTS - Mudlogger		16.7	1.4	1.4	1.4	1.4	0552552V	1	8/15/2005	8/4/2005	9/14/2005	8/15/2005	Mudlogger's Trailer, Window/Table at the BM34-14 Well (39°24.19N; 107°58.50W)
00000	Transit Control		13.7	0.1				0608926V						Transit Control - Cordilleran Arvada, CO office
000X9	Deploy Control		13.6	0.0				0414209V						Deploy Control - GTS Rig
00001	GTS - Company Man	A						0605807V		9/15/2005	9/14/2005			GTS Rig - Company Man (Ed Pilcher/Gary Dokes) Absent
00002	GTS - Driller		15.5	2.0	2.0	2.0	2.0	0605911V	2	9/15/2005	9/14/2005	10/16/2005	8/15/2005	GTS Rig - Driller (Alex)
00003	GTS - Tool Pusher	A						0610733V		9/15/2005	9/14/2005			GTS Rig - Tool Pusher (Larry Pickering/Rich Pickering) Absent
00004	GTS - Asst. Driller	A						0470248V		9/15/2005	9/14/2005			GTS Rig - Assistant Driller (Saqib)
00005	GTS - Shale Shaker		14.3	0.8	0.7	0.7	0.7	0555174V	2	9/15/2005	9/14/2005	10/16/2005	8/15/2005	GTS Rig - Center Shale Shaker BM34-24
00006	GTS - Rig Floor		14.7	1.1	1.2	1.2	1.2	0607283V	2	9/15/2005	9/14/2005	10/16/2005	8/15/2005	GTS Rig - Rig Platform BM 34-24
00007	GTS - Mud Tank		15.0	1.5	1.7	1.7	1.7	0555371V	2	9/15/2005	9/14/2005	10/16/2005	8/15/2005	GTS Rig - Mudmixing Tank - Pipe Inlet BM 34-24
00008	GTS - Mudlogger		14.8	1.2	2.6	2.6	2.6	0553918V	2	9/15/2005	9/14/2005	10/19/2005	8/15/2005	GTS Rig - BM36-13 Pason Mudlogger's Trailer (Jeff Spanke - Pason)
00000	Union Transit Control		13.9	0.3				0552201V		9/15/2005	9/14/2005			Transit Control - Cordilleran Arvada, CO office
000X9	Union Deploy Control	A						0412962V		9/15/2005	9/14/2005			Deploy Control - BM36-23 Pason Mudlogger's trailer
00009	Union - Driller	A						0605903V		9/15/2005	9/14/2005			Union Rig - Absent (Driller) (Absent)
00010	Union - Tool Pusher		16.6	3.0	3.0	3.0	3.0	0470375V	1	9/15/2005	9/14/2005	10/19/2005	9/15/2005	Union Rig - Tool Pusher (Chuck Kaisor) BM34-14/ BM 36-13
00011	Union - Mud Mixer	A						0469841V		9/15/2005	9/14/2005			Union Rig - Mud Mixer (Absent) BM 36-13
00012	Union - Shale Shaker	A						0606183V		9/15/2005	9/14/2005			Union Rig - Electrical Box Near Blue Shale Shaker (Absent) BM 36-13
00013	Union - Mud Tank	A						0551820V		9/15/2005	9/14/2005			Unoin Rig - Mud Mixing Tank Exterior (Absent) BM 36-13
00014	Union - Shale Shaker		14.6	1.0	1.0	1.0	1.0	0550689V	1	9/15/2005	9/14/2005	10/19/2005	9/15/2005	Union Rig - Red Shale Shaker BM 36-13
00015	Union - Doghouse	A						0608350V		9/15/2005	9/14/2005			Union Rig - Above Door Frame Near Pason's Equipment (Absent) BM 36-13
00016	Union - Drill Rig	A						0553801V		9/15/2005	9/14/2005			
00000	Transit Control		21.2	-0.6				0610581V		10/15/2005				Transit Control - Cordilleran Arvada, CO office
000X9	Deploy Control		21.8	0.0				0554062V		10/15/2005				Deploy Control - Company Man's Trailer
00001	GTS - Company Man		21.3	-0.5	-0.5	-0.5	-0.5	0468887V	3	10/15/2005	10/16/2005	11/17/2005	8/15/2005	GTS Rig - Company Man (Ed Pilcher/Gary Dokes)
00002	GTS - Driller		19.6	-2.2	-0.3	-0.3	-0.3	0553704V	2	10/15/2005	10/16/2005	11/17/2005	9/15/2005	GTS Rig - Driller (Alex)
00003	GTS - Tool Pusher	A						0610516V		10/15/2005	10/16/2005			GTS Rig - Tool Pusher (Larry Pickering/Rich Pickering)
00004	GTS - Asst Driller	A						0553635V		10/15/2005	10/16/2005			GTS Rig - Assistant Driller (Saqib)
00005	GTS - Shale Shaker		19.9	-1.9	-1.9	-1.2	-1.2	0605503V	3	10/15/2005	10/16/2005	11/17/2005	8/15/2005	GTS Rig - Center Shale Shaker BM34-24
00006	GTS - Rig Floor		18.2	-3.6	-3.6	-2.4	-2.4	0611473V	3	10/15/2005	10/16/2005	11/17/2005	8/15/2005	GTS Rig - Rig Platform BM34-24
00007	GTS - Mud Tank		17.9	-3.9	-3.9	-2.2	-2.2	0551609V	3	10/15/2005	10/16/2005	11/17/2005	8/15/2005	GTS Rig - Mud Mixing Tank - Pipe Inlet BM34-24
00008	GTS - Mudlogger		21.8	0.0	0.0	2.6	2.6	0610581V	3	10/15/2005	10/16/2005	11/17/2005	8/15/2005	GTS Rig - Mudlogger's Trailer (Jeff Spanke - Pason) BM36-23
00009	Union - Driller		18.3	-3.5	-3.5	-6.9	-6.9	0468944V	2	10/15/2005	10/16/2005	11/17/2005	9/15/2005	Union Rig - Driller (Brent Lane) BM 36-23
00010	Union - Tool Pusher		19.7	-2.1	-2.1	0.9	0.9	0554009V	2	10/15/2005	10/16/2005	11/17/2005	9/15/2005	Union Rig - Tool Pusher (Chuck Kaiser/Chris Chapman) BM 36-23
00011	Union - Company Man		19.2	-2.6	-2.6	-2.6	-2.6	0551445V	1	10/15/2005	10/16/2005	11/17/2005	10/15/2005	Union Rig - Company Man (Gary Dokes) BM 36-23
00012	Union - Company Man		19.7	-2.1	-2.1	-2.1	-2.1	0414325V	1	10/15/2005	10/16/2005	11/17/2005	10/15/2005	Union Rig - Company Man (Gary Dokes) Trailer (Window Curtains) BM 36-23
00013	Union - Shale Shaker		19.1	-2.6	-2.6	-2.6	-2.6	0551396V	1	10/15/2005	10/16/2005	11/17/2005	10/15/2005	Union Rig - Pason Box Adjacent to Shale Shaker and Rig BM 36-23
00014	Union - Shale Shaker	A						0611057V		10/15/2005	10/16/2005		10/15/2005	Union Rig - Red Shale Shaker BM 36-23
00015	Union - Mudlogger		19.6	-2.1	-2.1	-2.1	-2.1	0467687V	1	10/15/2005	10/16/2005	11/17/2005	10/15/2005	Union Rig - Mudlogger's Trailer (Jeff Spanke - Pason) BM 36-23
00016	Union - Water Tank		18.9	-2.8	-2.8	-2.8	-2.8	0470316V	1	10/15/2005	10/16/2005	11/17/2005	10/15/2005	Union Rig - Water Tank #16 BM 36-23
00000	Transit Control		12.3	0.2				0607567V		11/15/2005	11/17/2005			Transit Control - Cordilleran Arvada, CO office
000X9	Deploy Control		12.1	0.0				0606015V		11/15/2005	11/17/2005			Deploy Control -
00001	BM26-42 Well Pad		14.5	2.4	1.9	3.1	3.1	0412925V	3	11/15/2005	11/17/2005	12/7/2005	8/15/2005	BM26-42 Well Site - Production Tank (39°24.249N; 107°58.023W)
00002	BM26-42 Well Pad		13.4	1.3	-0.9	1.1	1.1	0555412V	3	11/15/2005	11/17/2005	12/7/2005	9/15/2005	BM26-42 Well Site - Separator Unit Water Outlet (39°24.254N; 107°58.022W)
00003	BM26-42 Well Pad	A						0413977V		11/15/2005	11/17/2005			BM26-42 Well Site - Wellhead Piping Flowback Line (39°24.269N; 107°58.037W)
00004	BM26-42 Well Pad		15.7	3.6	3.6	5.0	5.0	0469146V	3	11/15/2005	11/17/2005	12/7/2005	8/15/2005	BM26-42 Well Site - Fence NE Corner Adjacent to Pit (39°24.259N; 107°58.016W)
00005	BM26-42 Well Pad		13.9	1.9	0.0	0.7	0.7	0414331V	4	11/15/2005	11/17/2005	12/7/2005	8/15/2005	BM26-42 Well Site - SE Corner of Separator Unit (39°24.247N; 107°58.010W)
00006	BM26-42 Well Pad		15.1	3.0	-0.5	0.6	0.6	0610676V	4	11/15/2005	11/17/2005	12/7/2005	8/15/2005	BM26-42 Road - Aspen Tree overlooking reserve pit (39°24.300N; 107°58.019W)
00007	BM 36-13 Well Pad		14.6	2.5	-1.4	0.3	0.3	0610209V	4	11/15/2005	11/17/2005	12/7/2005	8/15/2005	BM 36-13 East Tank Ladder (39°23.872N; 107°56.651W)
00008	Retained Badge		12.6	0.5	0.6	3.2	3.2	0469782V	4	11/15/2005	11/17/2005	12/7/2005	8/15/2005	Returned with Badge to Cordilleran Arvada, CO office
00009	BM36-13 Well Pad		14.9	2.8	-0.7	-0.7	-0.7	0605930V	2	11/15/2005	11/17/2005	12/7/2005	9/15/2005	BM 36-13 Well Pad - Wellhead Piping to Pit (39°23.887N; 107°56.638W)
00010	BM36-13 Well Pad		14.1	2.0	-0.1	2.9	2.9	0414191V	3	11/15/2005	11/17/2005	12/7/2005	9/15/2005	BM 36-13 Well Pad, Separator Fence/Reserve Pit (39°23.880N; 107°56.637W)
00011	BM36-13 Well Pad		15.0	2.9	2.9	2.9	2.9	0605980V	1	11/15/2005	11/17/2005	12/7/2005		BM 36-13 Well Pad, SW Tank Battery Fence (39°23.868N; 107°56.644W)
00012	BM36-13 Well Pad		13.3	1.2	1.2	1.2	1.2	0552325V	1	11/15/2005	11/17/2005	12/7/2005		BM 36-13 Well Pad, Separator Unit, Solar Panel Post (39°23.877N; 107°56.640W)
00013	BM36-23 Well Pad	A						0610774V		11/15/2005	11/17/2005	5/17/2006		BM 36-23 Well Pad, Spruce Tree Overlooking Reserve Pit (39°23.763N;107°56.484W)
00014	BM36-23 Well Pad	A						0554776V		11/15/2005	11/17/2005	5/17/2006		BM 36-23 Well Pad, Spruce Tree East Side of Well Pad (39°23.707N; 107°56.541W)
00015	BM36-23 Well Pad		14.3	2.2	2.2	2.2	2.2	0553039V	2	11/15/2005	11/17/2005			BM 36-23 Well Pad, SW Corner Spruce Tree (39°23.709N; 107°56.558W)
00016	BM36-13 Well Pad		13.8	1.7	4.0	4.0	4.0	0605476V	4	11/15/2005	11/17/2005	12/7/2005		BM 36-13 Well Pad, West Production Tank Ladder (39°23.872N; 107°56.656W)
A - Absent		Minimum	12.1	-3.9	-3.9	-6.9	-6.9							
		Maximum	21.8	3.6	4	5	5							
		Average	16.20	0.23	0.03	0.53	0.53							
		Median	15.25	0.25	0	0.7	0.7							
		Variance	7.14	3.72	4.15	5.26	5.26							
		Standard Deviation	2.67	1.93	2.04	2.29	2.29							

Table 4
Isotech Gas Sample Results
2005-2006 Natural Gas Sample Analysis of PRESCO, Inc. Gas Wells
Battlement Mesa, Garfield County, Colorado

Isotech Lab No.	Sample Name	Date Collected	Time Collected	Helium (He) mol. %	Hydrogen (H_2) mol. %	Argon (Ar) mol. %	Oxygen (O_2) mol. %	Carbon Dioxide (CO_2) mol. %	Nitrogen (N_2) mol. %	Carbon Monoxide mol. %	Hydrogen Sulfide mol. %	Methane mol %	Ethane mol %	Ethylene mol %	Propane mol %	Iso-butane (iC_4) mol %	N-butane (nC_4) mol %	Iso-pentane (iC_5) mol %	N-pentane (nC_5) mol %	Hexanes + (C_6 +) mol %	$\delta\ ^{13}C_{1\ per\ mil}$	$\delta\ DC_{1\ per\ mil}$	$^{14}C_1$ (pMC)	Std. Dev.	Tritium (^{3}H) TU	Std. Dev.	Tritium (^{3}H) pCi/L	Comments:
91785	BM26-42	12/7/2005	10:28 AM	0.0021	0.0029	0.0265	0.527	5.34	2.33	ND	ND	84.23	4.51	ND	1.9	0.349	0.383	0.158	0.114	0.126	-36.99	-171.5	NA		NA		NA	Insufficient Sample Volume - Tritium & C14 not run
91786	BM27-44	12/7/2005	10:55 AM	0.0031	0.0042	0.258	5.78	4.6	24.78	ND	ND	60.22	2.95	ND	0.833	0.165	0.176	0.0658	0.0518	0.109	-36.88	-198.5	< 0.5		< 10		< 32.1	
94233	BM26-42	1/27/2006	10:15 AM	0.0023	0.0032	ND	0.0075	4.69	0.09	ND	ND	87.83	4.65	ND	1.54	0.332	0.365	0.145	0.108	0.239	-37.04	-181.5	< 0.6		< 10		< 32.1	
94234	BM36-13	1/27/2006	9:30 AM	0.0027	0.0077	ND	0.0077	6.96	0.31	ND	ND	86.14	4.38	ND	1.27	0.265	0.282	0.11	0.0825	0.181	-36.63	-171.6	< 0.5		< 10		< 32.1	
96760	BM26-42	4/5/2006	8:05 AM	0.0025	0.0041	ND	0.0307	3.77	0.2	ND	ND	88.65	4.66	ND	1.53	0.334	0.365	0.147	0.106	0.201	-36.97	-173.9	< 0.4		< 12		< 38.5	
			Average	0.00254	0.00442	0.14225	1.27058	5.072	5.542			81.414	4.23		1.4146	0.289	0.3142	0.12516	0.09246	0.1712								

ND or "<" - Not Detected
NA - Not Analyzed
pMC - Percent Modern Carbon
TU - Tritium Units (3.21 pCi/L)

Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. % Chemical analysis based on standards accurate to within 2%.

APPENDIX A

DEPARTMENT OF ENERGY
RULISON END STATE VISION DOCUMENT
FINAL – JANUARY 2005

DOE/NV--950

U.S. DEPARTMENT OF ENERGY

Rulison Site
ENVIRONMENTAL MANAGEMENT
END STATE VISION
Final

Executive Summary

The Environmental Management End State Vision is to be used as the primary tool for communicating the individual site end state to the involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements (DOE/EM, 2003).

Restoration activities have been conducted on the surface of the Rulison Site; however, an investigation of subsurface contamination has not yet been completed. Therefore, the surface and subsurface end states are treated separately within this document.

The Rulison Site is in the northern part of Battlement Mesa in southern Garfield County, Colorado. Ranching, farming, and oil and gas production historically have provided the dominant commercial interests in this region of Colorado, but retirement homes and tourism have increased in recent years. The nearest town, Parachute, lies approximately 8 miles northwest of the site, and the largest town in the area, Rifle, lies 12 miles to the northeast.

The Rulison test was part of the Plowshare Program, which was designed to develop peaceful uses for nuclear explosives. One underground nuclear test was conducted at the Rulison Site in 1969 to study the ability of nuclear explosions to stimulate natural gas production from low permeability formations. No further tests were conducted at the Rulison Site.

Cleanup associated with the original deactivation of the Rulison Site in 1972 included removing equipment and materials not needed for potential gas production activities, extensive soil sampling, and removing contaminated soil. Cleanup associated with abandonment of the Rulison Site in 1976 included removing all equipment and materials, plugging and abandoning the emplacement and reentry wells, backfilling the mud pits, and removing soil contaminated with tritium. In 1996, the DOE/Nevada Operations Office (now the Nevada Site Office [NSO]) completed preliminary site characterization for the surface area of the Rulison Site. During these activities, the surface contamination was removed and additional water-quality monitoring wells were drilled. In 1998, the DOE/NSO completed surface closure of the site and submitted the *Rulison Site Surface Closure Report* (DOE/NV, 1998). The State of Colorado accepted the surface closure report with no surface restrictions (Johnston, 2003a). The site is currently privately owned and is used for livestock grazing and for recreation, including fishing.

The subsurface investigation has not yet begun at the Rulison Site. It is expected to involve numerical modeling of radionuclide transport in the gas phase. The objective will be to determine if the subsurface restriction zone is sufficiently protective in the event gas production wells are drilled adjacent to the site. Based on the historic use of the site and characterization conducted at similar sites, the contaminants of concern for the subsurface of the Rulison Site are expected to include radioactive fission products, plutonium, uranium, and tritium, with the gaseous radionuclides (tritium, carbon-14, and krypton-85) being the most mobile in the environment; however, the extent of the subsurface hazard has yet to be defined.

The subsurface contamination is being addressed by implementing an approach based on defining a contaminant boundary at the Rulison Site and monitoring subsurface resource development to ensure that gaseous radionuclides do not migrate past the existing restriction boundary. Migration to the existing restriction boundary, both under non-stressed and stressed (production) conditions, is being evaluated. If migration is found to be significant (which may be determined by a risk assessment), then the restriction zone will be enlarged. Drilling and subsurface resource extraction within the contaminant boundary will be prohibited, and resource (natural gas) production may also be limited for some region outside the boundary. This approach will be protective because, though it is not technologically feasible to remediate the contamination associated with an underground nuclear test, the use (withdrawal) of and exposure to contaminated natural gas will be precluded by implementation of institutional controls restricting the drilling of wells within the boundary. Resource development patterns in the area will be monitored to assess whether the boundary remains protective if resource extraction characteristics change through time, and samples of natural gas from nearby wells may be monitored for radionuclides. If radionuclides are ever found in nearby production wells, the radionuclide transport model will be re-evaluated to determine if the drilling restriction area and associated institutional controls need to be changed.

According to the Life-Cycle Baseline Revision 5, the DOE/NSO expects to complete closure of the Rulison Site subsurface in fiscal year 2011. The DOE/NSO assumes that monitoring will be performed for 100 years (2011 to 2111), and will refine existing subsurface intrusion restrictions as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001). The end state for the subsurface of the Rulison Site will be to continue monitoring and maintenance of institutional controls indefinitely.

The end state has been achieved for the surface of the Rulison Site. The end state envisions leaving the Rulison Site in private ownership, as it now exists. The DOE will continue long-term stewardship activities for the subsurface contamination. The DOE has imposed deed restrictions on the site to prevent access to the test cavity, subsurface areas, and natural gas in perpetuity (DOE/EM, 2001). The U.S. Department of the Interior, Bureau of Land Management and the Colorado Oil and Gas Conservation Commission will exercise oversight of any wells located within three miles of the Rulison Site. This three-mile zone is sufficient to isolate contamination from potential receptors (IT, 1996).

The DOE/NSO developed a public participation plan for the Rulison Site Environmental Management End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.

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List of Acronyms and Abbreviations

bgs	Below ground surface
BLM	U.S. Department of the Interior, Bureau of Land Management
COC	Contaminant(s) of concern
CSM	Conceptual site model
DOE	U.S. Department of Energy
DOE/NSO	U.S. Department of Energy, Nevada Site Office
EM	U.S. Department of Energy, Environmental Management Program
EPA	U.S. Environmental Protection Agency
ft	Foot (feet)
ft^3	Cubic feet
FY	Fiscal year
LTHMP	Long-Term Hydrologic Monitoring Program
mi	Mile(s)
SGZ	Surface ground zero
TPH	Total petroleum hydrocarbons
USDA/FS	U.S. Department of Agriculture, Forest Service

1.0 Introduction

The Environmental Management End State Vision is to be used as the primary tool for communicating the individual site end state to the involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements (DOE/EM, 2003).

The environmental management end state vision juxtaposes land use with remediation requirements, establishing a conceptual completion goal (or end state) that is both realistic and protective of human health and the environment. The purpose of the vision is to identify where and how potentially harmful exposures to hazardous or radioactive contaminants might occur under projected future conditions, and to determine what actions will be necessary to minimize the potential for harm under those conditions. Consistent with the objectives of cleanup, the vision conceptualizes specific end state conditions that will minimize the potential for harm in the future.

The July 2003 DOE Policy 455.1, "Use of Risk-Based End States," requires DOE Environmental Management Program (EM) sites to define and document a risk-based end state vision that is acceptable to regulators and stakeholders, and then to revise clean-up program plans as necessary to achieve that end state in the most efficient manner (DOE, 2003). The policy is a formal mandate for EM sites to implement risk-based corrective action programs as described in numerous DOE and U.S. Environmental Protection Agency (EPA) publications, American Society of Testing and Materials Standard Guides, and National Research Council recommendations.

Environmental corrective action is an application of standard scientific, engineering, and mathematical principles, enabling steady progress in solving even very complex clean-up problems. The complexities of cleanup at a typical EM site are generally similar: multiple contaminants distributed in multiple environmental media, released over long periods of time and over large areas of land. Uncertainties in source(s), nature, extent, transport, and fate of contaminants are very large and can never be absolutely eliminated. Corrective action provides an objective means of managing uncertainties to the degree necessary and sufficient to make defensible decisions about effective clean-up actions.

The end state vision describes clean-up goals that would be protective under planned future uses. Proposed corrective actions based on risk and other factors associated with land use are presented, negotiated, and agreed to by the State of Colorado and DOE.

The DOE's risk-based end state initiative is fully consistent with the EPA's recent endorsement of systematic planning, which uses risk-based decision methods to ensure objectivity, defensibility, and cost-effectiveness in corrective action programs (EPA, 2001). The DOE Nevada Site Office (DOE/NSO) will collaborate with its stakeholders to revise the proposed environmental management end state vision, as needed, to define clear goals for completion of its EM-sponsored clean-up work.

The DOE/NSO developed a public participation plan for the Rulison Site End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.

Restoration activities have been conducted on the surface of the Rulison Site; however, an investigation of subsurface contamination has not yet been completed. Therefore, the surface and subsurface end states are treated separately within this document.

The Rulison Site is in the northern part of Battlement Mesa in southern Garfield County, Colorado. Battlement Mesa is in northwestern Colorado and consists of a high, basalt-capped mesa covered with aspen and pine trees in the upper elevations, and sagebrush and cedar in the lower elevations. High mountain ranges lie southeast and east of Battlement Mesa, and high plateaus lie southwest and west of the site. The Colorado River and Interstate Highway 70 are approximately 8 miles (mi) north of the Rulison Site, and have seen increasing commercial and population growth in recent years. Ranching, farming, and oil and gas production have historically provided the dominant commercial interests in this region of Colorado, but retirement homes and tourism have increased in recent years. The Rulison Site is privately owned and is used for livestock grazing and for recreation, including fishing. Parachute, the nearest town, lies 8 mi northwest of the site, and Rifle, the largest town in the area, lies 12 mi to the northeast.

The Rulison test was conducted under the Plowshare Program to evaluate the feasibility of using a nuclear device to stimulate natural gas production in low-permeability gas-producing geologic formations. On September 10, 1969, a 40-kiloton nuclear device was detonated at a depth of

8,426 feet (ft) below ground surface (bgs) in the R-E test hole. After the test, the R-EX pre-test exploration hole, located 300 ft southeast of the test hole, was redrilled to test gas production in the stimulation zone. Natural gas production testing was conducted in 1970 and 1971. Four separate production tests were conducted and 455 million cubic feet (ft^3) of gas were produced. In 1971, the production test well was shut-in. The R-E and R-EX drill holes were plugged and abandoned in 1976. Detailed descriptions of the site deactivation and abandonment activities are presented in the *Rulison Site Cleanup Report* (AEC, 1973) and the *Project Rulison Well Plugging and Site Abandonment Final Report* (ERDA, 1977).

The *Preliminary Site Characterization Report, Rulison Site, Colorado* (IT, 1996) documented the history and clean-up activities completed to that date, and made recommendations for the future of the Rulison Site. The *Rulison Site Surface Closure Report* (DOE/NV, 1998) was completed in 1998 and summarizes the clean-up activities that resulted in surface closure of the site. The State of Colorado accepted the surface closure report with no surface restrictions (Johnston, 2003b). The *Annual Water Sampling and Analysis, Calendar Year 2002* (EPA, 2002) summarizes groundwater quality monitoring completed by the EPA. The site characterization work plan for the Rulison Site subsurface will be based on the approach described in *Modeling Approach for Evaluating Radionuclide Transport in Nuclear-Stimulated Gas Reservoirs* (Cooper and Chapman, 2001). Upon construction of a dual-phase (liquid and gas) numerical flow and transport model, production stress will be applied to the modeled system to simulate gas development immediately beyond the current drilling restriction. The results will be analyzed to determine if the current restrictions are sufficiently protective. The present document summarizes results from these previous documents and addresses the current and future status and land use of the Rulison Site.

According to the Life-Cycle Baseline Revision 5, subsurface characterization of the Rulison Site will begin in fiscal year (FY) 2005, and subsurface closure of the Rulison Site is scheduled for completion in FY 2011.

1.1 Organization of the Report

The Rulison Site Environmental Management End State Vision is organized into five sections. Since the current state and end state are the same for the Rulison Site, only one map is presented for each subsection.

Section 1.0 introduces the site, including a brief discussion of past, present, and future site missions. This section also briefly discusses site hazards, the extent of environmental contamination, past remediation work, and any planned future clean-up work.

Section 2.0 describes the regional context end state. This section examines physical and surface interface and human and ecological land use in the regional context. A map showing the current state and the end state is also included for each subsection.

Section 3.0 describes the site-specific end state. This section examines physical and surface interface and human and ecological land use for the site and immediately adjacent lands. Legal ownership and demographics are also presented, and each subsection includes a map showing the current state and the end state.

Section 4.0 discusses specific site hazards including the nature of each hazard, potential impacts on human health and the environment, and any hazard mitigation identified. This section includes a current site-wide hazard map in addition to a current state/end state map for each specific hazard. A conceptual site model (CSM) is also included in this section. This model shows the current state/end state for each hazard. The CSM is used to show the known and potential contaminant pathways, potential receptors, and barriers that have been put in place to minimize exposure to contamination.

Section 5.0 provides references used to develop the Rulison Site Environmental Management End State Vision.

Attachment A provides a report table detailing that there are no variances between the end state vision and current remediation plans for this site.

1.2 Site Mission

The Rulison Site was active from 1968 to 1976. The site is located on Battlement Mesa in southern Garfield County, Colorado, approximately 8 mi southeast of the town of Parachute, and 12 mi southwest of Rifle. The Rulison test was part of the Plowshare Program, which was designed to develop peaceful uses for nuclear explosives. One underground nuclear test was conducted at the Rulison Site to evaluate the feasibility of using a nuclear device to stimulate natural gas production in low-permeability gas-producing geologic formations. The Rulison test involved a 40-kiloton nuclear device, which was detonated at a depth of 8,426 ft bgs in the R-E

test hole. The R-EX pre-test exploration hole, located 300 ft southeast of the test hole, was redrilled after the detonation to test gas production in the stimulation zone. Four separate production tests were conducted and 455 million ft^3 of gas were produced. In 1971, the production test well was shut-in. Site clean-up activities were conducted from 1972 to 1976. By 1976, all natural gas production wells at the Rulison Site had been plugged and abandoned.

The Rulison Site is currently under private ownership; however, the U.S. Government has acquired mineral interest as part of the oil shale reserve, and there are currently no mining claims. The deed has historic agreement language recognizing the oil and gas leases owned by Austral Oil Company, Inc., but these leases expired in 1972.

Surface contaminants at the Rulison Site included petroleum hydrocarbons associated with a drilling mud pit and surface contamination associated with decontamination of drilling equipment and fallout from gas flaring. All surface radioactive contamination was cleaned up in 1976 by excavating contaminated soil and transporting it to an off-site location (IT, 1996). Surface petroleum hydrocarbons were addressed in 1995.

Based on the historic use of the site and characterization conducted at similar sites, the contaminants of concern (COCs) for the subsurface of the Rulison Site are expected to include radioactive fission products, plutonium, uranium, and tritium, with the gaseous radionuclides (tritium, carbon-14, and krypton-85) being the most mobile in the environment. The DOE will retain long-term stewardship of the subsurface at the Rulison Site due to the presence of residual contamination (DOE/NV, 1998). Table 1.1 shows the representative source term for the Rulison Site.

Table 1.1 Representative Source Term for the Rulison Site

Mean radionuclide inventory for 76 nuclear tests detonated below or within 328 ft of the water table in Areas 19 and 20 at the Nevada Test Site. Values are decay corrected to January 1, 1994 (Smith, 2001). Unclassified site-specific mass estimates for the Rulison test are substituted where available from Reynolds (1971) and Smith (1971).

Radionuclide	Isotope Symbol	Half life ($t_{1/2}$; year)	Estimated Inventory (Ci)[a]
Tritium	H-3	1.23E+01	1.0E+04[b]
Carbon-14	C-14	5.73E+03	2.2E+00[c]
Aluminum-26	Al-26	7.30E+05	1.18E-04
Chlorine-36	Cl-36	3.01E+05	2.82E+00
Argon-39	Ar-39	2.69E+02	2.43E+01
Potassium-40	K-40	1.28E+09	6.17E+00
Calcium-41	Ca-41	1.03E+05	2.16E+01
Nickel-59	Ni-59	7.60E+04	5.25E-01
Nickel-63	Ni-63	1.00E+02	5.54E+01
Krypton-85	Kr-85	1.07E+01	1.11E+03[b]
Strontium-90	Sr-90	2.91E+01	1.57E+04
Zirconium-93	Zr-93	1.50E+06	5.49E-01
Niobium-93m	Nb-93m	1.61E+01	9.99E+01
Niobium-94	Nb-94	2.00E+04	2.28E+00
Technetium-99	Tc-99	2.13E+05	4.04E+00
Paladium-107	Pd-107	6.50E+06	2.07E-02
Cadmium-113m	Cd-113m	1.41E+01	1.53E+01
Tin-121m	Sn-121m	5.50E+01	5.67E+01
Tin-126	Sn-126	1.00E+05	6.47E-01
Iodine-129	I-129	1.57E+07	1.24E-02
Cesium-135	Cs-135	2.30E+06	4.17E-01
Cesium-137	Cs-137	3.02E+01	1.99E+04
Samarium-151	Sm-151	9.00E+01	7.51E+02
Europium-150	Eu-150	3.60E+01	1.46E+01
Europium-152	Eu-152	1.35E+01	4.33E+02
Europium-154	Eu-154	8.59E+00	2.04E+02
Holmium-166m	Hm-166m	1.20E+03	5.89E-01
Thorium-232	Th-232	1.40E+10	7.68E-04
Uranium-232	U-232	7.00E+01	3.36E+00
Uranium-233	U-233	1.59E+05	2.25E+00
Uranium-234	U-234	2.46E+05	1.62E+00
Uranium-235	U-235	7.04E+08	2.18E-02
Uranium-236	U-236	2.34E+07	6.22E-02
Uranium-238	U-238	4.47E+09	2.88E-02
Neptunium-237	Np-237	2.14E+06	4.80E-01
Plutonium-238	Pu-238	8.77E+01	9.42E+01
Plutonium-239	Pu-239	2.41E+04	2.54E+02
Plutonium-240	Pu-240	6.56E+03	8.16E+01
Plutonium-241	Pu-241	1.44E+01	1.18E+03
Plutonium-242	Pu-242	3.75E+05	4.42E-02
Americium-241	Am-241	4.33E+02	6.14E+01
Americium-243	Am-243	7.37E+03	2.36E-03
Curium-244	Cm-244	1.81E+01	3.91E+01

[a]Except where noted, value is from the mean unclassified radionuclide inventory for 76 nuclear tests detonated below or within 328 ft of the water table in Areas 19 and 20 of the Nevada Test Site.
[b]Value is an unclassified estimate for the Rulison test specifically, from Reynolds (1971).
[c]Value is an unclassified estimate for the Rulison test specifically, and is the total of gaseous species only, from Smith (1971).

1.3 Status of Clean-up Program

During the clean-up efforts at the Rulison Site, the device emplacement well and the drilling mud pits that were used to drill test wells were removed; however, some drilling fluids were left in a containment pond. The pond was left in place at the request of the landowner. Site characterization studies identified total petroleum hydrocarbons (TPH), benzene, ethylbenzene, toluene, xylenes, barium, chromium, and lead in the residual drilling mud left in the bottom of the containment pond (DOE/NV, 1998). Contaminated mud and pond sediment were excavated and removed to an off-site landfill. Closure of the pond and investigation of the surface ground zero (SGZ) were completed in 1995. The *Rulison Site Surface Closure Report* (DOE/NV, 1998) summarizes the clean-up activities that resulted in surface closure of the site. The State of Colorado accepted the surface closure plan with no surface restrictions (Johnston, 2003b). Therefore, the surface of the Rulison Site has achieved the end state.

A monument has been placed at the Rulison Site SGZ to mark the test cavity (Johnston, 2003a). An assessment of the contamination potential to area aquifers was conducted in 1996. The results of the assessment indicated that radionuclides posed little threat to the aquifers (Earman et al., 1996). Seven groundwater-monitoring wells installed to monitor the potential migration of contaminants from the pond into the shallow groundwater were abandoned in 2001. The EPA monitors water quality in wells and springs in the vicinity of the Rulison Site on an annual basis as part of the Long-Term Hydrologic Monitoring Program (LTHMP) (EPA, 2002). The DOE/NSO has not completed characterization of the subsurface at the site, but does not plan to remove subsurface contamination in or around the test cavity due to the lack of feasible remediation technology. The DOE/NSO will develop subsurface models to define contaminant boundaries and refine the existing subsurface intrusion restrictions, if necessary. According to the Life-Cycle Baseline Revision 5, subsurface characterization of the Rulison Site will begin in FY 2005, and subsurface closure of the site is scheduled for completion in FY 2011. Post-closure monitoring will be conducted as agreed upon in the site closure report for the subsurface. The DOE/NSO assumes monitoring will be performed for 100 years (2011 to 2111) (DOE/EM, 2001).

The DOE/NSO assumes that current land use designations and subsurface intrusion restrictions will continue into the foreseeable future. However, the DOE/NSO will reevaluate and modify subsurface restrictions, as appropriate, as part of the assessment and/or corrective action activities (DOE/EM, 2001).

2.0 Regional Context End State Description

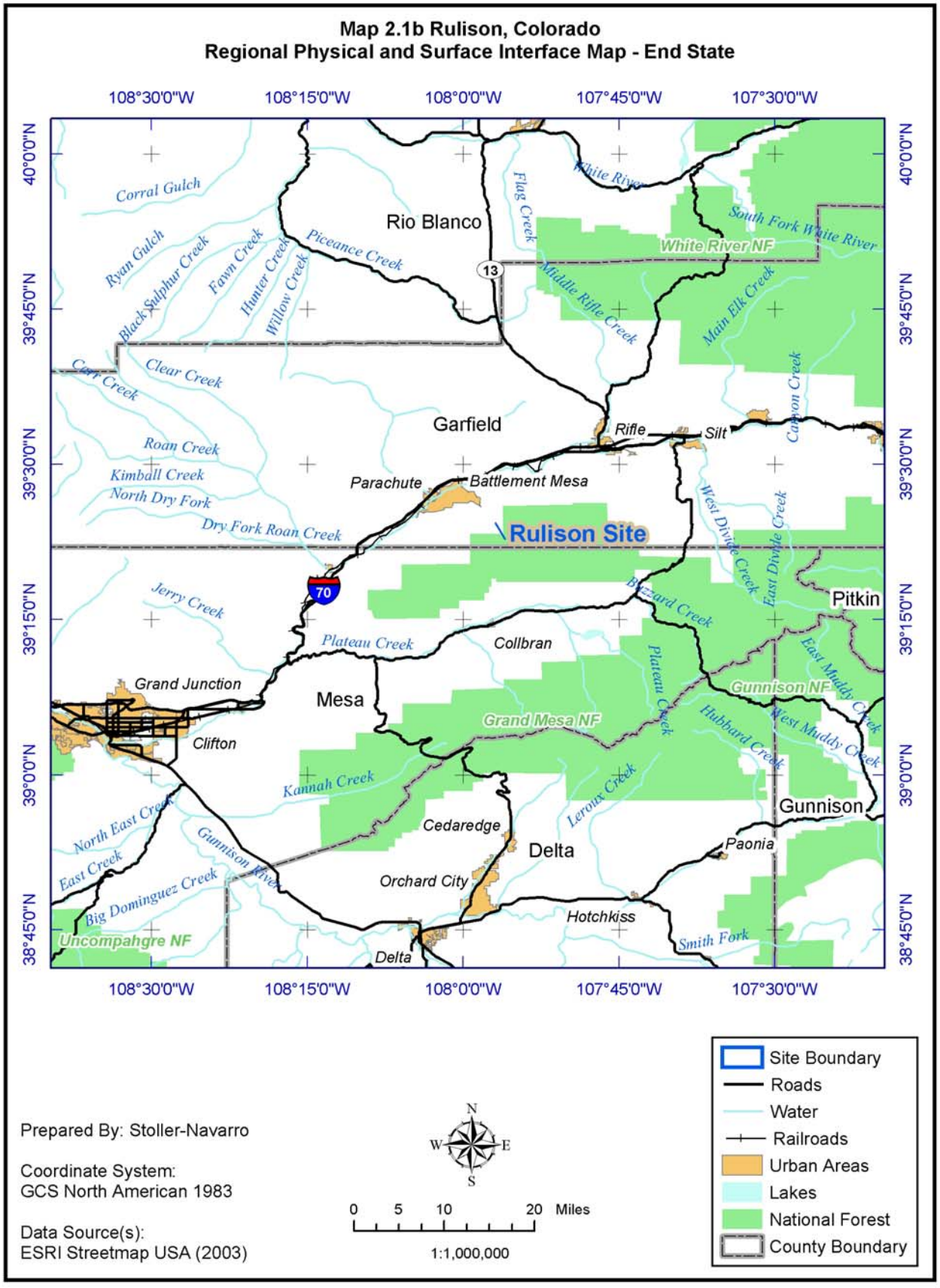
This section examines physical and surface interface and human and ecological land use in the regional context. This section also provides a discussion of current and planned future land use for the region surrounding the Rulison Site.

2.1 Regional Physical and Surface Interface

The Rulison Site is on the north slope of Battlement Mesa in southern Garfield County (Map 2.1b). The Colorado River Valley lies 8 mi north of the site. South of the site, the upper elevations of Battlement Mesa rise to over 10,000 ft. The east fork of Battlement Creek flows through the northern part of the site and discharges into the Colorado River. This region lies in a transition area between the glaciated high peaks of central Colorado and the arid canyon country of western Colorado. As such, the Battlement Mesa area contains characteristics of both regions.

Battlement Mesa is a basalt-capped highland that lies in the southern part of the Piceance Basin in northwestern Colorado. The Piceance Basin has produced oil and natural gas, coal-bed methane, and coal from the Tertiary Wasatch and Mesaverde Formations. The Piceance Creek structural basin is a large northwest-trending downwarp underlying northwestern Colorado. The Rulison Site is on the southwest limb of this basin such that beds penetrated by site boreholes dip gently northeastward. The basin contains about 27,000 ft of sedimentary rock. The Mancos Formation contains pro-deltaic marine mudstones and underlies the nuclear test horizon (Figure 2.0). The Rulison test was conducted in the Mesaverde Group, which is approximately 2,500 ft thick at the site. The Mesaverde Group is predominantly non-marine and consists of sandstone, shale, and coal deposited during the eastward advance of a large deltaic and coastal plain complex into a retreating sea. As a result, sandstone occurs in discontinuous lenses, many of which only extend for distances of a few thousand feet, interbedded with shale.

Above the Mesaverde Group is the Ohio Creek Formation. It is relatively thin in the area of the Rulison Site (37 to 76 ft thick) and is comprised of conglomerates, sandstones, and siltstones. Above this is an approximately 500-ft thick unnamed Paleocene-age formation between the Ohio Creek and Wasatch Formations. The Wasatch Formation (3,900 ft thick at the Rulison Site) contains clay, shale, and sandstone, with local occurrences of conglomerate, limestone, coal, and carbonaceous shale. Overlying the Wasatch is the Green River Formation, which is about 1,700 ft thick at the Rulison Site and is comprised of shale and marlstone, with minor amounts of sandstone, siltstone, and limestone. The Green River Formation is the primary formation of


Map 2.1b Rulison, Colorado
Regional Physical and Surface Interface Map - End State
108°30'0"W
108°15'0"W
108°0'0"W
107°45'0"W
107°30'0"W
40°0'0"N
39°45'0"N
39°30'0"N
39°15'0"N
39°0'0"N
38°45'0"N
Rio Blanco
Garfield
Mesa
Delta
Gunnison
Pitkin
Rulison Site
Parachute
Battlement Mesa
Rifle
Silt
Collbran
Grand Junction
Clifton
Cedaredge
Orchard City
Paonia
Hotchkiss
Delta
Corral Gulch
Ryan Gulch
Black Sulphur Creek
Fawn Creek
Hunter Creek
Willow Creek
Piceance Creek
Flag Creek
White River
Middle Rifle Creek
Main Elk Creek
South Fork White River
Canyon Creek
Clear Creek
Carr Creek
Roan Creek
Kimball Creek
North Dry Fork
Dry Fork Roan Creek
Jerry Creek
Plateau Creek
Kannah Creek
North East Creek
East Creek
Big Dominguez Creek
Gunnison River
Smith Fork
Leroux Creek
Hubbard Creek
West Muddy Creek
East Muddy Creek
Blizzard Creek
West Divide Creek
East Divide Creek
White River NF
Gunnison NF
Grand Mesa NF
Uncompahgre NF
13
70
Site Boundary
Roads
Water
Railroads
Urban Areas
Lakes
National Forest
County Boundary
Prepared By: Stoller-Navarro
Coordinate System:
GCS North American 1983
Data Source(s):
ESRI Streetmap USA (2003)
N
W
E
S
0 5 10 20 Miles
1:1,000,000

interest for oil shale development in the region. Quaternary-age deposits of alluvium, mudflows, talus accumulations, and fan and pediment gravels top the geologic section.

Though the groundwater resources in the Piceance Basin are described as relatively large, yields are often sustained for only short periods and water quality can be marginal. As a result, alluvium is the source of groundwater in most stream valleys. Aquifers in the area of the Rulison Site are generally limited to alluvium and terrace deposits because the underlying formations are typically impermeable and produce little, if any, water. Water in the Mesaverde Group may be immobile. An inventory of wells and springs at the time of the Rulison test indicated only one well in the surrounding area that produced water from bedrock. This well is reported to be 764 ft deep, completed in the Green River Formation. Testing in Well R-EX indicated that no water was produced from any formation, though the investigation primarily focused on depths below 6,000 ft.

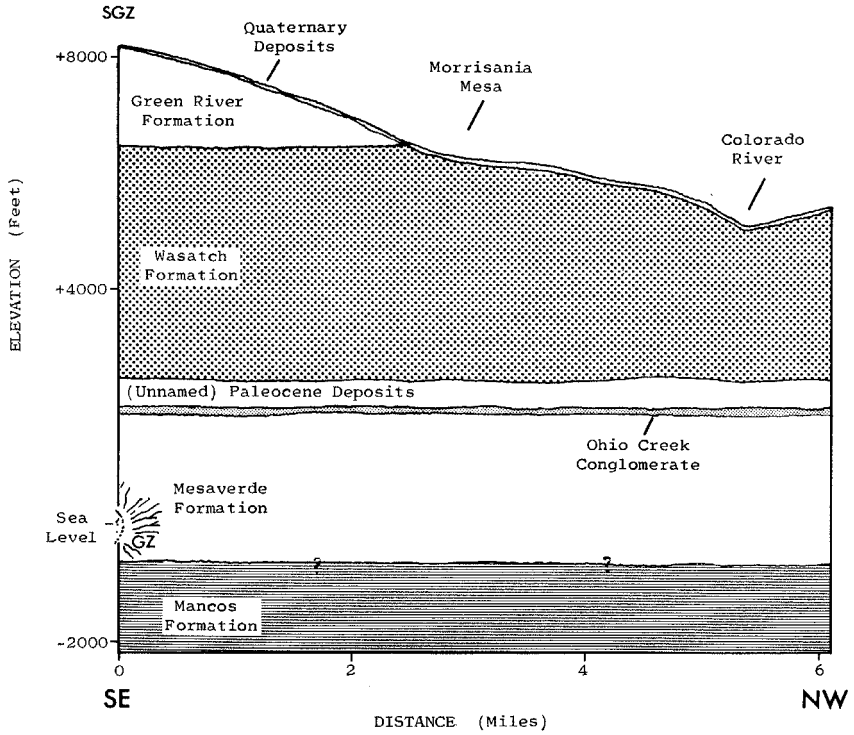


Figure 2.0

Diagrammatic Cross Section of the Rulison Site Along the Trend of Battlement Creek

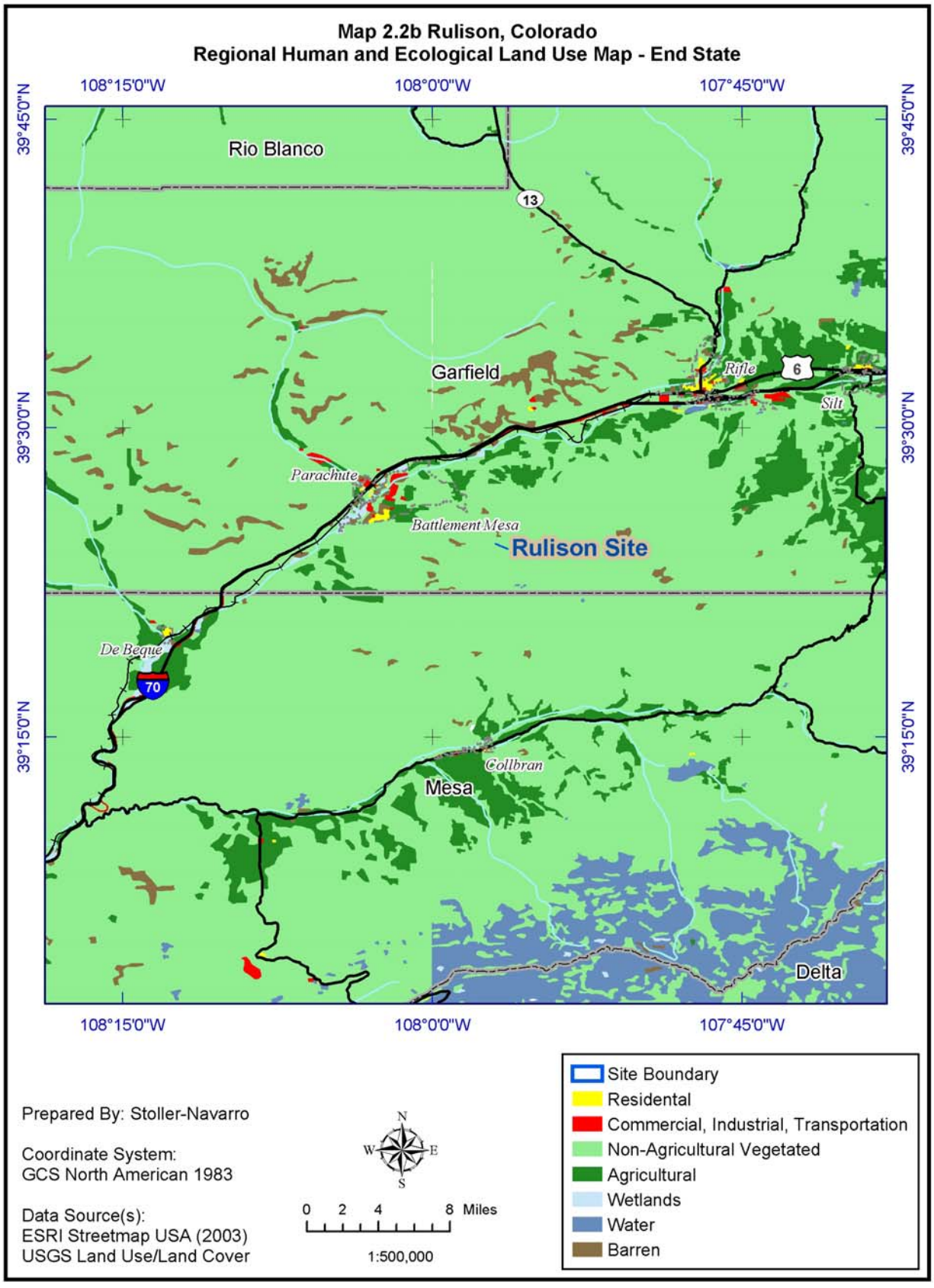
2.2 Human and Ecological Land Use

Human Land Use

Most of the land surrounding the Rulison Site is privately owned. The U.S. Department of the Interior, Bureau of Land Management (BLM) administers control over much of the federal land on Battlement Mesa, but higher elevations of the mesa are within the Grand Mesa National Forest, which is administered by the U. S. Department of Agriculture, Forest Service (USDA/FS). The Battlement Mesa region has been used for recreational purposes such as hunting and fishing, and for commercial purposes such as oil and gas production, grazing, and logging (Map 2.2b). Two natural gas production wells (Federal 28-95 and Federal 14-95) are located 2.7 mi from the Rulison Site SGZ; however, both are currently shut-in.

In recent years, the population of the Colorado River Valley has increased dramatically. The towns of Rifle and Parachute have expanded by as much as 40 percent in the past decade and a retirement community has been built on the lower slopes of Battlement Mesa. The encroaching development of summer homes and retirement residences in the region around the site can be expected to continue.

The small town of Parachute lies 8 mi northwest of the Rulison Site, and the larger town of Rifle lies 12 mi northeast. Grand Junction is the largest metropolitan area in the western half of Colorado, and it lies approximately 40 mi southwest of the site. The next largest community in the region is Glenwood Springs, approximately 35 mi east-northeast of the site.


Map 2.2b Rulison, Colorado
Regional Human and Ecological Land Use Map - End State
108°15'0"W
108°0'0"W
107°45'0"W
39°45'0"N
39°30'0"N
39°15'0"N
Rio Blanco
13
Garfield
Rifle
6
Silt
Parachute
Battlement Mesa
Rulison Site
De Beque
70
Collbran
Mesa
Delta
Prepared By: Stoller-Navarro
Coordinate System:
GCS North American 1983
Data Source(s):
ESRI Streetmap USA (2003)
USGS Land Use/Land Cover
N
W
E
S
0 2 4 8 Miles
1:500,000
Site Boundary
Residental
Commercial, Industrial, Transportation
Non-Agricultural Vegetated
Agricultural
Wetlands
Water
Barren

The future roles and responsibilities of the DOE, landowners, and other federal and state agencies are documented in Table 2.1 (Johnston, 2003b).

Table 2.1
DOE/NSO Land Status

Landlord	Surface Steward	Subsurface Steward	Withdrawal Order/Law	Specific Restriction Record	Oil/Gas Owner and Leases	Water Well Permits	Mineral Rights	Grazing Rights
Private Owner	Private Owner	**Current:** BLM and Colorado Oil and Gas Conservation Commission **Future:** DOE/Office of Legacy Management	**Surface:** General Land Office Order **Subsurface:** General Land Office Order	Glenwood Springs Resource Area Resource Management Plan and On-Site Plaque	Private Owner No Leases	Private Owner and DOE/NSO	U.S. Government	Private

As part of the LTHMP, the EPA regularly samples water from the Grand Valley municipal drinking water supply springs, water supply wells from five local ranches, and two sites in the vicinity of SGZ, including one test well and two surface discharge springs. No radioactive materials attributable to the Rulison test were detected in the samples collected in off-site areas between 2000 and 2002 (EPA, 2002).

Ecological Land Use

The area around the Rulison Site receives approximately 20 inches of rainfall per year and supports a variety of plants and animals. Forests, meadows, wetlands developed around beaver ponds, perennial streams, and creeks characterize the slopes of Battlement Mesa. The lower elevations support a community of sage, cedar, gambol oak, and mountain mahogany, which yields to firs, pines, and aspens in the higher elevations. The region supports deer, coyotes, raccoons, beavers, rabbits, chipmunks, marmots, and ground squirrels. A thriving bird community in the area includes eagles, doves, ravens, swallows, wrens, warblers, thrushes, sparrows, sandpipers, hummingbirds, robins, flickers, and sapsuckers. The flora and fauna currently found in the region surrounding the site are anticipated to continue as the species in the region for the foreseeable future (IT, 1996).

3.0 Site-Specific End State Description

This section examines physical and surface interface and human and ecological land use in the site-specific context. This section also provides a discussion of current and planned future land use for the site, legal ownership of the site and immediately adjacent lands, and demographics for the area.

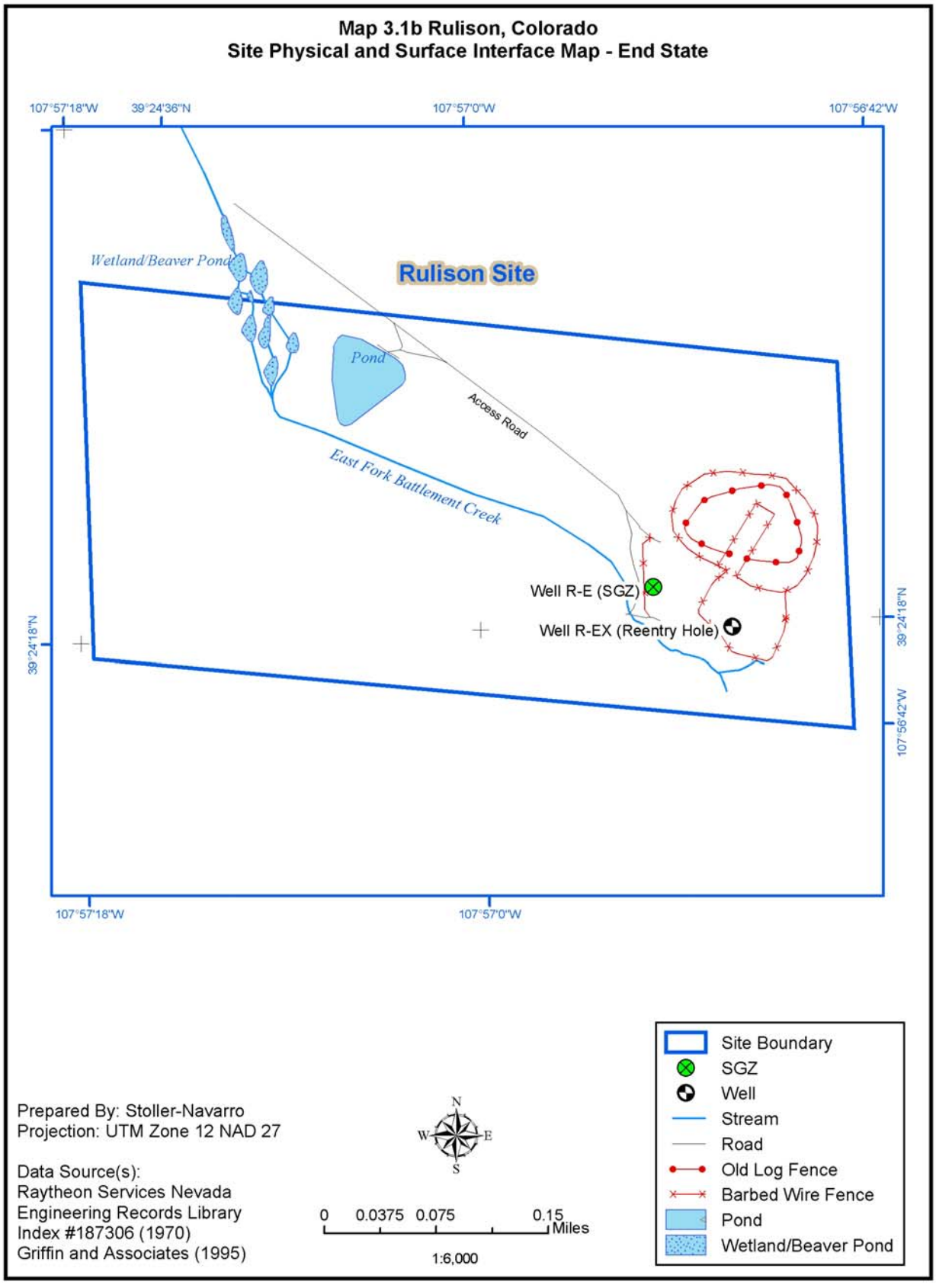
3.1 Physical and Surface Interface

The Rulison Site (Map 3.1b) is on the north slope of Battlement Mesa in upper Battlement Creek, at an elevation of 8,200 ft. The site encompasses the locations of the drilling mud pit and overflow pond, the emplacement drill hole, and the reentry drill hole. Both drill holes have been plugged and abandoned, and the mud pits have been reclaimed. The Rulison Site has received closure for surface contamination, and no further remediation is required (DOE/NV, 1998). The land surface of the Rulison Site is in its final end state.

Analysis of the potential for contamination of the aquifer in the area of the Rulison Site concluded that radionuclides from the Rulison test are totally contained within the Mesaverde Formation and pose no threat to groundwater supplies (Earman et al., 1996). The Rulison test device was placed at the base of the Mesa Verde Formation, at a depth of 8,426 ft bgs. Overlying the Mesa Verde Formation are the Fort Union, Wasatch, and Green River Formations. The Green River Formation crops out at the surface of the site and contains the shallow aquifers used by local water supply wells. Available data suggest that there is no hydraulic communication between water-saturated horizons in the Mesa Verde Formation and the aquifers in the Green River Formation (IT, 1996).

Subsurface contamination is being addressed by implementing an end state approach based on defining a contaminant boundary at the Rulison Site and monitoring subsurface resource development to ensure that gaseous radionuclides do not migrate past the contaminant boundary. The contaminant boundary will be defined on the basis of modeling the maximum extent to which gaseous radionuclides could migrate over 1,000 years. Drilling and subsurface resource extraction within the contaminant boundary will be prohibited, and resource (natural gas) production may also be limited for some region outside the boundary. This approach will be protective because, though it is not technologically feasible to remediate the contamination associated with an underground nuclear test, the use (withdrawal) of and exposure to contaminated natural gas will be precluded by implementation of institutional controls restricting

the drilling of wells within the boundary. Resource development patterns in the area will be monitored to assess whether the boundary remains protective if resource extraction characteristics change through time, and samples of natural gas from nearby wells may be monitored for radionuclides. If radionuclides are ever found in nearby production wells, the dual-phase radionuclide model will be re-evaluated to determine if the drilling restriction area and associated institutional controls need to be changed.


Map 3.1b Rulison, Colorado
Site Physical and Surface Interface Map - End State
107°57'18"W
39°24'36"N
107°57'0"W
107°56'42"W
Wetland/Beaver Pond
Rulison Site
Pond
Access Road
East Fork Battlement Creek
Well R-E (SGZ)
Well R-EX (Reentry Hole)
39°24'18"N
39°24'18"N
107°56'42"W
107°57'18"W
107°57'0"W
Site Boundary
SGZ
Well
Stream
Road
Old Log Fence
Barbed Wire Fence
Pond
Wetland/Beaver Pond
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
Raytheon Services Nevada
Engineering Records Library
Index #187306 (1970)
Griffin and Associates (1995)
N
W
E
S
0 0.0375 0.075 0.15 Miles
1:6,000

3.2 Human and Ecological Land Use

Human Land Use

The Rulison Site is privately owned land surrounded by private land to the west, south, and east, and by BLM land to the north (Map 3.2b). A summer residence is located on the site, approximately 1,400 ft from the former drilling fluid overflow pond, which has subsequently been converted into a fishpond. The site is used for livestock grazing and for recreation, including fishing. There are currently no mining claims and no oil and gas leases on the site. Future use of the site is anticipated to remain the same (IT, 1996).

Subsurface use restrictions at the Rulison Site will remain in place in perpetuity. These restrictions, shown in Map 3.2b, are described on the permanent monument located at the SGZ on site. The restrictions are as follows:

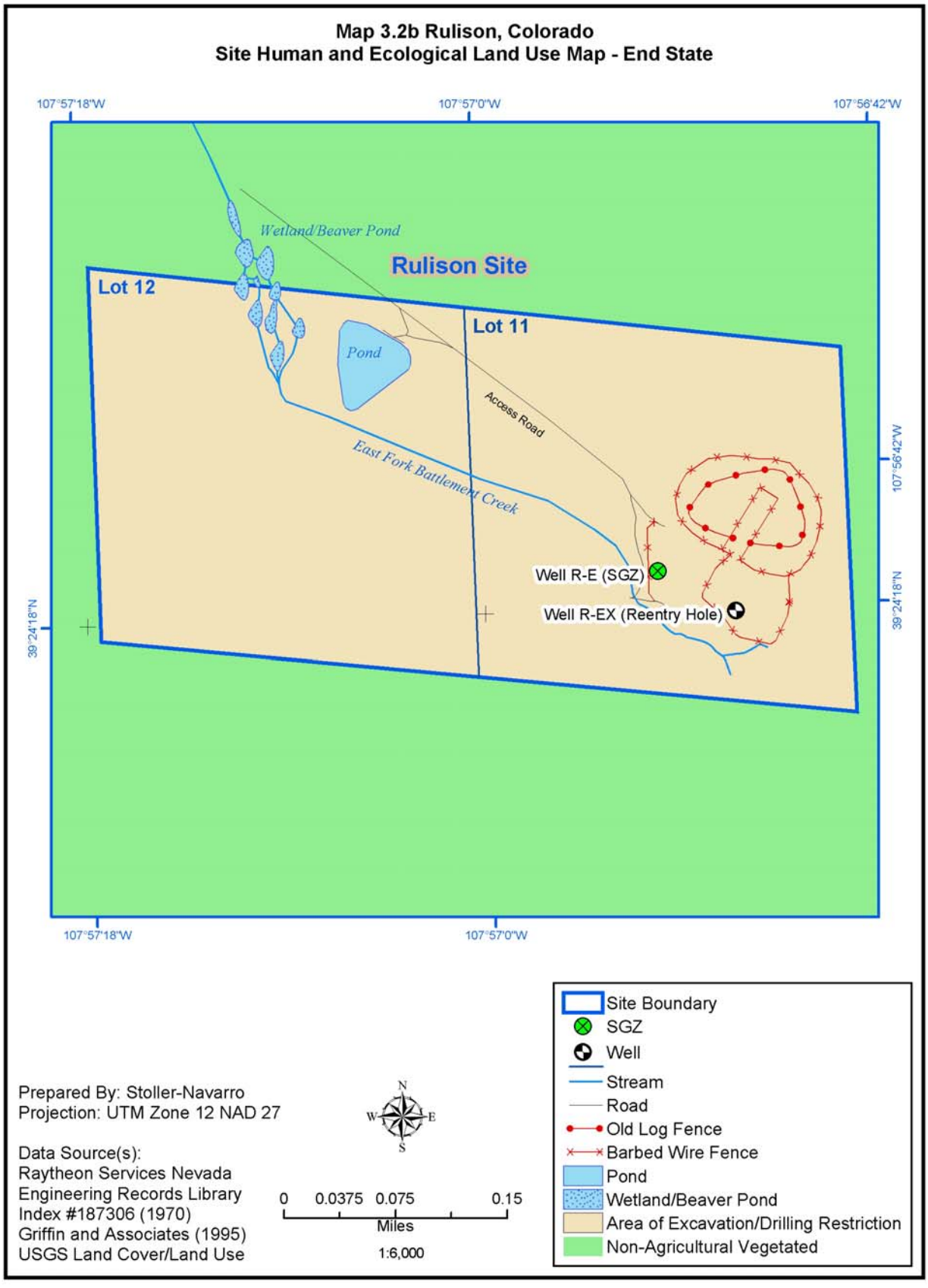
> "No excavation, drilling, and/or removal of subsurface materials to a depth of 12,450 ft is permitted within Lot 11, NE ¼ SW ¼ of Section 25, Township 7 South, Range 95 West, 6th Principal Meridian, Garfield County, Colorado, without U.S. Government permission. U.S. Atomic Energy Commission and the Department of the Interior" (Johnston, 2003a).

In addition to the restrictions placed within Lot 11, an arbitrary 3-mi limit for oil and gas drilling has been established by the State and BLM as referenced in the *Glenwood Springs Resource Area, Oil and Gas Leasing and Development Record of Decision and Resource Management Plan Amendment* (DOI, 1999). This 3-mi area is not a limitation; it is the zone within which any wells will be subjected to oversight measures established by the Colorado Oil and Gas Conservation Commission and review by the DOE for inclusion in a monitoring program. An actual risk-based restriction cannot be determined before completion of the subsurface characterization.

The DOE/NSO has developed a public participation plan for the Rulison Site RBES Vision. The plan provides a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that are submitted to the DOE/NSO will receive comment resolution.

Ecological Land Use

Clean-up activities associated with abandonment of the Rulison Site resulted in the regrading and reclamation of the mud pit, and conversion of the drilling mud pond into a spring-fed fishpond. The access roads have been maintained for use by the private landowners, but native grasses and trees have reestablished themselves over most of the rest of the site. The area now contains forests of spruce, pine, and aspen, meadows of native grasses, willows, and alder, and a beaver pond wetland. No threatened or endangered species are known to exist at the Rulison Site.

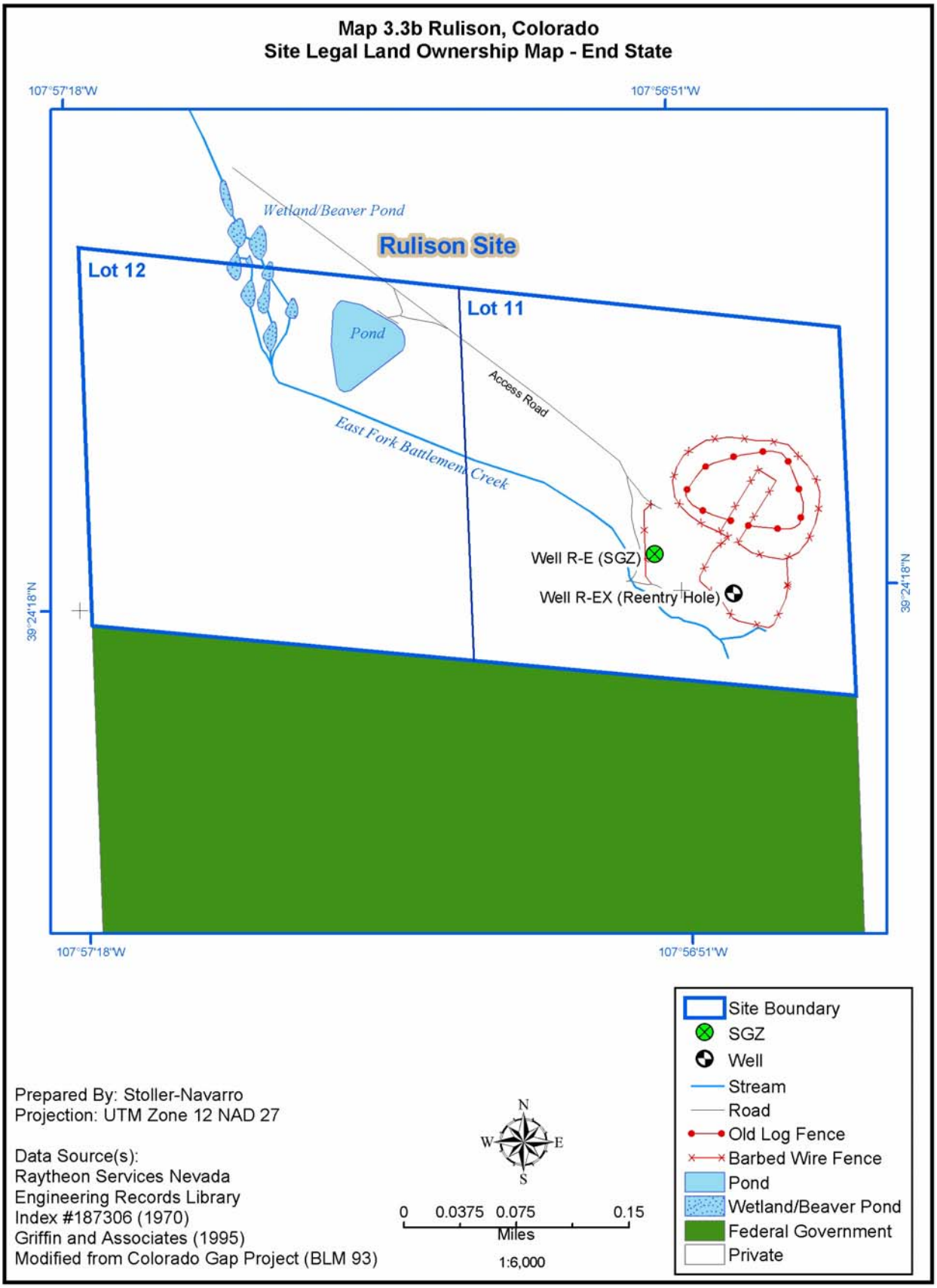

Map 3.2b Rulison, Colorado
Site Human and Ecological Land Use Map - End State
107°57'18"W
107°57'0"W
107°56'42"W
39°24'18"N
Wetland/Beaver Pond
Rulison Site
Lot 12
Lot 11
Pond
Access Road
East Fork Battlement Creek
Well R-E (SGZ)
Well R-EX (Reentry Hole)
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
Raytheon Services Nevada
Engineering Records Library
Index #187306 (1970)
Griffin and Associates (1995)
USGS Land Cover/Land Use
N
W
E
S
0 0.0375 0.075 0.15
Miles
1:6,000
Site Boundary
SGZ
Well
Stream
Road
Old Log Fence
Barbed Wire Fence
Pond
Wetland/Beaver Pond
Area of Excavation/Drilling Restriction
Non-Agricultural Vegetated

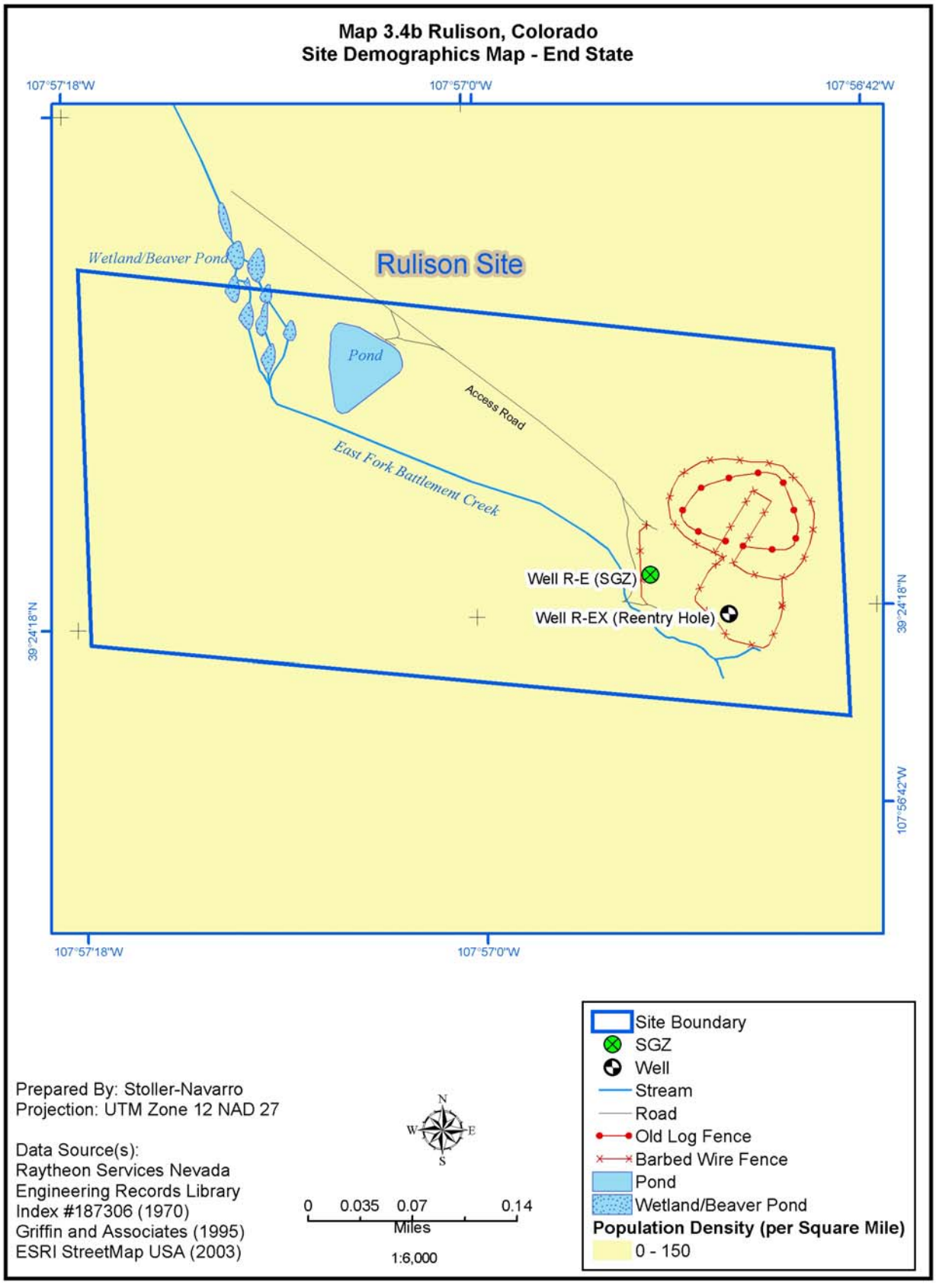
3.3 Site Context Legal Ownership

The Rulison Site is composed of Lots #11 and #12 in the north half of the south quarter of Section 25, Township 7 South, Range 95 West of the 6th Principal Meridian, Garfield County, Colorado (Map 3.3b). Both lots are privately owned, with Lot #11 belonging to Cary E. Weldon and Marcia and Wesley Kent, and Lot #12 belonging to Craig Hayward and Christy Hayward-Koeneke. Warranty Deed No. 463 states that all water, water rights, and ditch rights belong to Hayward. No subsurface restrictions are noted in the deed. Warranty Deed No. 463 applies to Lot #12, where there is no known risk. The mineral rights are owned by the U.S. Government and the entirety of Section 25 is withdrawn under General Land Office Order (June 3, 1919), Classification as Mineral Lands, so there are no mining claims in the section. The oil and gas lease owned by Austral Oil Company Inc. expired in 1972. There are current oil and gas leases on lots adjacent to the Rulison Site; however, no current drilling activity is associated with these leases (Johnston, 2003b). The BLM Glenwood Springs Resource Area Management Plan Amendment states, "Any wells located within three miles of Rulison will be subject to oversight measures established by the Colorado Oil and Gas Conservation Commission." The DOE has a Right of Entry Permit that has been signed by the landowners to access monitoring wells at the Rulison Site.

3.4 Site Context Demographics

The Rulison Site is in the southern part of Garfield County, in northwestern Colorado. The population of Garfield County, shown in Map 3.4b, was 43,791 in the 2000 census, which represented a 46 percent increase from 1990. Parachute, which lies 8 mi northwest of the Rulison Site, has a population of 1,006, and the population of Rifle, 12 mi to the northeast, is 6,784 (U.S. Census Bureau, 2000). Approximately 60 percent of the land in Garfield County is federally owned and administered by the BLM and USDA/FS. Farming, ranching, oil and gas production, and tourism dominate the local economy. The Rulison Site lies on Battlement Mesa, a region that has seen increasing real estate development for second homes and retirement homes. Because this area lies within the I-70 transportation corridor, this population growth trend is likely to continue in the future.


Map 3.3b Rulison, Colorado
Site Legal Land Ownership Map - End State
107°57'18"W
107°56'51"W
39°24'18"N
Wetland/Beaver Pond
Rulison Site
Lot 12
Lot 11
Pond
Access Road
East Fork Battlement Creek
Well R-E (SGZ)
Well R-EX (Reentry Hole)
Site Boundary
SGZ
Well
Stream
Road
Old Log Fence
Barbed Wire Fence
Pond
Wetland/Beaver Pond
Federal Government
Private
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
Raytheon Services Nevada
Engineering Records Library
Index #187306 (1970)
Griffin and Associates (1995)
Modified from Colorado Gap Project (BLM 93)
N
W
E
S
0 0.0375 0.075 0.15
Miles
1:6,000


Map 3.4b Rulison, Colorado
Site Demographics Map - End State
107°57'18"W
107°57'0"W
107°56'42"W
39°24'18"N
Wetland/Beaver Pond
Rulison Site
Pond
Access Road
East Fork Battlement Creek
Well R-E (SGZ)
Well R-EX (Reentry Hole)
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
Raytheon Services Nevada
Engineering Records Library
Index #187306 (1970)
Griffin and Associates (1995)
ESRI StreetMap USA (2003)
N
W
E
S
0 0.035 0.07 0.14
Miles
1:6,000
Site Boundary
SGZ
Well
Stream
Road
Old Log Fence
Barbed Wire Fence
Pond
Wetland/Beaver Pond
Population Density (per Square Mile)
0 - 150

4.0 Hazard Specific Discussion

Cleanup associated with the original deactivation of the Rulison Site in 1972 included removing all equipment and materials not needed for potential future gas production activities, excavating and removing radioactively contaminated soil, and characterizing the site's radiological condition by extensive soil sampling. Cleanup associated with abandonment of the Rulison Site in 1976 included removing all equipment and materials, plugging and abandoning emplacement and reentry wells, backfilling mud pits, and removing soil contaminated with tritium (IT, 1996).

A human health risk assessment was completed for the Rulison Site in FY 1996. The risk assessment evaluated materials that, if left in place, would require monitoring. Subsequent cleanup left the site in a state that poses no threat to human health or the environment (DOE/NV, 1998). The State of Colorado approved the surface closure with no restrictions and no further actions required (DOE/NV, 2000). The surface of the Rulison Site is in the end state.

The Rulison Site subsurface has not yet been characterized; however, natural gas is assumed to be the main contaminant migration pathway. Most contamination is believed to be isolated near the test cavity, approximately 8,400 ft bgs. Ongoing monitoring has confirmed that testing has not caused an increase in site radioactivity levels in surface or groundwater (DOE/NV, 2000). Subsurface intrusion restrictions are in place and will continue into the foreseeable future. The original shaft (R-E), and the reentry borehole (R-EX) were plugged and abandoned. Table 4.1 summarizes the hazards and risks associated with the site (DOE/NV, 2000). Restrictions are in place to prevent access to the test cavity, groundwater, and natural gas (DOE/NV, 2000).

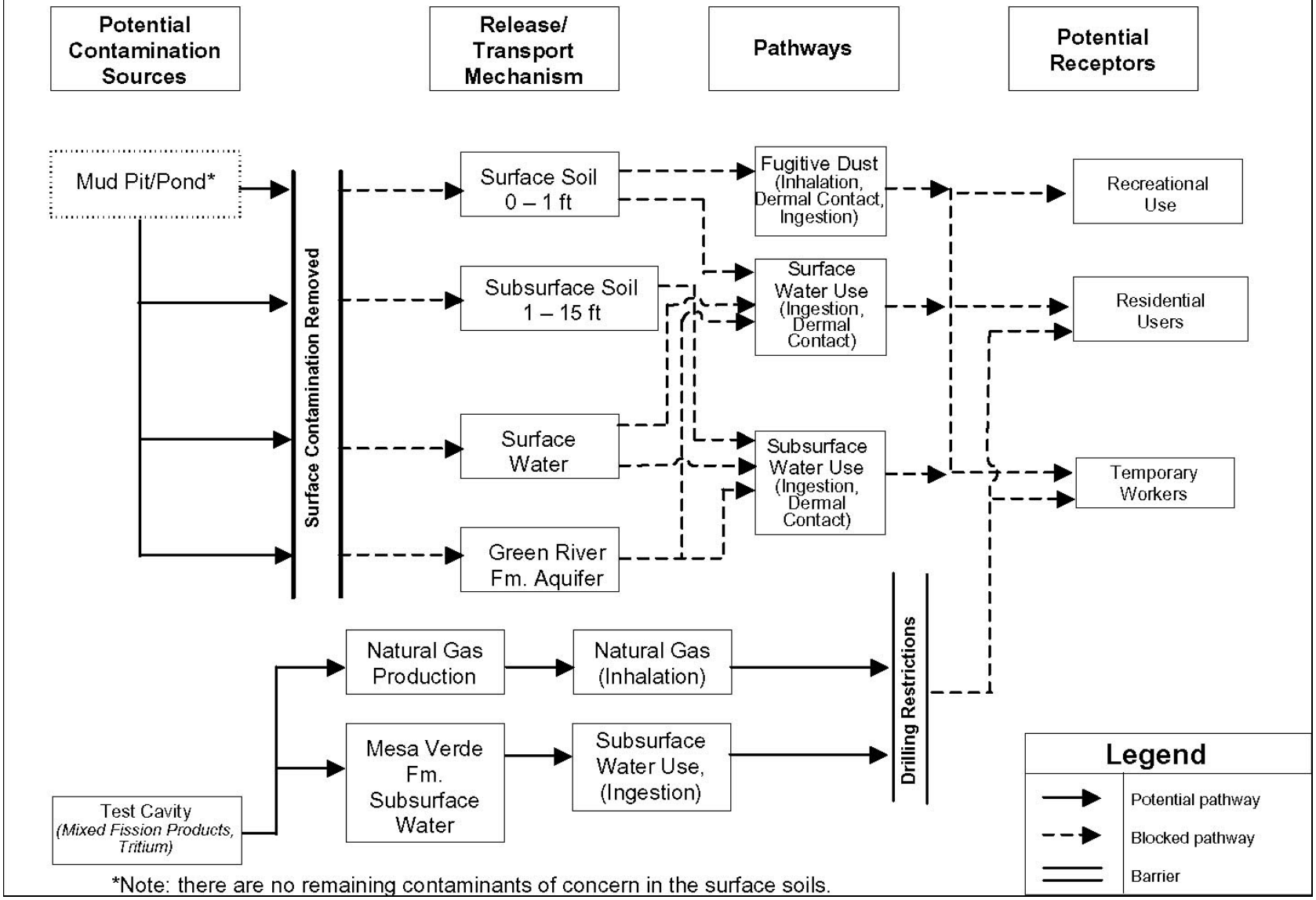
A CSM for the site is provided in Figure 4.0. The CSM illustrates the relationship between the identified potential sources of contamination, the mechanisms for release and migration away from the potential source, the pathways the contamination would follow once released, the exposure routes by which potential contamination would affect receptors, and the receptors that would be impacted by potential contamination.

Based on the results from the *Preliminary Site Characterization Report, Rulison Site, Colorado* (IT, 1996), additional clean-up activities and monitoring were completed in 1998. No surface source areas remain at the Rulison Site and the surface is in its end state. Descriptions of the subsurface hazard area and the surface area that received closure are provided in the following sections.

Table 4.1
Rulison Site Hazards and Risks

Material Category	Nature of Hazard	Nature of Potential Risk	Status of Current Management	Planned Risk Reduction Control	Anticipated Risk Reduction Progress	End-State Disposition and Risk
Deep (>8,000 ft bgs) natural gas, groundwater and test cavity	Groundwater and natural gas in the immediate vicinity of the test cavity are contaminated with radionuclides. Migratory potential of the contaminants via natural gas from the test cavity is being modeled. Additional subsurface characterization will be used for model refinement and validation.	Migratory potential of radionuclides in natural gas and groundwater is minimal. Existing monitoring data from surrounding wells have not indicated radionuclide contamination. If contaminant migration is verified, the most probable exposure scenarios would be via inhalation of, ingestion of, and dermal contact with natural gas.	Site subsurface characterization and groundwater modeling activities are ongoing. Natural gas modeling activities are ongoing. Site subsurface access is restricted.	Subsurface restrictions and institutional controls are in place and maintained. The subsurface risk-based compliance boundary will be refined based on subsurface modeling results. A refined long-term monitoring program will be implemented, if required and if technically feasible.	Currently, there is no feasible or cost effective corrective action technology to address test cavities and associated subsurface contamination that will prevent risk.	Subsurface restrictions and institutional controls will be maintained and long-term hydrologic monitoring will be implemented, based on the groundwater and natural gas modeling results.
Surface soil	TPH-contaminated material from the mud pits has been excavated and removed.	None	The site surface is in its end state. The site surface has been closed with regulatory agency approval.	None	None	Surface institutional controls are no longer required.

Figure 4.0 - Rulison Site Conceptual Site Model - Current State and End State



4.1 Surface Source Area 1

The Rulison Site sampling identified TPH, benzene, ethyl benzene, toluene, total xylenes, barium, chromium, and lead in the residual drilling mud left in the bottom of the containment pond. Contaminated mud, pond sediment, and soil from a location adjacent to the pond were excavated and removed to an off-site landfill. Subsequent sampling revealed no further contaminated soil in or around the pond. Closure of the pond and investigation of the SGZ area were completed in 1995 (DOE/NV, 1996). Seven groundwater-monitoring wells were installed to monitor the potential migration of contaminants from the pond into the shallow groundwater. These monitoring wells were abandoned in 2001.

The EPA monitors water quality in wells and springs in the vicinity of the Rulison Site on an annual basis. No radioactive contamination associated with the Rulison test has been detected in samples taken from the Grand Valley municipal drinking water system, water supply wells from five local ranches, and a spring and three wells on the test site (EPA, 2002).

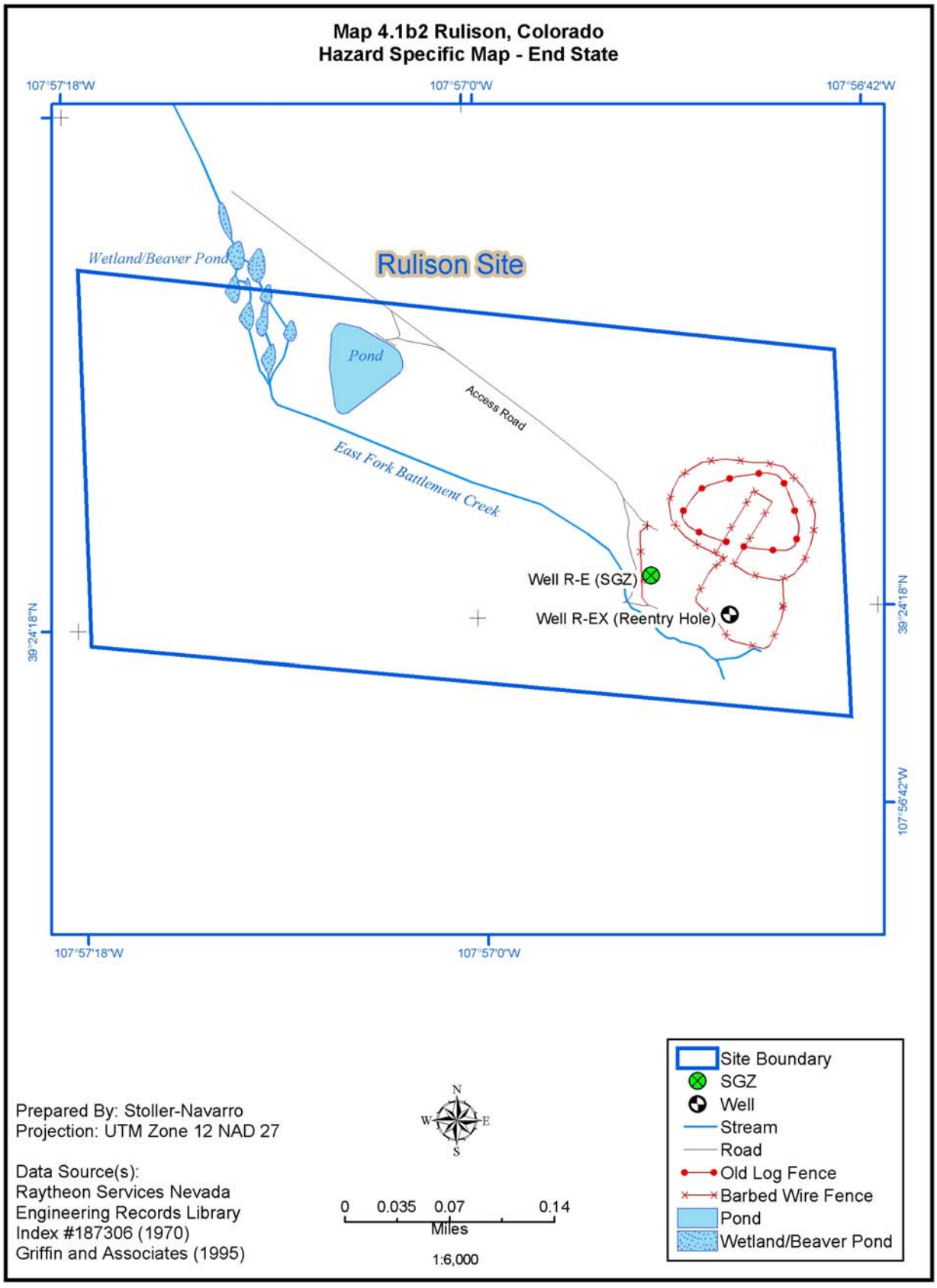
4.2 Subsurface Source Area 1

The Rulison Site contains a plugged emplacement hole and a plugged re-entry test hole. The nuclear device was placed in low permeability sandstone at a depth of 8,426 ft bgs. Emplacement was accomplished by drilling a vertical hole to a depth of 8,426 ft, lowering the device down hole, and plugging the hole to the surface. The test created an underground cavity that immediately collapsed to form a breccia-filled chimney, but this chimney did not reach the surface. The pre-test exploration hole was re-drilled into the test cavity for gas production tests. During subsurface nuclear testing, a number of fission by-products and other materials were released into the area immediately adjacent to the point of detonation. The radioactive by-products generated include original radioactive material that did not undergo fission, fission products, and activation products produced by the high neutron flux. Other materials that may have been released include lead from shielding material, synthetic materials used in control cables, and materials used in the emplacement borehole.

Clean-up associated with subsurface contamination included removing all equipment and materials and plugging and abandoning the emplacement and reentry wells (Map 4.1b2). The DOE/NSO does not plan to remediate the subsurface contamination because of the lack of feasible technologies for removing radioactive contamination from subsurface cavities formed by

underground nuclear tests. Water samples collected from municipal water supplies, local ranches, and springs and wells located on the test site indicate that no radionuclides attributable to the Rulison test have migrated into drinking water supplies (EPA, 2002).

Subsurface characterization at the Rulison Site will begin in FY 2005. Based on the historic use of the site and characterization conducted at similar sites, COCs for the subsurface are expected to include plutonium, tritium, and mixed fission products, with gaseous radionuclides (tritium, carbon-14, and krypton-85) being the most mobile in the environment. At the present time, the hazard extent has not been defined; however, the DOE/NSO will continue to investigate and model subsurface contamination (DOE/EM, 2001). According to the Life-Cycle Baseline Revision 5, subsurface closure of the Rulison Site is scheduled for completion in FY 2011.


Map 4.1b2 Rulison, Colorado
Hazard Specific Map - End State
107°57'18"W
107°57'0"W
107°56'42"W
39°24'18"N
Wetland/Beaver Pond
Rulison Site
Pond
Access Road
East Fork Battlement Creek
Well R-E (SGZ)
Well R-EX (Reentry Hole)
Site Boundary
SGZ
Well
Stream
Road
Old Log Fence
Barbed Wire Fence
Pond
Wetland/Beaver Pond
Prepared By: Stoller-Navarro
Projection: UTM Zone 12 NAD 27
Data Source(s):
Raytheon Services Nevada
Engineering Records Library
Index #187306 (1970)
Griffin and Associates (1995)
N
W
E
S
0 0.035 0.07 0.14
Miles
1:6,000

5.0 References

AEC, see U.S. Atomic Energy Commission.

Cooper, C.A., and J. Chapman. 2001. *Modeling Approach for Evaluating Radionuclide Transport in Nuclear-Stimulated Gas Reservoirs*, DOE/NV/13609--15, Publication No. 45186. Las Vegas, NV: Desert Research Institute.

DOE, see U.S. Department of Energy.

DOE/EM, see U.S. Department of Energy, Office of Environmental Management.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

DOI, see U.S. Department of the Interior.

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Attachment A – Discussion of Variances

The following variance report table is provided in accordance with Appendix D of the Environmental Management End State Vision Development Guidance dated September 11, 2003. The table below does not identify any variances, but does provide information clarifying why there are no perceived differences between the various plans and agreements governing activities at the site. There are no negative impacts in terms of scope, cost, schedule, and risk, and no known barriers to achieving the end state. Based on the above noted belief, the next steps are identified for future activities associated with the Rulison Site. There are no maps provided, as there are no differences between the end state based on the current requirements and the end state based on the end state vision. The maps within the main body of the end state document sufficiently identify pertinent information related to the Rulison Site.

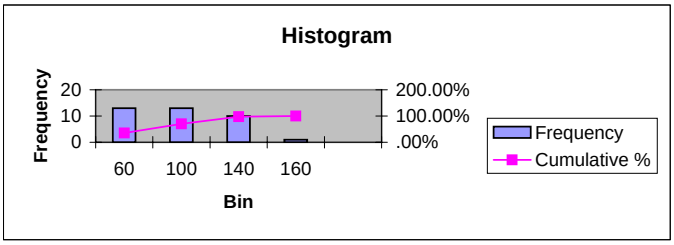
Rulison Site Variance Report				
ID No.	**Description of Variances**	**Impacts (in Terms of Scope, Cost, Schedule and Risk)**	**Barriers in Achieving the End State**	**Recommendations**
N/A	There are no known variances between the end state, the current Offsites baseline, the DOE/NSO Performance Management Plan, and/or regulatory agreements.	Clean-up decisions made for the Rulison Site are consistent with planned future use as residential, privately owned land. The State of Colorado and the private landowner have agreed to the clean closure of the surface, and understand issues associated with the residual contamination in the subsurface. The State and the private owner have not expressed opposition to future subsurface characterization activities and have not proposed alternative plans.	None at this time.	Support completion of future subsurface plans and documents and prepare the necessary long-term stewardship information for transfer of the management responsibility of the site subsurface to the Office of Legacy Management.

APPENDIX B

LUDLUM MODEL 3 SURVEY METER
AND GEIGER MUELLER PANCAKE PROBE
PRESCO DRILL CUTTING SCREENING RESULTS
FALL 2005

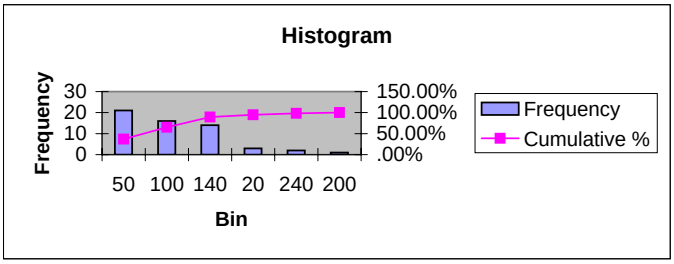
BM 26-42 Ludlum Model 3 Survey Meter/GM Pancake Probe Readings
Green River Fm Drill Cutting Screening Results

Bin	*Frequency*	*Cumulative %*	*Bin*	*Frequency*	*Cumulative %*
60	13	35.14%	60	13	35.14%
100	13	70.27%	100	13	70.27%
140	10	97.30%	140	10	97.30%
160	1	100.00%	160	1	100.00%
#Readings	37				



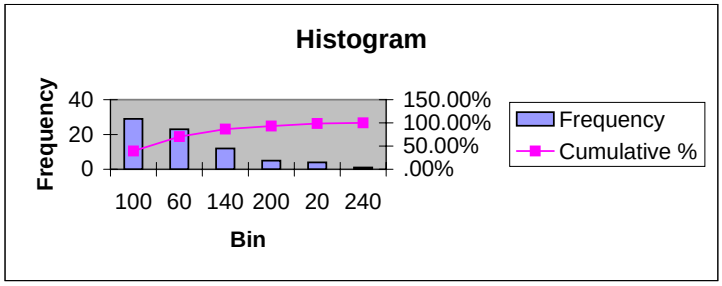
BM36-13 Ludlum Model 3 Survey Meter/GM Pancake
Green River Fm Drill Cutting Screening Results

Bin	*Frequency*	*Cumulative %*	*Bin*	*Frequency*	*Cumulative %*
20	3	5.26%	50	21	36.84%
50	21	42.11%	100	16	64.91%
100	16	70.18%	140	14	89.47%
140	14	94.74%	20	3	94.74%
200	1	96.49%	240	2	98.25%
240	2	100.00%	200	1	100.00%
#Readings	57				



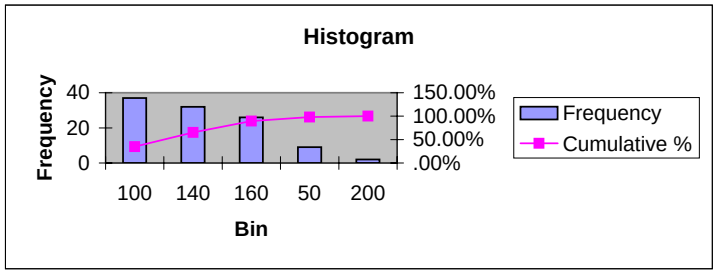
BM 26-42 Ludlum Model 3 Survey Meter/GM Pancake Probe Readings
Wasatch Fm Drill Cutting Screening Results

Bin	*Frequency*	*Cumulative %*	*Bin*	*Frequency*	*Cumulative %*
20	4	5.41%	100	29	39.19%
60	23	36.49%	60	23	70.27%
100	29	75.68%	140	12	86.49%
140	12	91.89%	200	5	93.24%
200	5	98.65%	20	4	98.65%
240	1	100.00%	240	1	100.00%
#Readings	74				



BM36-13 Ludlum Model 3 Survey Meter/GM Pancake Probe Readings
Wasatch Fm Drill Cutting Screening Results

Bin	*Frequency*	*Cumulative %*	*Bin*	*Frequency*	*Cumulative %*
50	9	8.49%	100	37	34.91%
100	37	43.40%	140	32	65.09%
140	32	73.58%	160	26	89.62%
160	26	98.11%	50	9	98.11%
200	2	100.00%	200	2	100.00%
#Readings	106				



Well Name:	BM 26-42	**Well Name:**	BM 36-13	**Well Name:**	BM 36-23	**Well Name:**	BM 34-24
Formation:	Green River		Green River		Green River - Not Evaluated		Green River - Not Evaluated
Min	60	Min	20				
Max	160	Max	240				
Average	98.37838	Average	93.85965				
Median	100	Median	100				
Mode	100	Mode	50				
Geometric	92.69663	Geometric	80.68994				
Variance	1089.262	Variance	2476.331				
Std Dev	33.00397	Std Dev	49.76275				
3 Std Dev	99.01192	3 Std Dev	149.2882				
4 Std Dev	132.0159	4 Std Dev	199.051				
Number of Readings:	37	Number of Readings:	57				
Formation:	Wasatch		Wasatch		Wasatch - Not Evaluated		Wasatch - Not Evaluated
Min	20	Min	50				
Max	240	Max	200				
Average	95.67568	Average	124.434				
Median	100	Median	140				
Mode	100	Mode	100				
Geometric	86.27623	Geometric	118.6593				
Variance	1592.111	Variance	1169.963				
Std Dev	39.90127	Std Dev	34.20472				
3 Std Dev	119.7038	3 Std Dev	102.6141				
4 Std Dev	159.6051	4 Std Dev	136.8189				
Number of Readings:	74	Number of Readings:	106				
Formation:	Mesaverde Group		Mesaverde Group		Mesaverde Group		Mesaverde Group
Min	60	Min	50	Min	20	Min	70
Max	200	Max	260	Max	180	Max	200
Average	132.1622	Average	141.4667	Average	116.087	Average	106.25
Median	140	Median	140	Median	120	Median	100
Mode	100	Mode	140	Mode	100	Mode	100
Geomean	127.6756	Geometric	135.3302	Geometric	111.0074	Geometric	102.7346
Variance	1165.595	Variance	1671.182	Variance	928.1664	Variance	885.9375
Std Dev	34.14082	Std Dev	40.8801	Std Dev	30.46582	Std Dev	29.7647
3 Std Dev	102.4224	3 Std Dev	122.6403	3 Std Dev	91.39747	3 Std Dev	89.29411
4 Std Dev	136.5633	4 Std Dev	163.5204	4 Std Dev	121.8633	4 Std Dev	119.0588
Number of Readings:	74	Number of Readings:	75	Number of Readings:	46	Number of Readings:	96

PRESCO Drill Cutting Screening with Ludlum Model 3 Survey Meter and Geiger Mueller Pancake Probe

BM 26-42 Gas Well Screening Results in Counts Per Minute (CPM)

Green River Fm.

Depth (ft)	CPM
354	100
384	140
1243	100
1275	100
1307	140
1338	60
1370	60
1402	60
1433	60
1465	100
1497	100
1528	100
1560	100
1592	60
1624	60
1655	60
1687	60
1717	140
1747	100
1777	100
1807	140
1837	60
1867	100
1897	60
1927	100
1957	100
1987	140
2017	140
2047	60
2077	140
2107	60
2137	140
2167	140
2197	140
2227	60
2257	100
2287	160

Min	60
Max	160
Average	98.3784
Median	100
Mode	100
Geometric Mean	92.6966
Std Dev	33.004
3 Std Dev	99.0119
4 Std Dev	132.016

Wasatch Fm.

Depth (ft)	CPM
2317	160
2853	100
2916	60
3139	100
3394	100
3424	100
3600	100
3650	100
3700	140
3750	140
3800	140
3850	60
3900	100
3950	160
4000	100
4050	160
4100	140
4150	140
4200	160
4250	160
4300	100
4350	100
4400	100
4450	140
4500	140
4550	100
4600	100
4650	60
4700	100
4750	100
4800	60
4850	100
4900	140
4950	100
5000	140
5050	140
5100	100
5150	100
5500	100
5530	140
5560	100
5590	60
5650	100
5680	100
5710	240
5890	100
5920	60
5950	60
5980	60
6010	60
6040	60
6070	60
6100	60
6130	60
6160	60
6190	60
6220	60
6250	60
6280	60
6310	60
6340	60
6370	60
6400	60
6430	20
6460	20
6490	20
6520	20
6550	60
6580	100
6610	100
6640	100
6670	100
6730	140
6760	100

Min	20
Max	240
Average	95.6757
Median	100
Mode	100
Geometric Mean	86.2762
Std Dev	39.9013
3 Std Dev	119.704
4 Std Dev	159.605

Mesaverde Group

Depth (ft)	CPM
6850	140
6880	200
6970	140
7000	140
7030	140
7060	140
7090	140
7120	100
7150	100
7180	100
7210	160
7240	160
7270	200
7300	160
7330	160
7360	100
7390	100
7420	160
7450	100
7480	200
7510	160
7540	160
7570	100
7600	100
7630	160
7660	140
7690	160
7720	140
7750	100
7780	100
7810	100
7840	140
7870	160
7900	100
7930	100
7960	160
7990	100
8020	140
8050	100
8080	100
8110	100
8140	160
8170	140
8200	160
8230	100
8260	100
8290	100
8320	140
8350	100
8380	100
8410	140
8440	100
8470	100
8500	100
8530	200
8560	160
8590	160
8620	100
8650	100
8680	100
8710	140
8740	200
8770	140
8800	200
8830	200
8860	60
8890	100
8950	140
8980	140
9010	140
9040	160
9070	140
9100	60
9130	140

Min	60
Max	200
Average	132.162
Median	140
Mode	100
Geometric Mean	127.676
Std Dev	34.1408
3 Std Dev	102.422
4 Std Dev	136.563

PRESCO Drill Cutting Screening with Ludlum Model 3 Survey Meter and Geiger Mueller Pancake Probe
BM 34-24 Well Screening in Counts Per Minute (CPM)

Mesaverde Group

Depth (ft)	Reading (CPM)
6510	80
6540	120
6570	80
6600	80
6630	80
6660	110
6690	110
6720	100
6750	100
6780	70
6810	100
6840	120
6870	100
6900	100
6930	100
6960	80
6990	100
7030	120
7060	70
7090	100
7120	100
7150	130
7180	80
7210	80
7240	100
7270	100
7300	100
7330	100
7360	120
7390	100
7420	200
7450	100
7480	80
7510	120
7540	80
7570	80
7600	130
7630	100
7660	70
7690	80
7720	80
7750	100
7780	90
7810	80
7840	80
7870	180
7900	180
7930	120
7960	80
7990	140
8020	80
8050	80
8080	120
8110	120
8140	110
8170	130
8200	80
8230	100
8260	80
8290	80
8320	70
8350	120
8380	80
8410	100
8440	100
8470	80
8500	180
8530	110
8560	180
8590	150
8620	100
8650	110
8680	100
8710	80
8740	120
8770	120
8800	80
8830	120
8860	100
8890	100
8920	130
8950	80
8980	90
9010	100
9040	80
9070	120
9100	100
9130	100
9160	120
9190	100
9220	140
9250	180
9280	200
9310	180
9340	80
9370	120

Min	70
Max	200
Average	106.25
Median	100
Mode	100
Geometric Mean	102.735
Std Dev	29.7647
3 Std Dev	89.2941
4 Std Dev	119.059

PRESCO Drill Cutting Screening with Ludlum Model 3 Survey Meter and Geiger Mueller Pancake Probe
BM 36-13 Gas Well Readings in Counts Per Minute (CPM)

Green River Fm

Depth (ft)	CPM
136	140
220	140
250	140
280	100
310	140
340	140
664	140
764	100
796	200
823	100
855	100
886	100
917	140
949	140
980	100
1010	100
1040	140
1070	240
1100	100
1160	140
1170	50
1208	240
1233	140
1265	100
1296	140
1328	100
1360	140
1391	100
1423	140
1480	50
1510	20
1540	50
1570	20
1540	50
1570	20
1600	50
1630	50
1660	50
1708	50
1771	50
1803	50
1834	50
1866	50
1898	100
1930	50
1961	100
1993	50
2034	50
2097	50
2132	100
2230	50
2265	50
2298	100
2340	100
2375	50
2397	50
2440	50

Min	20
Max	240
Average	93.85965
Median	100
Mode	50
Geometric Mean	80.68994
Std Dev	49.76275
3 Std Dev	149.2882
4 Std Dev	199.051

Wasatch Fm

Depth (ft)	CPM
2580	100
2600	50
2650	50
2700	100
2750	50
2800	160
2850	50
2900	50
2950	100
3000	100
3050	160
3100	140
3150	140
3200	100
3250	100
3300	100
3350	100
3400	100
3450	100
3500	160
3550	160
3600	140
3650	140
3700	160
3850	160
3900	160
3950	50
4000	50
4050	100
4100	100
4150	100
4200	100
4250	140
4300	140
4350	100
4400	100
4450	140
4500	100
4550	140
4580	100
4610	140
4640	160
4670	200
4700	160
4730	140
4760	200
4790	160
4820	160
4850	160
4880	140
4910	50
4940	140
4970	160
5000	160
5030	100
5060	100
5090	160
5120	160
5150	140
5180	160
5210	140
5240	160
5270	140
5300	50
5330	140
5360	140
5390	140
5420	100
5450	100
5480	140
5510	140
5540	160
5570	140
5600	140
5630	160
5660	140
5690	140
5720	100
5750	100
5780	160
5810	160
5840	100
5870	140
5900	100
5930	100
5960	160
5990	140
6020	100
6050	100
6080	140
6110	100
6140	160
6170	140
6200	100
6230	160
6320	140
6350	100
6380	160
6410	100
6440	140
6470	140
6500	100
6530	140
6560	100
6590	100
6620	100

Min	50
Max	200
Average	124.434
Median	140
Mode	100
Geometric Mean	118.6593
Std Dev	34.20472
3 Std Dev	102.6141
4 Std Dev	136.8189

Mesaverde Group

Depth (ft)	CPM
6650	160
6680	160
6710	140
6740	100
6770	140
6800	100
6830	140
6860	140
6890	140
6920	160
6950	140
6980	140
7010	100
7040	160
7070	140
7100	160
7130	100
7160	140
7190	200
7220	160
7250	160
7280	200
7310	50
7340	140
7370	240
7400	160
7430	140
7460	100
7490	140
7520	50
7550	50
7580	100
7610	160
7640	140
7670	140
7700	100
7730	100
7760	140
7790	240
7820	160
7850	100
7880	140
7910	140
7940	140
7970	160
8000	260
8030	260
8060	240
8090	160
8120	140
8150	140
8180	100
8210	100
8240	140
8270	140
8300	140
8330	140
8360	140
8390	140
8420	100
8450	140
8480	160
8510	100
8540	100
8570	140
8600	140
8630	140
8660	160
8690	200
8720	140
8750	140
8780	100
8810	140
8840	160
8870	100

Min	50
Max	260
Average	141.4667
Median	140
Mode	140
Geometric Mean	135.3302
Std Dev	40.8801
3 Std Dev	122.6403
4 Std Dev	163.5204

PRESCO Drill Cutting Screening with Ludlum Model 3 Survey Meter and Geiger Mueller Pancake Probe
BM 36-23 Well Screening in Counts Per Minute (CPM)

Mesaverde Group

Depth (ft)	Reading (CPM)
6760	100
6790	120
6820	100
6850	100
6880	110
6910	120
6940	100
6970	80
7030	100
7060	80
7150	120
7180	130
7210	150
7240	100
7360	120
7480	80
7600	100
7660	130
7840	120
7900	130
7960	100
8020	100
8260	150
8290	150
8320	100
8350	120
8380	100
8410	100
8440	80
8470	80
8500	100
8530	120
8560	180
8590	120
8620	120
8650	120
8680	120
8710	100
8740	150
8770	180
8800	150
8890	20
8920	180
8950	180
8980	100
9020	130

Min	20
Max	180
Average	116.087
Median	120
Geometric Mean	111.0074
Mode	100
Std Dev	30.46582
3 Std Dev	91.39747
4 Std Dev	121.8633

BM 26-42 Well Screening
Green River Fm.

Depth (ft)	CPM
354	100
384	140
1243	100
1275	100
1307	140
1338	60
1370	60
1402	60
1433	60
1465	100
1497	100
1528	100
1560	100
1592	60
1624	60
1655	60
1687	60
1717	140
1747	100
1777	100
1807	140
1837	60
1867	100
1897	60
1927	100
1957	100
1987	140
2017	140
2047	60
2077	140
2107	60
2137	140
2167	140
2197	140
2227	60
2257	100
2287	160

Min	60
Max	160
Average	98.3784
Median	100
Mode	100
Geometric Mean	92.6966
Variance	1089.26
Std Dev	33.004
3 Std Dev	99.0119
4 Std Dev	132.016
Number of Readings	37

BM 36-13 Well Screening
Green River Fm

Depth (ft)	CPM
136	140
220	140
250	140
280	100
310	140
340	140
664	140
764	100
796	200
823	100
855	100
886	100
917	140
949	140
980	100
1010	100
1040	140
1070	240
1100	100
1160	140
1170	50
1208	240
1233	140
1265	100
1296	140
1328	100
1360	140
1391	100
1423	140
1480	50
1510	20
1540	50
1570	20
1540	50
1570	20
1600	50
1630	50
1660	50
1708	50
1771	50
1803	50
1834	50
1866	50
1898	100
1930	50
1961	100
1993	50
2034	50
2097	50
2132	100
2230	50
2265	50
2298	100
2340	100
2375	50
2397	50
2440	50

Min	20
Max	240
Average	93.8596
Median	100
Mode	50
Geometric Mean	80.6899
Variance	2476.33
Std Dev	49.7627
3 Std Dev	149.288
4 Std Dev	199.051
Number of Readings	57

BM 26-42 Screening
Wasatch Fm.

Depth (ft)	CPM
2317	160
2853	100
2916	60
3139	100
3394	100
3424	100
3600	100
3650	100
3700	140
3750	140
3800	140
3850	60
3900	100
3950	160
4000	100
4050	160
4100	140
4150	140
4200	160
4250	160
4300	100
4350	100
4400	100
4450	140
4500	140
4550	100
4600	100
4650	60
4700	100
4750	100
4800	60
4850	100
4900	140
4950	100
5000	140
5050	140
5100	100
5150	100
5500	100
5530	140
5560	100
5590	60
5650	100
5680	100
5710	240
5890	100
5920	60
5950	60
5980	60
6010	60
6040	60
6070	60
6100	60
6130	60
6160	60
6190	60
6220	60
6250	60
6280	60
6310	60
6340	60
6370	60
6400	60
6430	20
6460	20
6490	20
6520	20
6550	60
6580	100
6610	100
6640	100
6670	100
6730	140
6760	100

Min	20
Max	240
Average	95.6757
Median	100
Mode	100
Geometric Mean	86.2762
Variance	1592.11
Std Dev	39.9013
3 Std Dev	119.704
4 Std Dev	159.605
Number of Readings	74

BM 36-13
Wasatch Fm

Depth (ft)	CPM
2580	100
2600	50
2650	50
2700	100
2750	50
2800	160
2850	50
2900	50
2950	100
3000	100
3050	160
3100	140
3150	140
3200	100
3250	100
3300	100
3350	100
3400	100
3450	100
3500	160
3550	160
3600	140
3650	140
3700	160
3850	160
3900	160
3950	50
4000	50
4050	100
4100	100
4150	100
4200	100
4250	140
4300	140
4350	100
4400	100
4450	140
4500	100
4550	140
4580	100
4610	140
4640	160
4670	200
4700	160
4730	140
4760	200
4790	160
4820	160
4850	160
4880	140
4910	50
4940	140
4970	160
5000	160
5030	100
5060	100
5090	160
5120	160
5150	140
5180	160
5210	140
5240	160
5270	140
5300	50
5330	140
5360	140
5390	140
5420	100
5450	100
5480	140
5510	140
5540	160
5570	140
5600	140
5630	160
5660	140
5690	140
5720	100
5750	100
5780	160
5810	160
5840	100
5870	140
5900	100
5930	100
5960	160
5990	140
6020	100
6050	100
6080	140
6110	100
6140	160
6170	140
6200	100
6230	160
6320	140
6350	100
6380	160
6410	100
6440	140
6470	140
6500	100
6530	140
6560	100
6590	100
6620	100

Min	50
Max	200
Average	124.434
Median	140
Mode	100
Geometric Mean	118.659
Variance	1169.96
Std Dev	34.2047
3 Std Dev	102.614
4 Std Dev	136.819
Number of Readings	106

BM 26-42
Well Cutting Screening

Mesaverde Group

Depth (ft)	Reading (CPM)
6850	140
6880	200
6970	140
7000	140
7030	140
7060	140
7090	140
7120	100
7150	100
7180	100
7210	160
7240	160
7270	200
7300	160
7330	160
7360	100
7390	100
7420	160
7450	100
7480	200
7510	160
7540	160
7570	100
7600	100
7630	160
7660	140
7690	160
7720	140
7750	100
7780	100
7810	100
7840	140
7870	160
7900	100
7930	100
7960	160
7990	100
8020	140
8050	100
8080	100
8110	100
8140	160
8170	140
8200	160
8230	100
8260	100
8290	100
8320	140
8350	100
8380	100
8410	140
8440	100
8470	100
8500	100
8530	200
8560	160
8590	160
8620	100
8650	100
8680	100
8710	140
8740	200
8770	140
8800	200
8830	200
8860	60
8890	100
8950	140
8980	140
9010	140
9040	160
9070	140
9100	60
9130	140

Min	60
Max	200
Average	132.1622
Median	140
Mode	100
Geomean	127.6756
Variance	1165.595
Std Dev	34.14082
3 Std Dev	102.4224
4 Std Dev	136.5633
Number of Readings	74

BM 36-13
Well Cutting Screening

Mesaverde Group

Depth (ft)	Reading (CPM)
6650	160
6680	160
6710	140
6740	100
6770	140
6800	100
6830	140
6860	140
6890	140
6920	160
6950	140
6980	140
7010	100
7040	160
7070	140
7100	160
7130	100
7160	140
7190	200
7220	160
7250	160
7280	200
7310	50
7340	140
7370	240
7400	160
7430	140
7460	100
7490	140
7520	50
7550	50
7580	100
7610	160
7640	140
7670	140
7700	100
7730	100
7760	140
7790	240
7820	160
7850	100
7880	140
7910	140
7940	140
7970	160
8000	260
8030	260
8060	240
8090	160
8120	140
8150	140
8180	100
8210	100
8240	140
8270	140
8300	140
8330	140
8360	140
8390	140
8420	100
8450	140
8480	160
8510	100
8540	100
8570	140
8600	140
8630	140
8660	160
8690	200
8720	140
8750	140
8780	100
8810	140
8840	160
8870	100

Min	50
Max	260
Average	141.4667
Median	140
Mode	140
Geometric Mean	135.3302
Variance	1671.182
Std Dev	40.8801
3 Std Dev	122.6403
4 Std Dev	163.5204
Number of Readings	75

BM 36-23
Well Cutting Screening

Mesaverde Group

Depth (ft)	Reading (CPM)
6760	100
6790	120
6820	100
6850	100
6880	110
6910	120
6940	100
6970	80
7030	100
7060	80
7150	120
7180	130
7210	150
7240	100
7360	120
7480	80
7600	100
7660	130
7840	120
7900	130
7960	100
8020	100
8260	150
8290	150
8320	100
8350	120
8380	100
8410	100
8440	80
8470	80
8500	100
8530	120
8560	180
8590	120
8620	120
8650	120
8680	120
8710	100
8740	150
8770	180
8800	150
8890	20
8920	180
8950	180
8980	100
9020	130

Min	20
Max	180
Average	116.087
Median	120
Mode	100
Geometric Mean	111.0074
Variance	928.1664
Std Dev	30.46582
3 Std Dev	91.39747
4 Std Dev	121.8633
Number of Readings	46

BM 34-24
Well Cutting Screening

Mesaverde Group

Depth (ft)	Reading (CPM)
6510	80
6540	120
6570	80
6600	80
6630	80
6660	110
6690	110
6720	100
6750	100
6780	70
6810	100
6840	120
6870	100
6900	100
6930	100
6960	80
6990	100
7030	120
7060	70
7090	100
7120	100
7150	130
7180	80
7210	80
7240	100
7270	100
7300	100
7330	100
7360	120
7390	100
7420	200
7450	100
7480	80
7510	120
7540	80
7570	80
7600	130
7630	100
7660	70
7690	80
7720	80
7750	100
7780	90
7810	80
7840	80
7870	180
7900	180
7930	120
7960	80
7990	140
8020	80
8050	80
8080	120
8110	120
8140	110
8170	130
8200	80
8230	100
8260	80
8290	80
8320	70
8350	120
8380	80
8410	100
8440	100
8470	80
8500	180
8530	110
8560	180
8590	150
8620	100
8650	110
8680	100
8710	80
8740	120
8770	120
8800	80
8830	120
8860	100
8890	100
8920	130
8950	80
8980	90
9010	100
9040	80
9070	120
9100	100
9130	100
9160	120
9190	100
9220	140
9250	180
9280	200
9310	180
9340	80
9370	120

Min	70
Max	200
Average	106.25
Median	100
Mode	100
Geometric Mean	102.7346
Variance	885.9375
Std Dev	29.7647
3 Std Dev	89.29411
4 Std Dev	119.0588
Number of Readings	96

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CORDILLERAN COMPLIANCE SERV ORDER NO. 237607

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 218381

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR-229526

Cal. Date 16-Jun-05 Cal Due Date 16-Jun-06 Cal. Interval 1 Year Meterface 202-608

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 70 °F RH 42 % Alt 697.8 mm Hg

☑ New Instrument Instrument Received ☐ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 29 mV Det. Oper. 900 V at 29 mV Threshold Dial Ratio ____ = ____ mV

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	150 mR/hr		1.5
X 100	50 mR/hr		0.5
X 10	15 mR/hr		1.5
X 10	5 mR/hr		0.52
X 1	1.5 mR/hr = 4480 cpm		1.5
X 1	1.0 mR/hr		1.0
X 0.1	448 cpm		1.5
X 0.1	149 cpm		0.5

*Uncertainty within ± 10% C.F. within ± 20%

X 0.1 **Range(s) Calibrated Electronically**

Digital Readout: REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale: REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☑ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☑ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ____ ☐ Beta S/N ____ ☐ Other ____

☑ m 500 S/N 141244 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 68160950

Calibrated By: Joyce Arnold Date 16-Jun-05

Reviewed By: Gloria Orozco Date 16 Jun 05

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.
FORM C22A 11/26/2003

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed: ____

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 325-235-5494
501 OAK STREET FAX NO. 325-235-46
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CORDILLERAN COMPLIANCE SERV. ORDER NO. 242079 / 295033

Mfg. Ludlum Measurements, Inc. Model 3 Serial No. 209539

Mfg. Ludlum Measurements, Inc. Model 44-9 Serial No. PR-221218

Cal. Date 7-Sep-05 Cal Due Date 7-Sep-06 Cal. Interval 1 Year Meterface 202-608

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 52 % Alt 702.8 mm H

☐ New Instrument Instrument Received ☐ Within Toler. +-10% ☑ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☐ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 2.2 VDC

☐ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☑ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 900 V Input Sens. 29 mV Det. Oper. 900 V at 29 mV Threshold Dial Ratio ____ = ____

☐ HV Readout (2 points) Ref./Inst. ____ / ____ V Ref./Inst. ____ / ____ V

COMMENTS:

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 100	150 mR/hr	1.6	1.5
X 100	50 mR/hr	0.6	0.55
X 10	15 mR/hr	1.6	1.5
X 10	5 mR/hr	0.55	0.5
X 1	1.5 mR/hr = 4420 cpm	1.5	1.5
X 1	1.0 mR/hr	1.0	1.0
X 0.1	447 cpm	1.55	1.5
X 0.1	149 cpm	0.55	0.5

*Uncertainty within ± 10% C.F. within ± 20%

X 0.1 **Range(s) Calibrated Electronically**

Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities o other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration technique The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-19

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☑ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☑ E552 ☐ E551 ☐ 720 ☐ 734 ☐ 1616 ☐ Neutron Am-241 Be S/N T-3

☐ Alpha S/N ____ ☐ Beta S/N ____ ☐ Other ____

☑ m 500 S/N 189506 ☐ Oscilloscope S/N ____ ☑ Multimeter S/N 57390613

Calibrated By: William Tinsley Date 7-September-05

Reviewed By: [signature] Date 7 Sept 05

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ ____

APPENDIX C

LANDAUER® ENVIRONMENTAL BADGE RESULTS

PRODUCT CATALOG

Environmental/Low Level Dosimeter

Designed to meet ANSI standards, the environmental/low level dosimeter is rugged enough to withstand the rigors of outdoor usage and environmental extremes, and sensitive enough to provide accurate reporting to 0.1 mrem (1 µSv). The Environmental/Low Level dosimeter is for both indoor and outdoor use in applications such as environmental monitoring, low-level exposure studies, and determining exposure to members of the public for compliance with current guidelines and the Code of Federal Regulations (10CFR20).

Landauer's service includes automatic exchange out of dosimeters for each use period, processing and analysis, data management, reporting of exposure results, direct computer access via the Internet to Landauer's database for shipment tracking, and customer service and technical support programs.

Detailed Specifications (.pdf)



Contact us for pricing

Service Features

Feature	Description
Shipping Frequencies	Monthly Quarterly Onetime only

All Categories this product can be found in:

- » Area/Environmental Monitoring
- » TLD

LANDAUER
Landauer, Inc. 2 Science Road Glenwood, Illinois 60425-1586 Telephone: (708) 755-7000 Facsimile: (708) 755-7016

ENVIRONMENTAL / LOW LEVEL DOSIMETRY REPORT

ADDRESS

CORDILLERAN COMPLIANCE SERVICE
ATTN : JAMES HIX
5550 MARSHALL
ARVADA, CO 80002

ACCOUNT NO. 291329

SERIES CODE

FOR EXPOSURE PERIOD 08/15/2005

LOCATION ID NUMBER	IDENTIFIER (CLIENT SUPPLIED)	NOTE CODE	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) GROSS	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) NET	NET CUMULATIVE TOTALS (MILLIREMS) CALENDAR QUARTER	YEAR TO DATE	PERMANENT	ADJUST-MENTS	NUMBER OF DOSIMETERS REPORTED	INCEPTION DATE OF PERM. TOTAL
00000	TRANSIT CONTROL		13.7	-1.6						
000X9	DEPLOY CONTROL		15.3	0.0						
00001			16.0	0.7	0.7	0.7	0.7		1	08/15/2005
00002		A								08/15/2005
00003		A								08/15/2005
00004			17.2	1.9	1.9	1.9	1.9		1	08/15/2005
00005			15.2	-0.1	-0.1	-0.1	-0.1		1	08/15/2005
00006			15.3	0.0	0.0	0.0	0.0		1	08/15/2005
00007			15.5	0.2	0.2	0.2	0.2		1	08/15/2005
00008			16.7	1.4	1.4	1.4	1.4		1	08/15/2005

NOTES (COLUMN 3) : A Absent

Q.C. Release	Process No.	Reported Date	Date Processed	Date Received	Minimum Detectable Dose In This Process, Millirems Ambient Dose Equivalent	ONLY PAGE
LD	GG737A	09/22/2005	09/22/2005	09/21/2005	0.01	1

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ARVADA, CO 80002

ACCOUNT NO. 291329

SERIES CODE

FOR EXPOSURE PERIOD 09/15/2005

LOCATION ID NUMBER	IDENTIFIER (CLIENT SUPPLIED)	NOTE CODE	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) GROSS	NET	NET CUMULATIVE TOTALS (MILLIREMS) CALENDAR QUARTER	YEAR TO DATE	PERMANENT	ADJUST-MENTS	NUMBER OF DOSIMETERS REPORTED	INCEPTION DATE OF PERM. TOTAL
00000	TRANSIT CONTROL		13.7	0.1						
00000	TRANSIT CONTROL		13.9	0.3						
000X9	DEPLOY CONTROL	A								
000X9	DEPLOY CONTROL		13.6	0.0						
00001		A			0.7	0.7	0.7		1	08/15/2005
00002			15.5	2.0	2.0	2.0	2.0		1	09/15/2005
00003		A								09/15/2005
00004		A			1.9	1.9	1.9		1	08/15/2005
00005			14.3	0.8	0.7	0.7	0.7		2	08/15/2005
00006			14.7	1.1	1.2	1.2	1.2		2	08/15/2005
00007			15.0	1.5	1.7	1.7	1.7		2	08/15/2005
00008			14.8	1.2	2.6	2.6	2.6		2	08/15/2005
00009	UNION	A								09/15/2005
00010	UNION		16.6	3.0	3.0	3.0	3.0		1	09/15/2005
00011	UNION	A								09/15/2005
00012	UNION	A								09/15/2005
00013	UNION	A								09/15/2005
00014	UNION		14.6	1.0	1.0	1.0	1.0		1	09/15/2005

NOTES (COLUMN 3) : A Absent

Q.C. Release	Process No.	Reported Date	Date Processed	Date Received	Minimum Detectable Dose In This Process, Millirems Ambient Dose Equivalent	PAGE
LD	GG893A	10/28/2005	10/26/2005	10/21/2005	0.02	1

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SERIES CODE

FOR EXPOSURE PERIOD 09/15/2005

LOCATION ID NUMBER	IDENTIFIER (CLIENT SUPPLIED)	NOTE CODE	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) GROSS	NET	NET CUMULATIVE TOTALS (MILLIREMS) CALENDAR QUARTER	YEAR TO DATE	PERMANENT	ADJUST-MENTS	NUMBER OF DOSIMETERS REPORTED	INCEPTION DATE OF PERM. TOTAL
00015	UNION	A								09/15/2005
00016	UNION	A								09/15/2005

NOTES (COLUMN 3) : A Absent

Q.C. Release	Process No.	Reported Date	Date Processed	Date Received	Minimum Detectable Dose In This Process, Millirems Ambient Dose Equivalent	LAST PAGE
LD	GG893A	10/28/2005	10/26/2005	10/21/2005	0.02	2

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FOR EXPOSURE PERIOD 10/15/2005

LOCATION ID NUMBER	IDENTIFIER (CLIENT SUPPLIED)	NOTE CODE	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT)		NET CUMULATIVE TOTALS (MILLIREMS)			ADJUST-MENTS	NUMBER OF DOSIMETERS REPORTED	INCEPTION DATE OF PERM. TOTAL
			GROSS	NET	CALENDAR QUARTER	YEAR TO DATE	PERMANENT			
00000	TRANSIT CONTROL		21.2	-0.6						
000X9	DEPLOY CONTROL		21.8	0.0						
00001	GTS RIG		21.3	-0.5	-0.5	0.3	0.3		3	08/15/2005
00002	GTS RIG		19.6	-2.2	-2.2	-0.3	-0.3		2	09/15/2005
00003	GTS RIG	A								10/15/2005
00004	GTS RIG	A				1.4	1.4		2	08/15/2005
00005	GTS RIG		19.9	-1.9	-1.9	-1.2	-1.2		3	08/15/2005
00006	GTS RIG		18.2	-3.6	-3.6	-2.4	-2.4		3	08/15/2005
00007	GTS RIG		17.9	-3.9	-3.9	-2.2	-2.2		3	08/15/2005
00008	GTS RIG		21.8	0.0	0.0	2.6	2.6		3	08/15/2005
00009	UNION		18.3	-3.5	-3.5	-6.9	-6.9		2	09/15/2005
00010	UNION		19.7	-2.1	-2.1	0.9	0.9		2	09/15/2005
00011	UNION		19.2	-2.6	-2.6	-2.6	-2.6		1	10/15/2005
00012	UNION		19.7	-2.1	-2.1	-2.1	-2.1		1	10/15/2005
00013	UNION		19.1	-2.6	-2.6	-2.6	-2.6		1	10/15/2005
00014	UNION	A				1.0	1.0		1	09/15/2005
00015	UNION		19.6	-2.1	-2.1	-2.1	-2.1		1	10/15/2005
00016	UNION		18.9	-2.8	-2.8	-2.8	-2.8		1	10/15/2005

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FOR EXPOSURE PERIOD 09/15/2005

LOCATION ID NUMBER	IDENTIFIER (CLIENT SUPPLIED)	NOTE CODE	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) GROSS	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) NET	NET CUMULATIVE TOTALS (MILLIREMS) CALENDAR QUARTER	YEAR TO DATE	PERMANENT	ADJUST-MENTS	NUMBER OF DOSIMETERS REPORTED	INCEPTION DATE OF PERM. TOTAL
000X9	DEPLOY CONTROL		29.4	0.0						
00001			29.4	0.0	0.7	0.7	0.7		2	08/15/2005
00003		A								09/15/2005
00004			28.9	-0.5	1.4	1.4	1.4		2	08/15/2005
00009	UNION		26.0	-3.5	-3.5	-3.5	-3.5		1	09/15/2005
00011	UNION	A								09/15/2005
00012	UNION	A								09/15/2005
00013	UNION	A								09/15/2005
00015	UNION	A								09/15/2005
00016	UNION	A								09/15/2005

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ARVADA, CO 80002

ACCOUNT NO. 291329

SERIES CODE

FOR EXPOSURE PERIOD 11/15/2005

LOCATION ID NUMBER	IDENTIFIER (CLIENT SUPPLIED)	NOTE CODE	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) GROSS	EXPOSURE OF DOSIMETER (MILLIREMS AMBIENT DOSE EQUIVALENT) NET	NET CUMULATIVE TOTALS (MILLIREMS) CALENDAR QUARTER	NET CUMULATIVE TOTALS (MILLIREMS) YEAR TO DATE	NET CUMULATIVE TOTALS (MILLIREMS) PERMANENT	ADJUST-MENTS	NUMBER OF DOSIMETERS REPORTED	INCEPTION DATE OF PERM. TOTAL
00000	TRANSIT CONTROL		12.3	0.2						
000X9	DEPLOY CONTROL		12.1	0.0						
00001	GTS RIG		14.5	2.4	1.9	3.1	3.1		3	08/15/2005
00002	GTS RIG		13.4	1.3	-0.9	1.1	1.1		3	09/15/2005
00004	GTS RIG		15.7	3.6	3.6	5.0	5.0		3	08/15/2005
00005	GTS RIG		13.9	1.9	0.0	0.7	0.7		4	08/15/2005
00006	GTS RIG		15.1	3.0	-0.5	0.6	0.6		4	08/15/2005
00007	GTS RIG		14.6	2.5	-1.4	0.3	0.3		4	08/15/2005
00008	GTS RIG		12.6	0.5	0.6	3.2	3.2		4	08/15/2005
00009	UNION		14.9	2.8	-0.7	-0.7	-0.7		2	09/15/2005
00010	UNION		14.1	2.0	-0.1	2.9	2.9		3	09/15/2005
00011	UNION		15.0	2.9	2.9	2.9	2.9		1	/ /
00012	UNION		13.3	1.2	1.2	1.2	1.2		1	/ /
00015	UNION		14.3	2.2	2.2	2.2	2.2		2	/ /
00015	UNION		13.8	1.7	4.0	4.0	4.0		3	/ /

Q.C. Release	Process No.	Reported Date	Date Processed	Date Received	Minimum Detectable Dose In This Process, Millirems Ambient Dose Equivalent	ONLY PAGE
LD	GH171A	12/20/2005	12/20/2005	12/16/2005	0.02	1

APPENDINX D

DESERT RESEARCH INSTITUTE
RULISON: GAS SAMPLING OF PROXIMATE PRODUCING WELLS
AUGUST 2005

DOE/NV/13609-LTR2005-001

Letter Report

Rulison:
Gas Sampling of Proximate Producing Wells

prepared by

Craig Shirley
Division of Hydrologic Sciences
Desert Research Institute
Nevada System of Higher Education

submitted to

Nevada Site Office
National Nuclear Security Administration
U.S. Department of Energy
Las Vegas, Nevada

August 2005

The work upon which this report is based was supported by the U.S. Department of Energy under Contract #DE-AC52-00NV13609; intended for limited distribution.

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INTRODUCTION

Five currently producing commercial gas wells near the site of the Project Rulison gas stimulation test were sampled and the gas analyzed for tritium. Sample wells were selected based on current gas production status and proximity to the Project Rulison underground nuclear test. Information on the location wells and production status of oil and gas was obtained from the Colorado Oil and Gas Commission Geographic Information System (COGIS) and is found in the Appendix.

Five wells meeting these criteria were selected for sampling (see Figure 1). All wells are operated by Encana Oil & Gas (USA) Inc. and were in production on the sampling date, May 5, 2005.

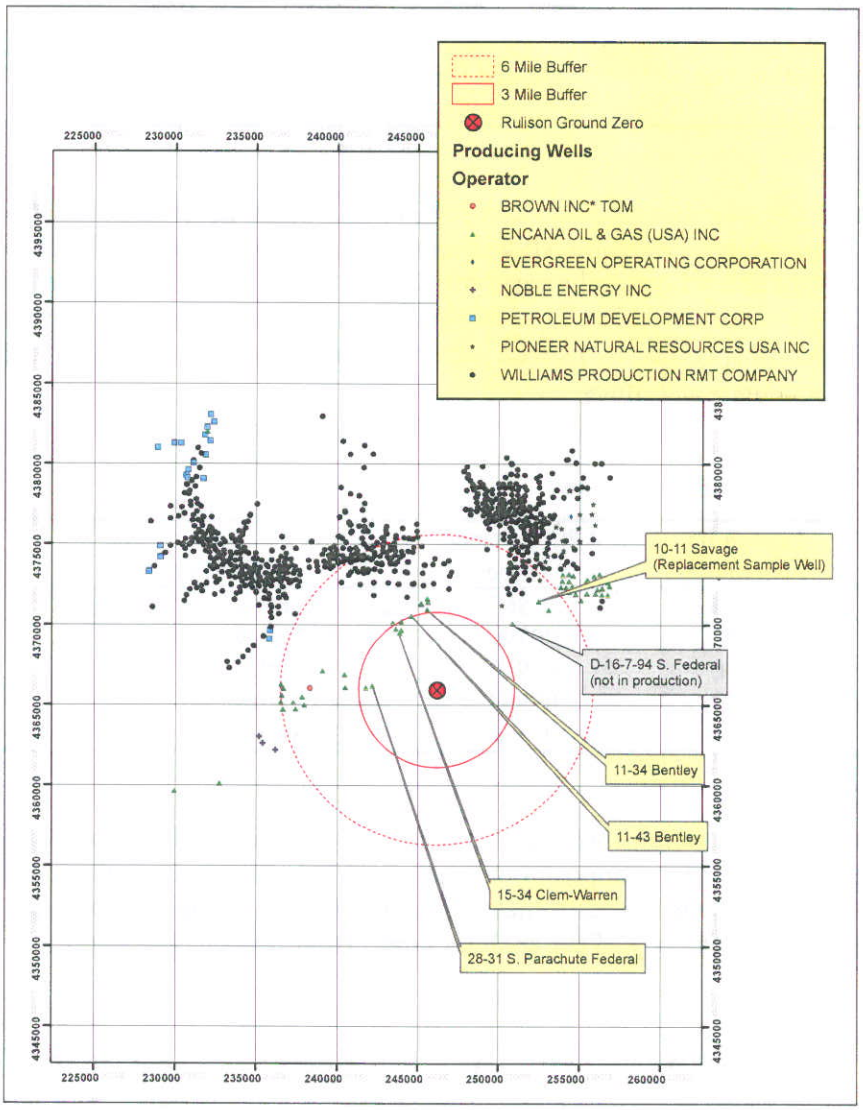


Figure 1. Sample wells.

The Rulison device was placed 8,426 feet below the ground surface at an elevation of -276 feet (see Figure 2). As shown in Table 1, four of the five sampled wells have perforated intervals that span the same elevation as the stimulation test. Well 28-31 South Parachute Federal has perforations that come within 146 vertical feet of the test.

Table 1. Elevation of perforated intervals and Rulison Test.

Well	Elevation of Highest Perforations (ft)	Elevation of Lowest Perforations (ft)	
28-31 S. Parachute Federal	1,806	-126	
15-34 Clem-Warren	1,095	-1,118	
11-43 Bentley	1,271	-975	
11-34 Bentley	1,009	-921	
10-11 Savage	807	-599	
Stimulation Test	**Ground Elevation (ft)**	**Depth of Burial (ft)**	**Elevation (ft)**
Rulison	8,154	8,426	-272

The wells were sampled between 8:40 am and 11:30 am (MDT) on May 5, 2005. Five new 20-pound steel propane bottles were used to obtain the samples. Each container was filled with wellhead gas and purged three times to ensure representative samples. The samples were obtained directly at the wellheads with the pressure being limited to less than 30 psi, as specified by Isotech Laboratories, the analytical facility. Table 2 lists the samples, locations and times.

Table 2. Sample numbering by well.

Sample Number	Isotech ID Number	API Sequence Number	Well name	Sample Time
1	82354	07867	28-31 S. Parachute Federal	8:40 am
2	82355	09790	15-34 Clem-Warren	9:53 am
3	82356	07910	11-43 Bentley	10:38 am
4	82357	07959	11-34 Bentley	10:20 am
5	82358	07186	10-11 Savage	11:27 am

The collected samples were sent to Isotech Laboratories, 1308 Parkland Court, Champaign, IL 61821, for compositional analysis, $\delta^{13}C$ analysis of methane, ^{14}C and ^{3}H analysis of methane by beta spectrometry. The results are summarized in Table 3 and detailed in the attached copy of the analysis report from Isotech (Appendix).

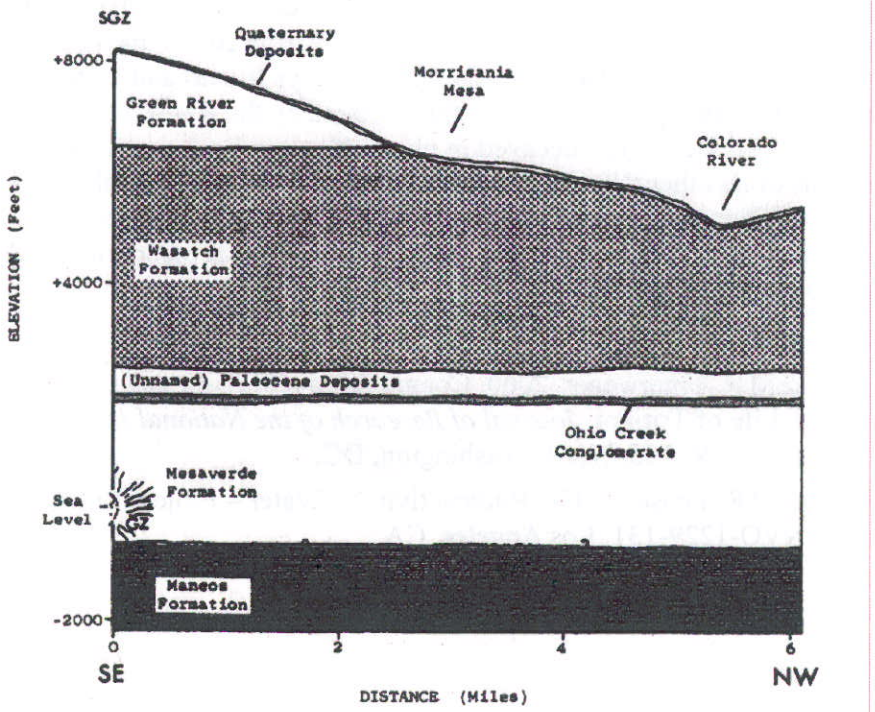


Figure 2. Cross section with Rulison emplacement (from Nork and Fenske, 1970).

Table 3. Sample results.

Isotech Lab No.	Sample Name	He %	H_2 %	Ar %	O_2 %	CO_2 %	N_2 %
82354	Sample #1	0.0029	0.0022	0.0061	0.0731	0.91	0.43
82355	Sample #2	0.0023	0.0015	0.0106	0.190	1.50	0.89
82356	Sample #3	0.0024	0.0012	0.0487	1.00	2.77	4.07
82357	Sample #4	0.0023	0	0.0261	0.502	4.45	2.17
82358	Sample #5	0.0021	0.0028	0.0268	0.527	1.30	2.10

Isotech Lab No.	Sample Name	C_1 %	C_2 %	C_3 %	iC_4 %	nC_4 %	iC_5 %	nC_5 %	C_6+ %
82354	Sample #1	91.69	4.57	1.32	0.276	0.291	0.117	0.0881	0.223
82355	Sample #2	92.59	3.37	0.869	0.178	0.178	0.0709	0.0503	0.0981
82356	Sample #3	87.77	3.11	0.752	0.158	0.138	0.0557	0.0370	0.0863
82357	Sample #4	88.19	3.63	0.643	0.155	0.0914	0.0407	0.0261	0.0783
82358	Sample #5	88.43	5.61	1.41	0.241	0.187	0.0518	0.0362	0.0745

Isotech Lab No.	Sample Name	MS date	$\delta^{13}C_1$ ‰	δDC_1 ‰	$^{14}C_1$ pMC	Std. Dev.	Tritium C_1 TU	Std. Dev.
82354	Sample #1	5/12/2005	-37.19	-173.1	< 0.6		< 10	
82355	Sample #2	5/12/2005	-36.63	-167.5	< 0.6		< 10	
82356	Sample #3	5/12/2005	-36.02	-167.5	< 0.7		< 10	
82357	Sample #4	5/18/2005	-36.19	-172.9	< 0.6		< 10	
82358	Sample #5	5/18/2005	-38.01	-177.8	< 0.6		< 10	

Chemical analysis based on standards accurate to within 2%

Subsequent to the stimulation test, 455 million cubic feet (ft^3) of gas was produced from the nearby (311 ft) R-EX well, which reduced the mass of tritium left in the subsurface. Tritium has a half-life of 4,500 (±8) days (Lucas and Unterweger, 2000), thus approximately 86.5 percent of the tritium created by the Rulison test and not removed by gas production has decayed in place. All samples show tritium concentrations of less then 10 tritium units, which is considered to be the lower limit of detection. One tritium unit equals 1 tritium atom per 10^{18} hydrogen atoms or approximately 0.1183 bequerels per liter (Bq/L). Expressed as picocuries per liter, 1 TU equals approximately 3.19 pCi/L.

REFERENCES

Lucas, L.L and M.P. Unterweger, 2000. Comprehensive Review and Critical Evaluation of the Half-Life of Tritium, *Journal of Research of the National Institute of Standards and Technology*, V. 105, No. 4, Washington, DC.

Nork, W.E. and P.R. Fenske, 1970. Radioactivity in Water – Project Rulison. In *Teledyne Isotopes*, NVO-1229-131. Los Angeles, CA.

APPENDIX: Rulison Tritium Decay Calculations

NIST decay rate in days is 4,500 plus or minus 8 days.

$$\lambda(t) := e^{\frac{-\ln(2)}{4500}\cdot t} \qquad \lambda_{low}(t) := e^{\frac{-\ln(2)}{4500-8}\cdot t} \qquad \lambda_{hi}(t) := e^{\frac{-\ln(2)}{4500+8}\cdot t}$$

Zero Time is 3:00 pm, MDT, September 10, 1969 (2100 UT).

Calculate Julian date to facilitate elapsed time in days.

ZeroTime :=JD(1969,9,10,21) ZeroTime = 2440475.4

Sample times range from 8:40 am, MDT to 11:27 am, MDT, on May 5, 2005 (1440 UT to 1727 UT).

SampleTime1:= JD(2005,5,5,14.666) SampleTime1 = 2453496.11

SampleTime2:=JD(2005,5,5,17.45) SampleTime2 = 2453496.23

t_1:=SampleTime1 – ZeroTime t_1 = 13020.74

t_2:=SampleTime2 – ZeroTime t_2 = 13020.85

Elapsed time in days from Rulison detonation until first and last samples taken

Calculate decay based on elapsed times and high, low, and mean decay rates

$\lambda(t_1) = 13.458\%$ $\lambda_{low}(t_1) = 13.410\%$ $\lambda_{hi}(t_1) = 13.506\%$

$1.0 - \lambda(t_1) = 86.542\%$ $1.0 - \lambda_{low}(t_1) = 86.590\%$ $1.0 - \lambda_{hi}(t_1) = 86.494\%$

$\lambda(t_2) = 13.457\%$ $\lambda_{low}(t_2) = 13.409\%$ $\lambda_{hi}(t_2) = 13.505\%$

$1.0 - \lambda(t_2) = 86.543\%$ $1.0 - \lambda_{low}(t_2) = 86.591\%$ $1.0 - \lambda_{hi}(t_2) = 86.495\%$

The decay ranges from 86.494% using the longest half life of 4,508 days and the earliest sample time to 86.543% using the shortest half life of 4,492 days and the last sampling time.

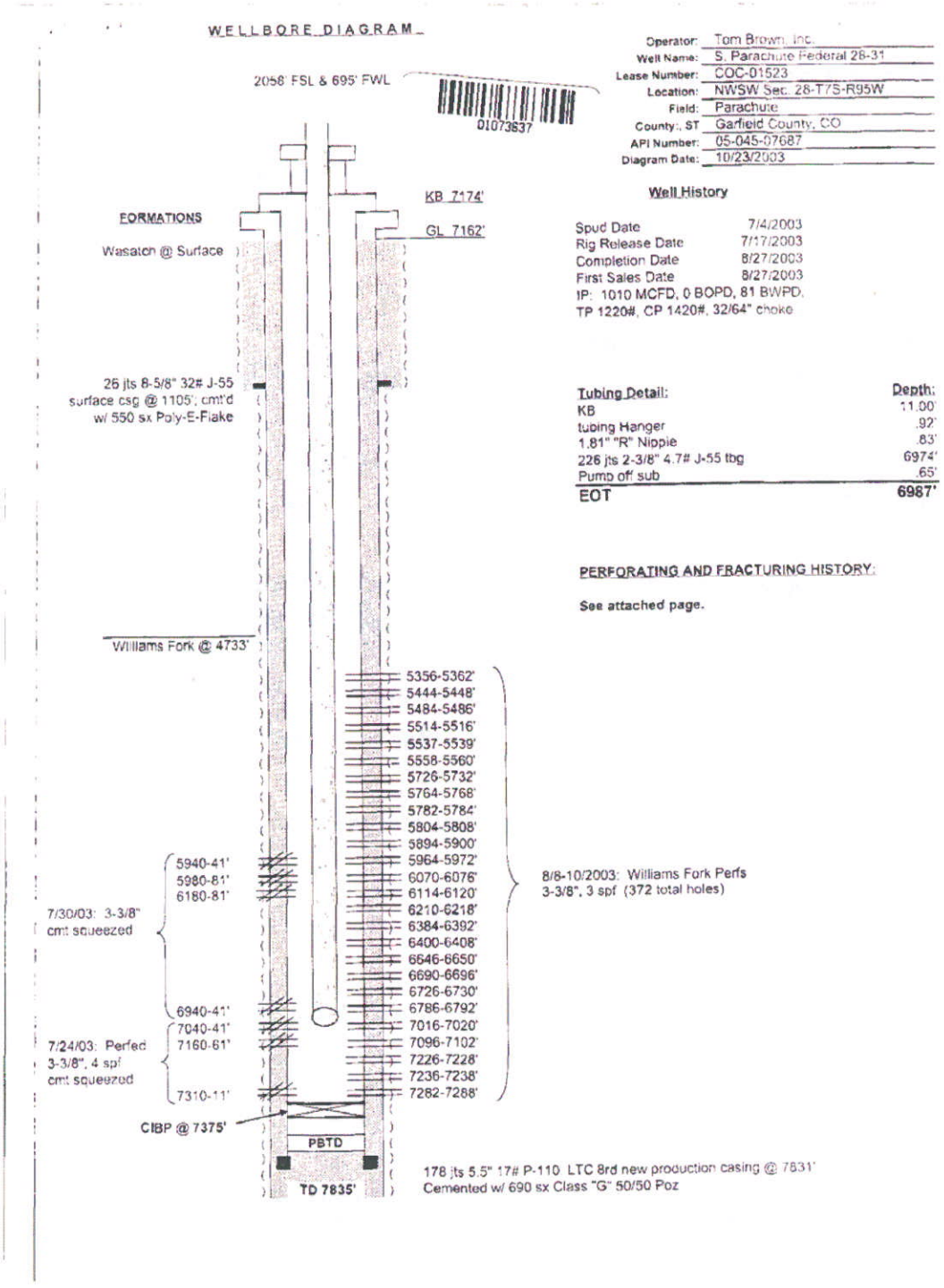


Figure A1. S. Parachute Federal 28-31 wellbore diagram (from Colorado Oil & Gas Commission Database).

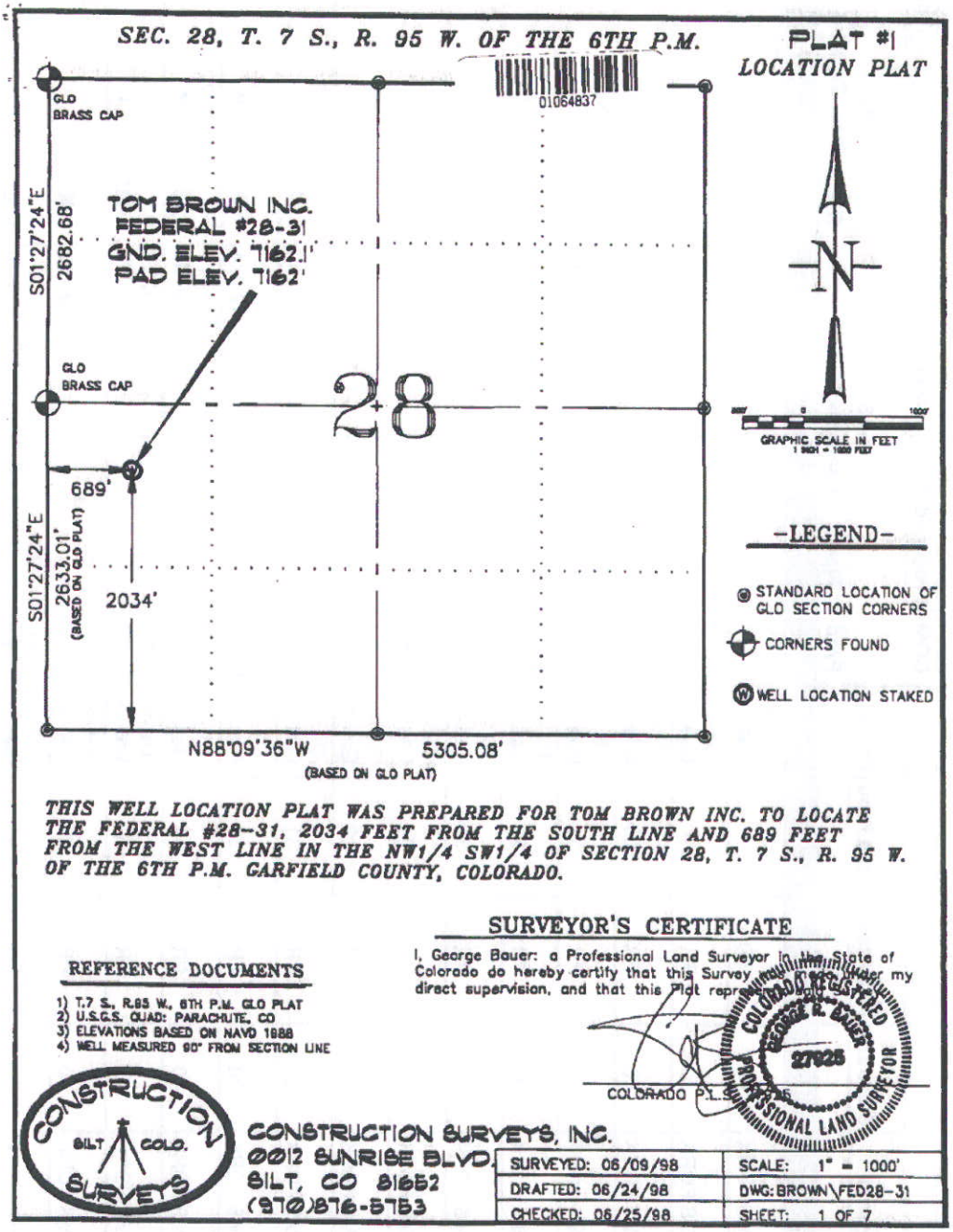


Figure A2. Location plat for S. Parachute Federal 28-31 (from Colorado Oil & Gas Commission Database).

Table A1. Production data for S. Parachute Federal 28-31 (from Colorado Oil & Gas Commission Database).

							OIL						Water Prod	Water(psig)	
							BOM	Produced	Sold	Adj.	EOM	Gravity		Tbg.	Csg.
Year	Month	Formation	Sidetrack	Well Status	Days Prod	Product	GAS						Water Disp. Code	Gas (psig)	
							Prod	Flared	Used	Shrinkage	Sold	BTU		Tbg.	Csg.
2003	Jul	WILLIAMS FORK	00	WO		Oil -> Gas ->									
2003	Aug	WILLIAMS FORK	00	PR	4	Oil -> Gas ->	5,386				5,386	1,000			
2003	Sep	WILLIAMS FORK	00	PR	28	Oil -> Gas ->	26,798				26,798	1,067	1,707 P		
2003	Oct	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	29,381				29,381	1,067	945 P		
2003	Nov	WILLIAMS FORK	00	PR	29	Oil -> Gas ->	22,946				22,946	1,067	527 I		
2003	Dec	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	20,290				20,290	1,067	165 P		
2004	Jan	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	17,593				17,593	1,067	476 I		
2004	Feb	WILLIAMS FORK	00	PR	29	Oil -> Gas ->	14,370				14,370	1,067	360 I		
2004	Mar	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	15,168	132			132 15,168	1,067	307 I		
2004	Apr	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	132 12,874			-5	127 12,874	1,067	139 M		
2004	May	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	127 14,137	14			141 14,137	1,081	327 M		
2004	Jun	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	141 12,770			-12	129 12,770	1,081	135 I		
2004	Jul	WILLIAMS FORK	00	PR	29	Oil -> Gas ->	129 12,760	62			191 12,760	1,081			
2004	Aug	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	191 13,400	25			216 13,400	1,088			

2004	Sep	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	216 11,330	12	183		45 11,330	55.6 1,088	130 M		
2004	Oct	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	45 12,279				45 12,279	1,088			
2004	Nov	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	45 11,176				45 11,176	1,088			
2004	Dec	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	45 10,850				45 10,850	1,088			
2005	Jan	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	45 10,311				45 10,311	1,088			
2005	Feb	WILLIAMS FORK	00	PR	28	Oil -> Gas ->	45 8,567				45 8,567	1,088			

Clem 15-34

Operator: Tom Brown, Inc.
Field: Parachute
Location: NESE SEC. 15-T7S-R95W

Spud Date: 04/14/2004
Compl Date: 06/26/2004

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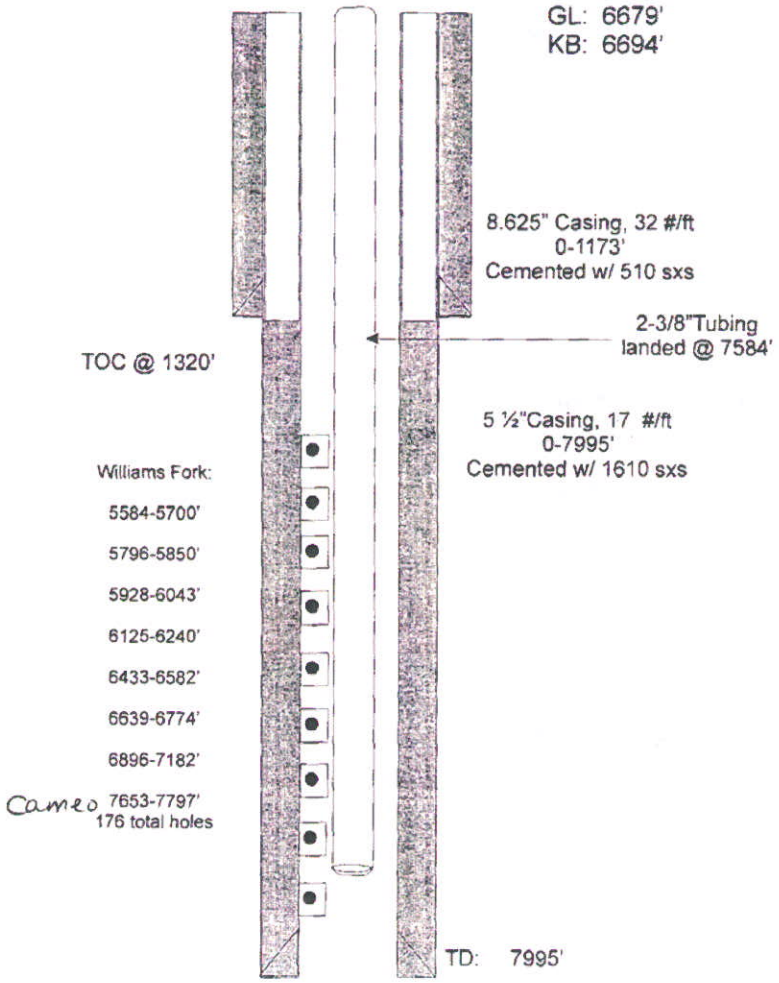


Figure A3. Wellbore diagram for Clem-Warren 15-34 (from Colorado Oil & Gas Commission Database).

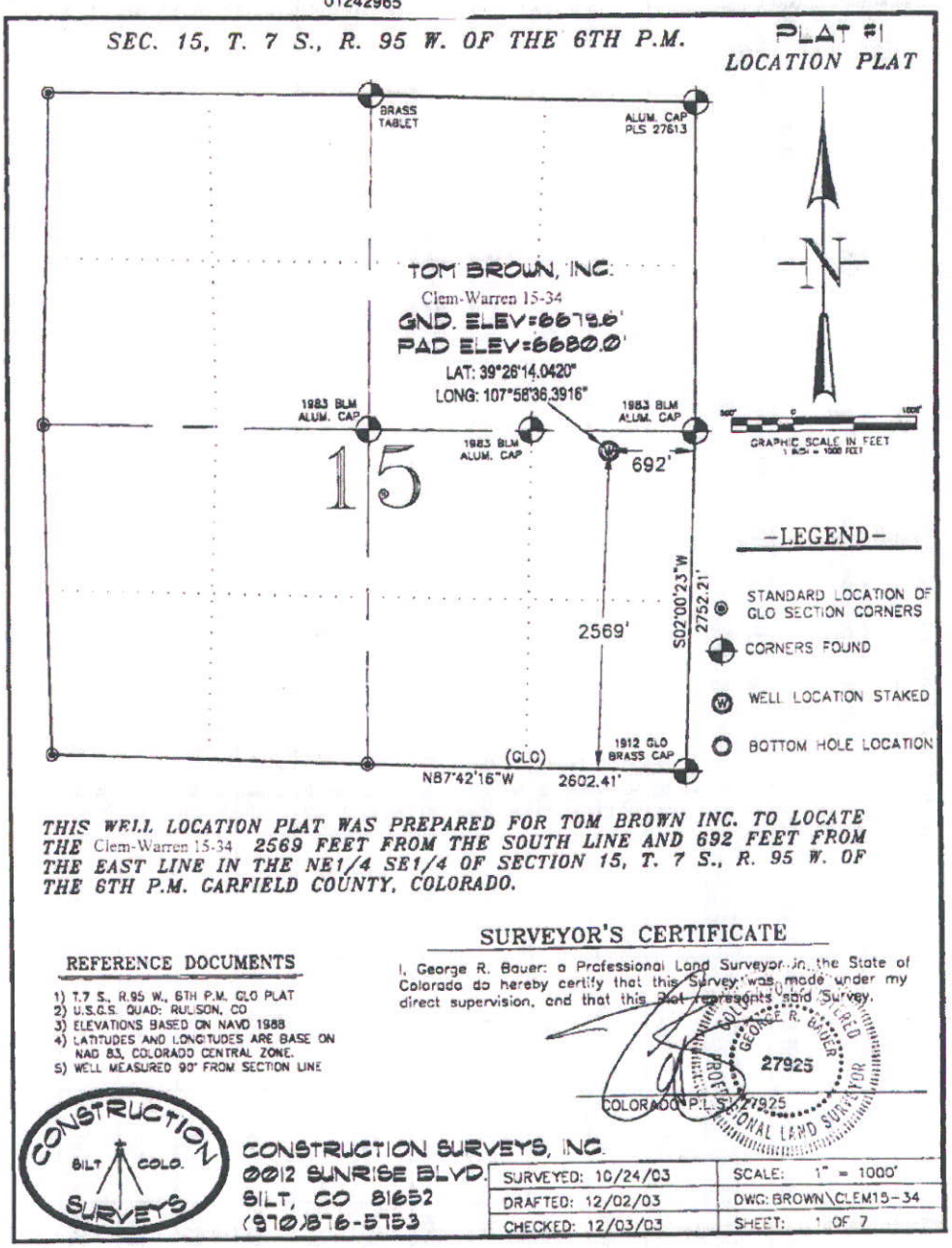


Figure A4. Location Plat for Clem-Warren 15-34 (from Colorado Oil & Gas Commission Database).

Table A2. Production data for Clem-Warren 15-34 (from Colorado Oil & Gas Commission Database).

							OIL						Water Prod	Water(psig)	
							BOM	Produced	Sold	Adj.	EOM	Gravity		Tbg.	Csg.
Year	Month	Formation	Sidetrack	Well Status	Days Prod	Product	GAS						Water Disp. Code	Gas (psig)	
							Prod	Flared	Used	Shrinkage	Sold	BTU		Tbg.	Csg.
2004	Apr	WILLIAMS FORK	00	WO		Oil -> Gas ->									
2004	May	WILLIAMS FORK	00	WO		Oil -> Gas ->									
2004	Jun	WILLIAMS FORK	00	PR	6	Oil -> Gas ->	898				898	1,075			
2004	Jul	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	29,129				29,129	1,053			
2004	Aug	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	20,498				20,498	1,050			
2004	Sep	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	16,082				16,082	1,051			
2004	Oct	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	14,210				14,210	1,051			
2004	Nov	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	12,048	65			65 12,048	1,051			
2004	Dec	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	65 10,487	12			77 10,487	1,060			
2005	Jan	WILLIAMS FORK	00	PR	28	Oil -> Gas ->	77 9,663	2			79 9,663	1,060			
2005	Feb	WILLIAMS FORK	00	PR	27	Oil -> Gas ->	79 8,261			-27	52 8,261	1,060			

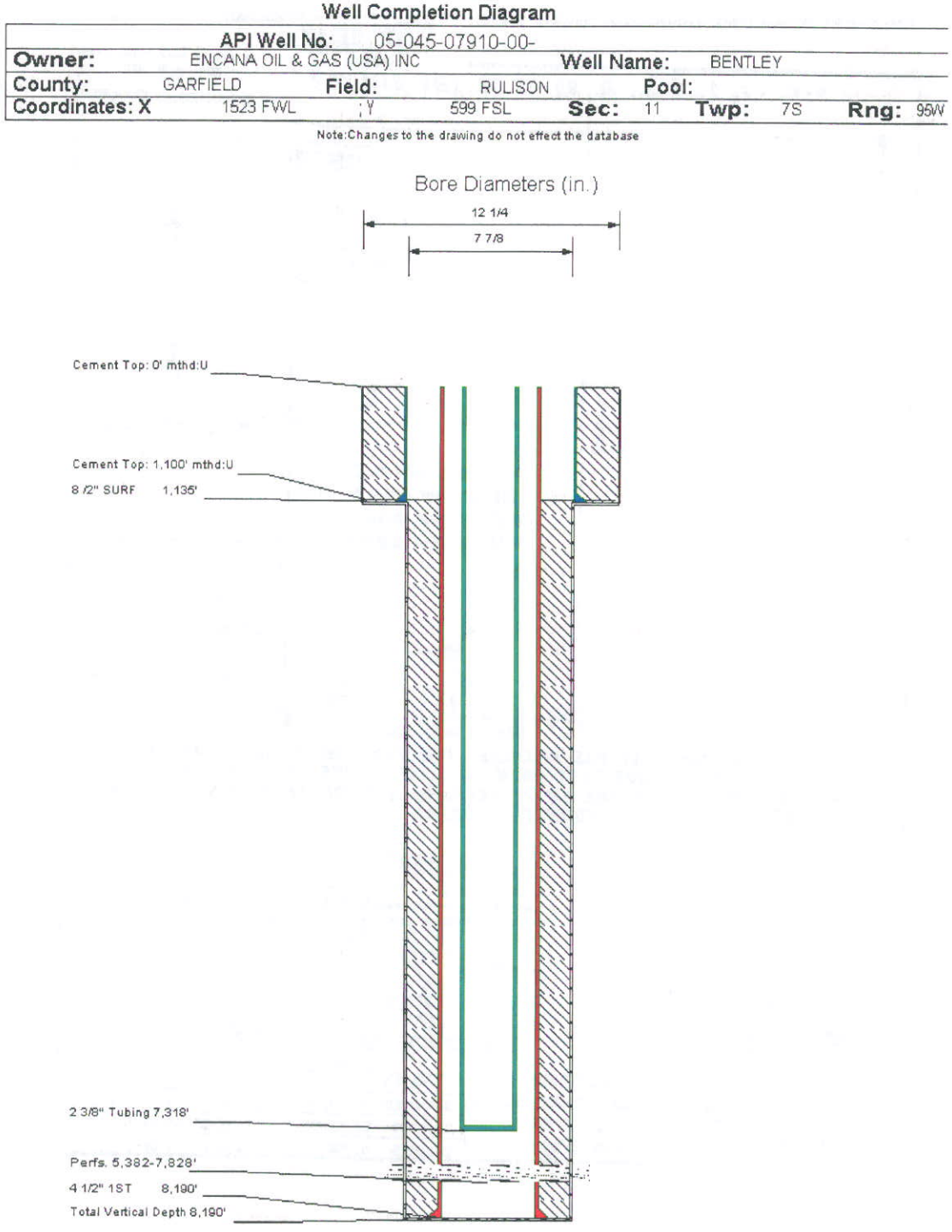


Figure A5. Wellbore diagram for Bentley 11-43 (from Colorado Oil & Gas Commission Database).

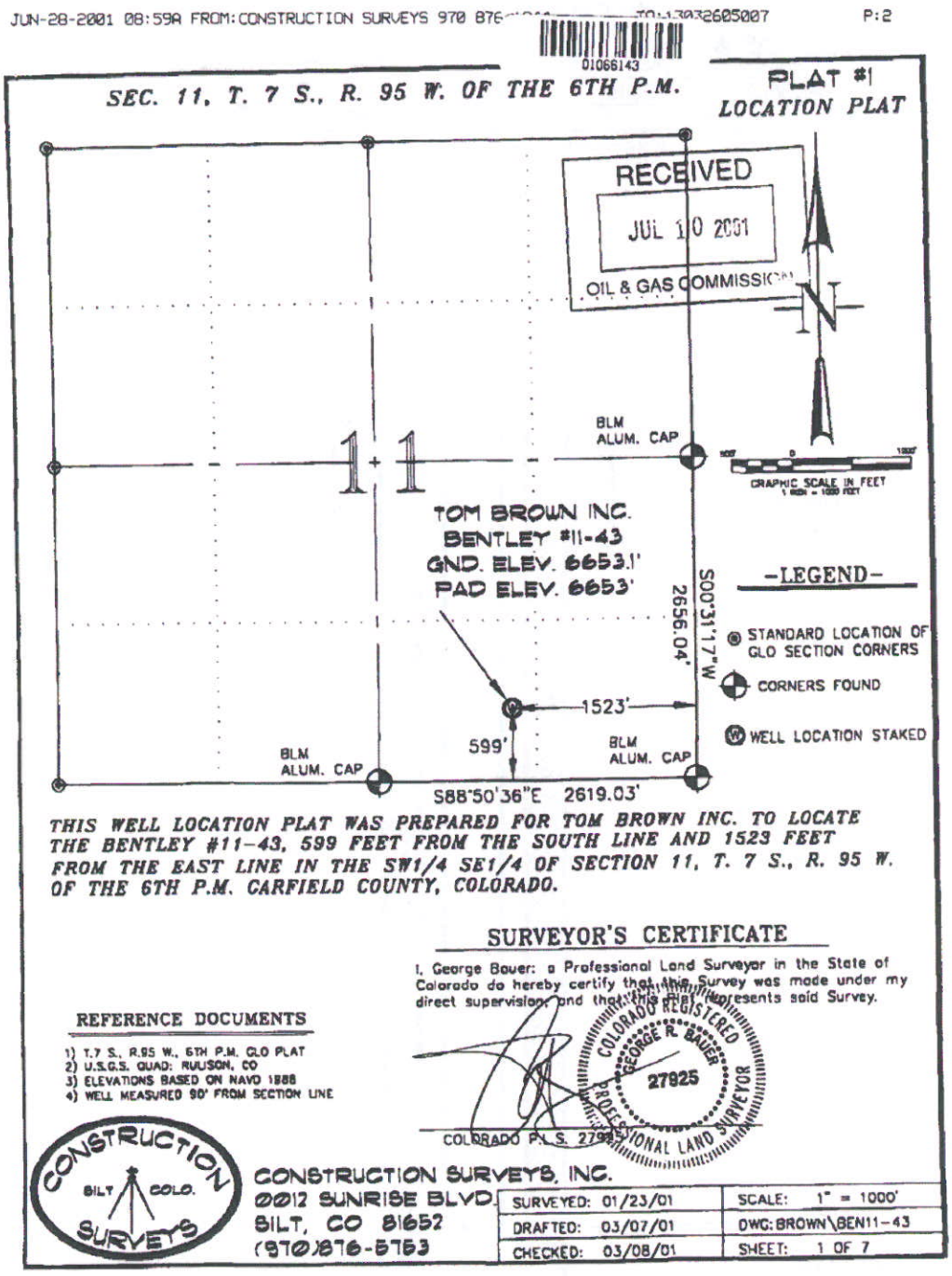


Figure A6. Location plat for Bentley 11-43 (from Colorado Oil & Gas Commission Database)

Table A3. Production data for Bentley 11-43 (from Colorado Oil & Gas Commission Database).

							OIL						Water Prod	Water(psig)	
							BOM	Produced	Sold	Adj.	EOM	Gravity		Tbg.	Csg.
Year	Month	Formation	Sidetrack	Well Status	Days Prod	Product	GAS						Water Disp. Code	Gas (psig)	
							Prod	Flared	Used	Shrinkage	Sold	BTU		Tbg.	Csg.
2003	Sep	WILLIAMS FORK	00	WO		Oil ->
Gas ->									
2003	Oct	WILLIAMS FORK	00	WO		Oil ->
Gas ->									
2003	Nov	WILLIAMS FORK	00	PR	26	Oil ->
Gas ->	48,184				48,184	1,040			
2003	Dec	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	48,243				48,243	1,028	3,461
P		
2004	Jan	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	39,284				39,284	1,028	2,496
M		
2004	Feb	WILLIAMS FORK	00	PR	29	Oil ->
Gas ->	32,503	45			45
32,503	1,053	1,790
M		
2004	Mar	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	45
30,796	4			49
30,796	1,053	1,416
M		
2004	Apr	WILLIAMS FORK	00	PR	30	Oil ->
Gas ->	49
27,019				49
27,019	1,053	929
M		
2004	May	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	49
25,433				49
25,433	1,035	757
M		
2004	Jun	WILLIAMS FORK	00	PR	30	Oil ->
Gas ->	49
22,799				49
22,799	1,035	2,235
M		
2004	Jul	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	49
23,209				49
23,209	1,035			
2004	Aug	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	49
20,550				49
20,550	1,012			
2004	Sep	WILLIAMS FORK	00	PR	30	Oil ->
Gas ->	49
18,821				49
18,821	1,012	580
M		
2004	Oct	WILLIAMS FORK	00	PR	31	Oil ->
Gas ->	49
18,183				49
18,183	1,012			

2004	Nov	WILLIAMS FORK	00	PR	29	Oil -> Gas ->	49 16,450				49 16,450	1,012			
2004	Dec	WILLIAMS FORK	00	PR	24	Oil -> Gas ->	49 12,676	1			50 12,676	1,012			
2005	Jan	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	50 18,639			-6	44 18,639	1,012			
2005	Feb	WILLIAMS FORK	00	PR	28	Oil -> Gas ->	44 14,733				44 14,733	1,011			

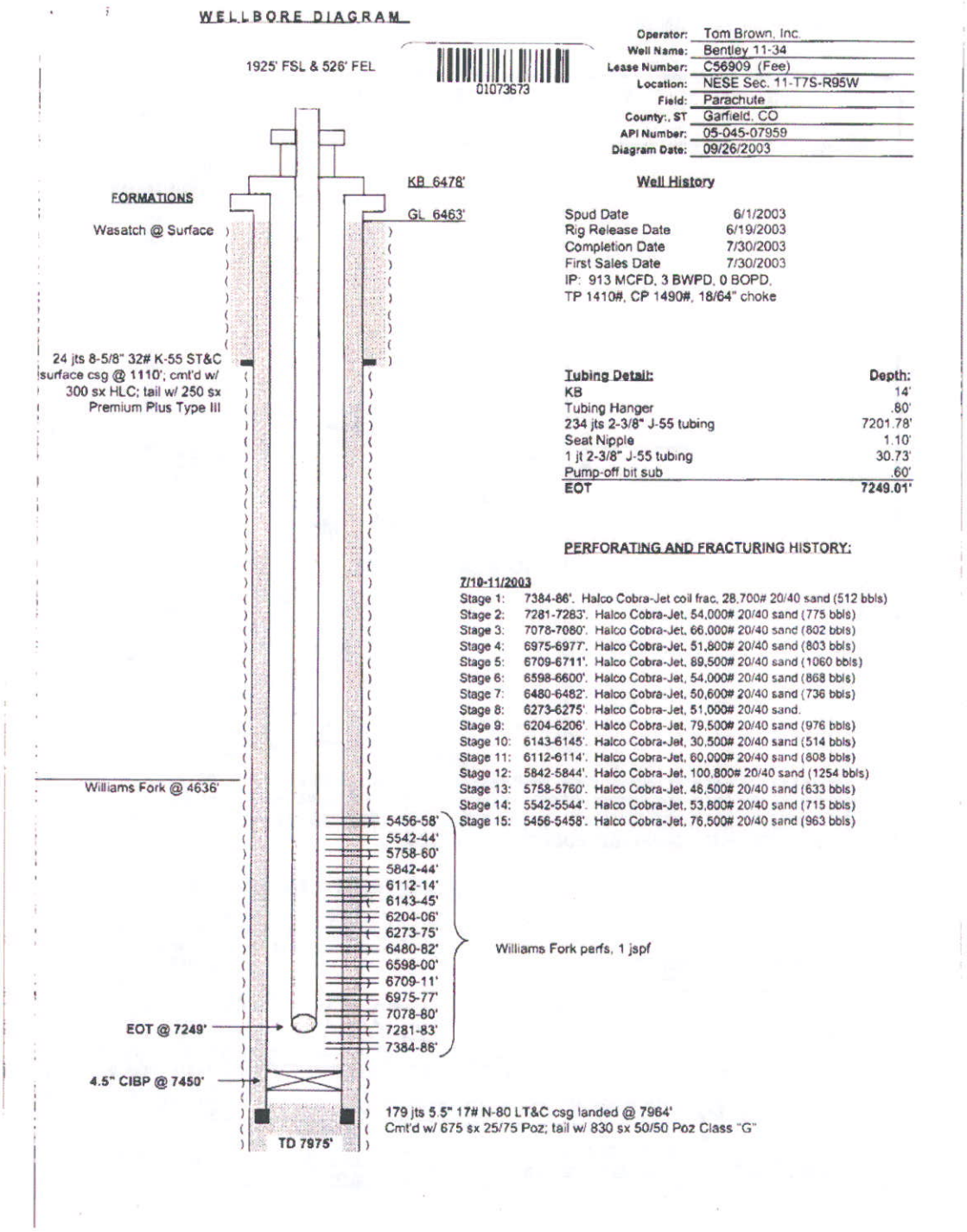


Figure A7. Wellbore diagram for Bentley 11-34 (from Colorado Oil & Gas Commission Database).

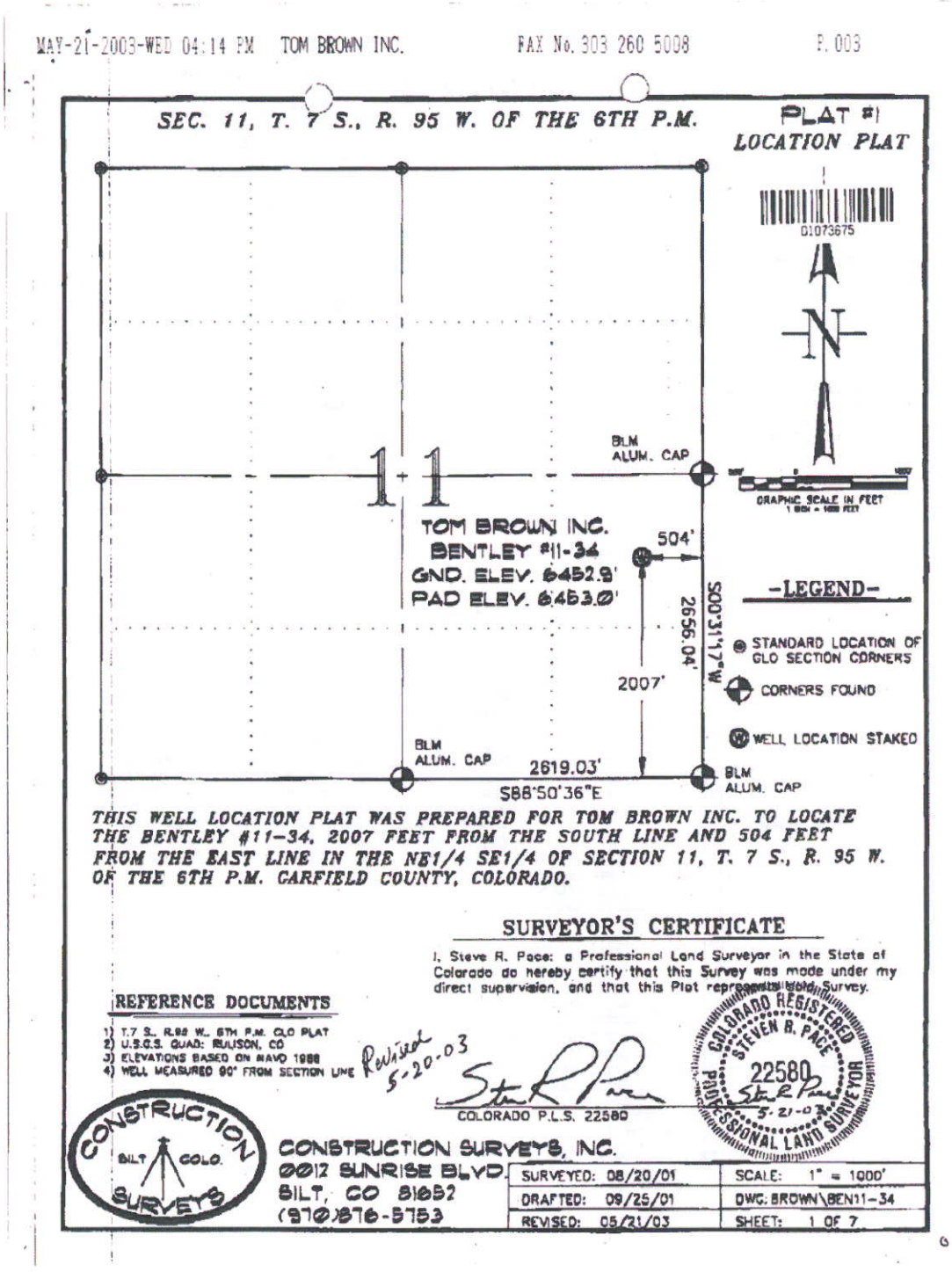


Figure A8. Location plat for Bentley 11-34 (from Colorado Oil & Gas Commission Database).

Table A4. Production data for Bentley 11-34 (from Colorado Oil & Gas Commission Database).

							OIL						Water Prod	Water(psig)	
							BOM	Produced	Sold	Adj.	EOM	Gravity		Tbg.	Csg.
Year	Month	Formation	Sidetrack	Well Status	Days Prod	Product	GAS						Water Disp. Code	Gas (psig)	
							Prod	Flared	Used	Shrinkage	Sold	BTU		Tbg.	Csg.
2003	Jun	WILLIAMS FORK	00	WO		Oil -> Gas ->									
2003	Jul	WILLIAMS FORK	00	PR	3	Oil -> Gas ->	2,346				2,346	1,122	3 P		
2003	Aug	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	29,275				29,275	1,089	44 P		
2003	Sep	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	20,248	54			54 20,248	1,077	1,219 P		
2003	Oct	WILLIAMS FORK	00	PR	29	Oil -> Gas ->	54 17,883	21			75 17,883	1,077	909 P		
2003	Nov	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	75 14,993				75 14,993	1,077	712 P		
2003	Dec	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	75 15,049				75 15,049	1,077	642 P		
2004	Jan	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	75 14,089				75 14,089	1,077	624 M		
2004	Feb	WILLIAMS FORK	00	PR	29	Oil -> Gas ->	75 12,087				75 12,087	1,083	580 M		
2004	Mar	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	75 11,626				75 11,626	1,083	1,133 M		
2004	Apr	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	75 9,923				75 9,923	1,083	313 M		
2004	May	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	75 10,525				75 10,525	1,081	383 M		
2004	Jun	WILLIAMS FORK	00	PR	27	Oil -> Gas ->	75 9,157			-15	60 9,157	1,081	1,225 M		
2004	Jul	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	60 9,664				60 9,664	1,081			

2004	Aug	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	60 9,120				60 9,120	1,081			
2004	Sep	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	60 8,647				60 8,647	1,081			
2004	Oct	WILLIAMS FORK	00	PR	31	Oil -> Gas ->	60 8,618	20			80 8,618	1,081			
2004	Nov	WILLIAMS FORK	00	PR	30	Oil -> Gas ->	80 7,611				80 7,611	1,081			
2004	Dec	WILLIAMS FORK	00	PR	26	Oil -> Gas ->	80 6,095				80 6,095	1,081			
2005	Jan	WILLIAMS FORK	00	PR	23	Oil -> Gas ->	80 7,373				80 7,373	1,081			
2005	Feb	WILLIAMS FORK	00	PR	28	Oil -> Gas ->	80 7,537				80 7,537	1,018			

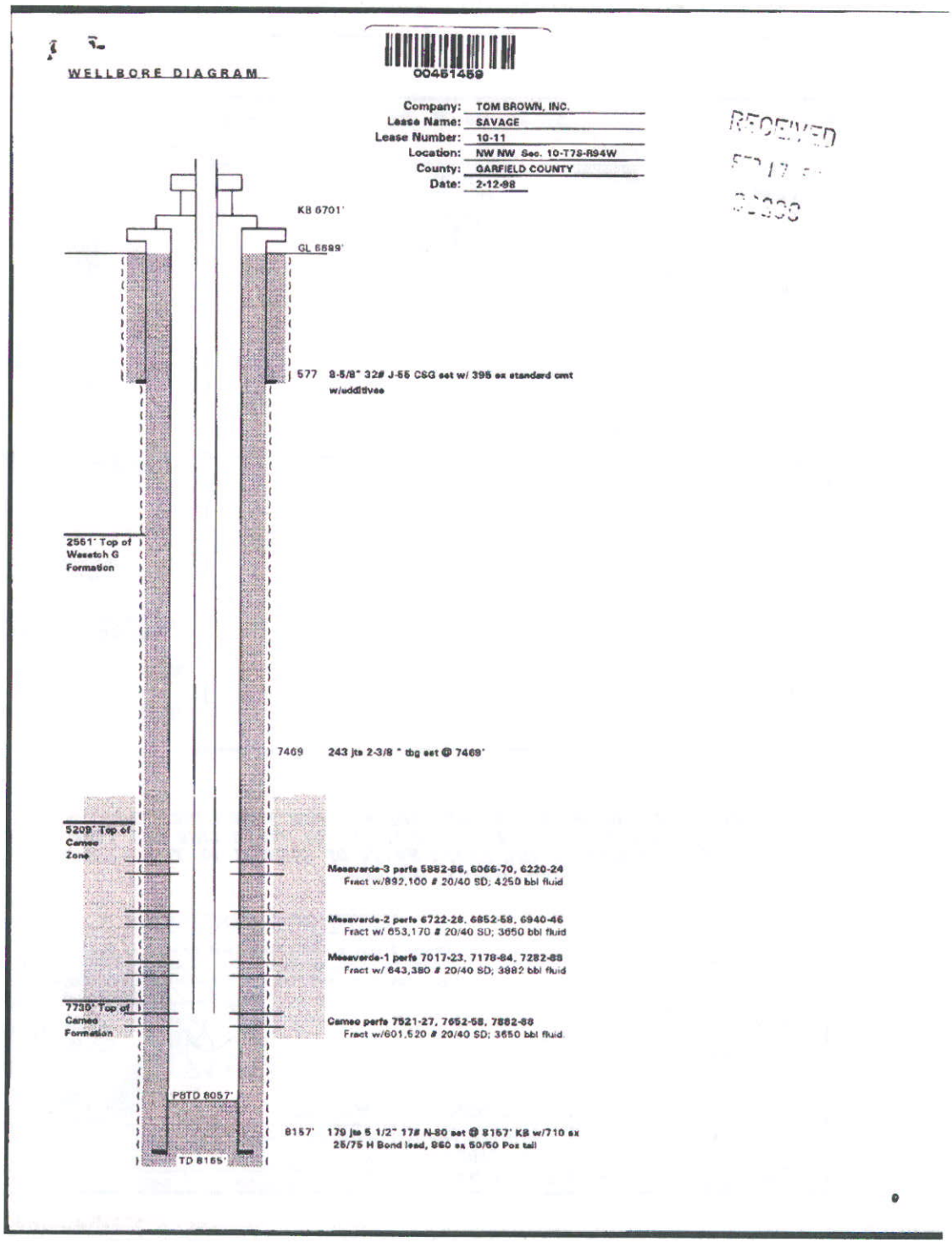


Figure A9. Wellbore Diagram for 10-11 Savage (from Colorado Oil & Gas Commission Database)

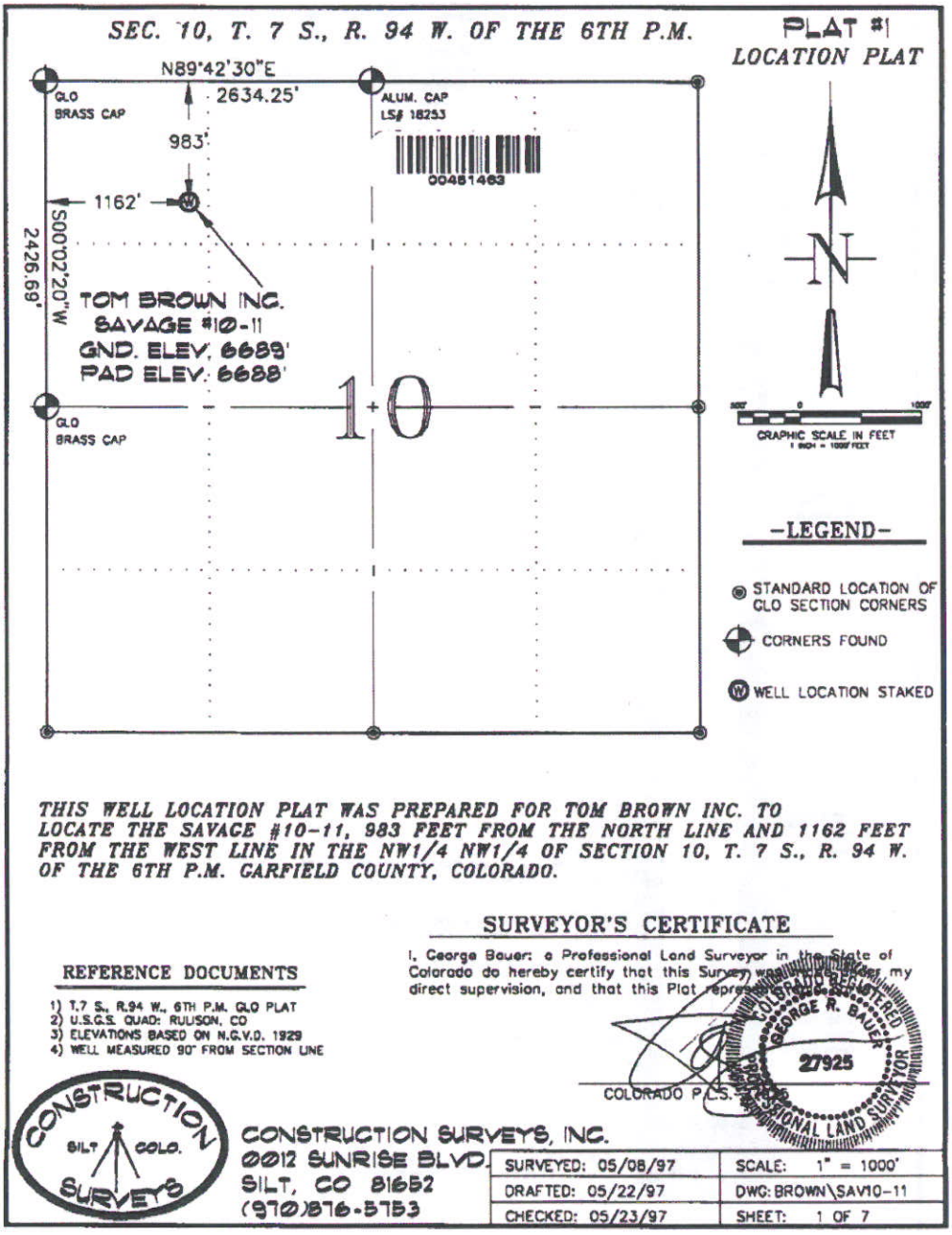


Figure A10. Well 10-11 Savage Location Plat (from Colorado Oil & Gas Commission Database).

Table A5. Production data for Well 10-11 Savage (from Colorado Oil & Gas Commission Database).

							OIL						Water Prod	Water(psig)	
							BOM	Produced	Sold	Adj.	EOM	Gravity		Tbg.	Csg.
Year	Month	Formation	Sidetrack	Well Status	Days Prod	Product	GAS						Water Disp. Code	Gas (psig)	
							Prod	Flared	Used	Shrinkage	Sold	BTU		Tbg.	Csg.
1999	Jan	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	174	35			209		204		
						Gas ->	7,116		93		7,023	1,112	M		
1999	Feb	WILLIAMS FORK - CAMEO	00	PR	28	Oil ->	209	23			232		235		
						Gas ->	6,360		84		6,276	1,112	M		
1999	Mar	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	232	25			257		174		
						Gas ->	6,712		93		6,619	1,112	M		
1999	Apr	WILLIAMS FORK - CAMEO	00	PR	30	Oil ->	257	33	190		100	57.2	165		
						Gas ->	6,180		90		6,090	1,112	M		
1999	May	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	100	30			130		133		
						Gas ->	5,712		93		5,619	1,081	M		
1999	Jun	WILLIAMS FORK - CAMEO	00	PR	30	Oil ->	130	24			154		132		
						Gas ->	5,721		90		5,631	1,081	M		
1999	Jul	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	154	20			174		151		
						Gas ->	5,646		93		5,553	1,109	M		
1999	Aug	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	174	26			200		106		
						Gas ->	5,674		93		5,581	1,109	M		
1999	Sep	WILLIAMS FORK - CAMEO	00	PR	30	Oil ->	200	25			225		228		
						Gas ->	5,280		90		5,190	1,109	M		
1999	Oct	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	225	23	198		50	56.3	124		
						Gas ->	5,210		93		5,117	1,123	M		
1999	Nov	WILLIAMS FORK - CAMEO	00	PR	30	Oil ->	50	24			74		136		
						Gas ->	5,087		90		4,997	1,123	M		
1999	Dec	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	74	35			109		124		
						Gas ->	5,157		93		5,064	1,123	M		
2000	Jan	WILLIAMS FORK - CAMEO	00	PR	31	Oil ->	109				109		135		
						Gas ->	5,191		93		5,098	1,123	M		
2000	Feb	WILLIAMS FORK - CAMEO	00	PR	29	Oil ->	109	48			157		54		
						Gas ->	4,347		87		4,260	1,123	M		

2000	Mar	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	157 4,994		93		157 4,901	1,123	187 M		
2000	Apr	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	157 4,722	20	90		177 4,632	1,123	209 M		
2000	May	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	177 4,845	13	93		190 4,752	1,123	229 M		
2000	Jun	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	190 4,652	22	90		212 4,562	1,129	157 M		
2000	Jul	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	212 4,730	8	185 93		35 4,637	55.9 1,129	167 M		
2000	Aug	WILLIAMS FORK - CAMEO	00	PR	27	Oil -> Gas ->	35 3,973	22	81		57 3,892	1,129	80 M		
2000	Sep	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	57 3,956	13	90		70 3,866	1,129	70 M		
2000	Oct	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	70 3,865	10	93		80 3,772	1,129	30 M		
2000	Nov	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	80 4,035	24	90		104 3,945	1,129	200 M		
2000	Dec	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	104 3,814	36	84		140 3,730	1,129	85 M		
2001	Jan	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	140 4,145		93		140 4,052	1,129	150 M		
2001	Feb	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	140 3,690	10	84		150 3,606	1,129	150 M		
2001	Mar	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	150 4,081	20	93		170 3,988	1,129	115 M		
2001	Apr	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	170 3,355	24	90		194 3,265	1,129	100 M		
2001	May	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	194 2,209	15	93		209 2,116	1,129	60 M		
2001	Jun	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	209 3,101	16	90		225 3,011	1,129	60 M		
2001	Jul	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	225 3,754	19	189 93		55 3,661	55.1 1,129	70 M		
2001	Aug	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	55 3,657		93	-27	28 3,564	1,129	70 M		

2001	Sep	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	28 3,285	29	84		57 3,201	1,129	30 M		
2001	Oct	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	57 2,587	10	93		67 2,494	1,129	100 M		
2001	Nov	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	67 3,872	30	90		97 3,782	1,129	80 M		
2001	Dec	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	97 3,843	63	93		160 3,750	1,129	140 M		
2002	Jan	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	160 759		90		160 669	1,129	20 M		
2002	Feb	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	160 3,773	24	84		184 3,689	1,129	40 M		
2002	Mar	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	184 3,285	66	93		250 3,192	1,075	46 M		
2002	Apr	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	250 2,829		90	-96	154 2,739	1,074	40 M		
2002	May	WILLIAMS FORK - CAMEO	00	PR	17	Oil -> Gas ->	154 2,265	35	51		189 2,214	1,075	40 M		
2002	Jun	WILLIAMS FORK - CAMEO	00	PR	26	Oil -> Gas ->	189 2,349	11	78		200 2,271	1,075	60 M		
2002	Jul	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	200 3,058	10	93		210 2,965	1,075	55 M		
2002	Aug	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	210 2,996		93		210 2,903	1,075	60 M		
2002	Sep	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	210 2,876	20	90		230 2,786	1,110	70 M		
2002	Oct	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	230 2,788	51	84		281 2,704	1,110	30 M		
2002	Nov	WILLIAMS FORK - CAMEO	00	PR	27	Oil -> Gas ->	281 3,008		81	-104	177 2,927	1,110	140 M		
2002	Dec	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	177 2,407	23	93		200 2,314	1,109	110 M		
2003	Jan	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	200 2,340	10	93		210 2,247	1,109	100 M		
2003	Feb	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	210 1,645	30	84		240 1,561	1,109			

2003	Mar	WILLIAMS FORK - CAMEO	00	PR	10	Oil -> Gas ->	240 311	20	30		260 281	1,109			
2003	Apr	WILLIAMS FORK - CAMEO	00	PR	23	Oil -> Gas ->	260 4,272	16	69		276 4,203	1,120			
2003	May	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	276 3,247	20	186 93		110 3,154	55.6 1,120			
2003	Jun	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	110 2,102	10	90		120 2,012	1,120			
2003	Jul	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	120 2,459	10	93		130 2,366	1,120			
2003	Aug	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	130 2,628	10	93		140 2,535	1,120			
2003	Sep	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	140 2,851	20	90		160 2,761	1,120			
2003	Oct	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	160 3,150		90		160 3,060	1,119			
2003	Nov	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	160 2,784		84		160 2,700	1,119			
2003	Dec	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	160 3,482	22	142 93		40 3,389	53.1 1,119			
2004	Jan	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	40 3,011		93		40 2,918	1,119			
2004	Feb	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	40 2,326		84	-8	32 2,242	1,119	36 M		
2004	Mar	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	32 2,929		90		32 2,839	1,119	96 M		
2004	Apr	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	32 2,525	13	90		45 2,435	1,119	120 M		
2004	May	WILLIAMS FORK - CAMEO	00	PR	9	Oil -> Gas ->	45 982		27		45 955	1,125	36 M		
2004	Jun	WILLIAMS FORK - CAMEO	00	SI		Oil -> Gas ->	45				45				
2004	Jul	WILLIAMS FORK - CAMEO	00	SI		Oil -> Gas ->	45				45				
2004	Aug	WILLIAMS FORK - CAMEO	00	SI		Oil -> Gas ->	45				45				

2004	Sep	WILLIAMS FORK - CAMEO	00	SI		Oil -> Gas ->	45				45				
2004	Oct	WILLIAMS FORK - CAMEO	00	PR	19	Oil -> Gas ->	45 3,488				45 3,488	 1,125	78 M		
2004	Nov	WILLIAMS FORK - CAMEO	00	PR	30	Oil -> Gas ->	45 6,213	362	182		225 6,213	54.0 1,105	180 M		
2004	Dec	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	225 1,759	105	285		45 1,759	54.1 1,105	186 M		
2005	Jan	WILLIAMS FORK - CAMEO	00	PR	31	Oil -> Gas ->	45 4,786				45 4,786	 1,105	186 M		
2005	Feb	WILLIAMS FORK - CAMEO	00	PR	28	Oil -> Gas ->	45 3,438				45 3,438	 1,105	168 M		

DISTRIBUTION

Public Reading Facility
c/o Nuclear Testing Archive
Nevada Site Office
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U.S. Department of Energy
P.O. Box 98521
Las Vegas, NV 89193-8521

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Oak Ridge, TN 37831-9939
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APPENDIX E

PRESCO, INC. WELL GAS SAMPLES
2005 – 2006

ISOTECH®

www.isotechlabs.com mail@isotechlabs.com

Isotech Laboratories, Inc. 1308 Parkland Court Champaign, IL 61821-1826 Telephone 217/398-3490 FAX 217/398-3493

March 3, 2006

James Hix
Cordilleran Compliance
5550 Marshall Street
Arvada, CO 80002

Dear James:

Enclosed are the analysis report for the 4 gas samples recently submitted from your project number E04243. These samples were assigned to Isotech job numbers 6756 & 6902. These are the same data that were emailed to you earlier. If you have any questions, or if there is anything else we can do for you, please do not hesitate to contact us.

We will hold the samples until 03/30/06 in case you should want any additional analyses carried out and will then dispose of the remaining sample material. If you need us to hold the samples longer, please contact us. I have also enclosed an invoice for this work and would appreciate it if you would pass it on to the appropriate office for processing. Thank you for choosing Isotech for your analysis needs, we appreciate your business.

Sincerely,

Steven R. Pelphrey

Steven R. Pelphrey
Laboratory Manager

Enclosure

SRP:cw

ANALYSIS REPORT

Lab #:	91785	Job #:	6756
Sample Name/Number:	BM26-42		
Company:	Cordilleran Compliance Services		
Date Sampled:	12/07/2005		
Container:	Steel tank		
Field/Site Name:	E04243 PRESCO		
Location:	Battlement Mesa, Garfield Co.		
Formation/Depth:			
Sampling Point:			
Date Received:	12/09/2005	Date Reported:	2/15/2006

Component	Chemical mol. %	Delta C-13 per mil	Delta D per mil	C-14 conc. pMC	Tritium TU
Carbon Monoxide	nd				
Hydrogen Sulfide	nd				
Helium	0.0021				
Hydrogen	0.0029				
Argon	0.0265				
Oxygen	0.527				
Nitrogen	2.33				
Carbon Dioxide	5.34	-6.12			
Methane	84.23	-36.99	-171.5		
Ethane	4.51				
Ethylene	nd				
Propane	1.90				
Iso-butane	0.349				
N-butane	0.383				
Iso-pentane	0.158				
N-pentane	0.114				
Hexanes +	0.126				

Total BTU/cu.ft. dry @ 60deg F & 14.7psia, calculated: 1024

Specific gravity, calculated: 0.677

Remarks:

Sample arrived under vacuum, therefore radiocarbon and tritium analyses could not be completed due to limited sample amount.

nd = not detected. na = not analyzed. Isotopic composition of carbon is relative to VPDB. Isotopic composition of hydrogen is relative to VSMOW. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. % Chemical analysis based on standards accurate to within 2%.

ANALYSIS REPORT

Lab #:	91786	Job #:	6756
Sample Name/Number:	BM27-44		
Company:	Cordilleran Compliance Services		
Date Sampled:	12/07/2005		
Container:	Steel tank		
Field/Site Name:	E04243 PRESCO		
Location:	Battlement Mesa, Garfield Co.		
Formation/Depth:			
Sampling Point:			
Date Received:	12/09/2005	Date Reported:	2/15/2006

Component	Chemical mol. %	Delta C-13 per mil	Delta D per mil	C-14 conc. pMC	Tritium TU
Carbon Monoxide	nd				
Hydrogen Sulfide	nd				
Helium	0.0031				
Hydrogen	0.0042				
Argon	0.258				
Oxygen	5.78				
Nitrogen	24.78				
Carbon Dioxide	4.60	-5.54			
Methane	60.22	-36.88	-198.5	< 0.50	< 10.0
Ethane	2.95				
Ethylene	nd				
Propane	0.833				
Iso-butane	0.165				
N-butane	0.176				
Iso-pentane	0.0658				
N-pentane	0.0518				
Hexanes +	0.109				

Total BTU/cu.ft. dry @ 60deg F & 14.7psia, calculated: 705
Specific gravity, calculated: 0.767

nd = not detected. na = not analyzed. Isotopic composition of carbon is relative to VPDB. Isotopic composition of hydrogen is relative to VSMOW. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. % Chemical analysis based on standards accurate to within 2%.

ANALYSIS REPORT

Lab #:	94233	Job #:	6902
Sample Name/Number:	BM26-42		
Company:	Cordilleran Compliance Services		
Date Sampled:	1/27/2006	Cylinder:	17A
Container:	Steel tank		
Field/Site Name:	Presco E04243		
Location:			
Formation/Depth:			
Sampling Point:			
Date Received:	1/30/2006	Date Reported:	2/21/2006

Component	Chemical mol. %	Delta C-13 per mil	Delta D per mil	C-14 conc. pMC	Tritium TU
Carbon Monoxide	nd				
Hydrogen Sulfide	nd				
Helium	0.0023				
Hydrogen	0.0032				
Argon	nd				
Oxygen	0.0075				
Nitrogen	0.090				
Carbon Dioxide	4.69	-5.25			
Methane	87.83	-37.04	-181.5	< 0.60	< 10.0
Ethane	4.65				
Ethylene	nd				
Propane	1.54				
Iso-butane	0.332				
N-butane	0.365				
Iso-pentane	0.145				
N-pentane	0.108				
Hexanes +	0.239				

Total BTU/cu.ft. dry @ 60deg F & 14.7psia, calculated: 1057

Specific gravity, calculated: 0.658

nd = not detected. na = not analyzed. Isotopic composition of carbon is relative to VPDB. Isotopic composition of hydrogen is relative to VSMOW. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. % Chemical analysis based on standards accurate to within 2%

ANALYSIS REPORT

Lab #:	94234	Job #:	6902
Sample Name/Number:	BM36-13		
Company:	Cordilleran Compliance Services		
Date Sampled:	1/27/2006	Cylinder:	24A
Container:	Steel tank		
Field/Site Name:	Presco E04243		
Location:			
Formation/Depth:			
Sampling Point:			
Date Received:	1/30/2006	Date Reported:	2/21/2006

Component	Chemical mol. %	Delta C-13 per mil	Delta D per mil	C-14 conc. pMC	Tritium TU
Carbon Monoxide	nd				
Hydrogen Sulfide	nd				
Helium	0.0027				
Hydrogen	0.0077				
Argon	nd				
Oxygen	0.0077				
Nitrogen	0.31				
Carbon Dioxide	6.96	-5.08			
Methane	86.14	-36.63	-171.6	< 0.50	< 10.0
Ethane	4.38				
Ethylene	nd				
Propane	1.27				
Iso-butane	0.265				
N-butane	0.282				
Iso-pentane	0.110				
N-pentane	0.0825				
Hexanes +	0.181				

Total BTU/cu.ft. dry @ 60deg F & 14.7psia, calculated: 1018

Specific gravity, calculated: 0.672

nd = not detected. na = not analyzed. Isotopic composition of carbon is relative to VPDB. Isotopic composition of hydrogen is relative to VSMOW. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. % Chemical analysis based on standards accurate to within 2%.

ISOTECH®

www.isotechlabs.com mail@isotechlabs.com

Isotech Laboratories, Inc. 1308 Parkland Court Champaign, IL 61821-1826 Telephone 217/398-3490 FAX 217/398-3493

April 25, 2006

James Hix
Cordilleran Compliance
5550 Marshall Street
Arvada, CO 80002

Dear James:

Enclosed is the analysis report for the gas sample recently submitted from project EO4243 for RUSH turnaround. This sample was assigned to Isotech job number 7103. These are the same data that were emailed to you earlier. If you have any questions, or if there is anything else we can do for you, please do not hesitate to contact us.

We will hold the sample until 05/17/06 in case you should want any additional analyses carried out and will then dispose of the remaining sample material. If you need us to hold the sample longer, please contact us. I have also enclosed an invoice for this work and would appreciate it if you would pass it on to the appropriate office for processing. Thank you for choosing Isotech for your analysis needs, we appreciate your business.

Sincerely,

Steven R. Pelphrey

Steven R. Pelphrey
Laboratory Manager

Enclosure

SRP:cw

ANALYSIS REPORT

Lab #:	96760	Job #:	7103
Sample Name/Number:	BM 26-42		
Company:	Cordilleran Compliance Services		
Date Sampled:	4/05/2006	Cylinder:	7A
Container:	Steel tank		
Field/Site Name:	Presco (E04243)		
Location:			
Formation/Depth:			
Sampling Point:			
Date Received:	4/06/2006	Date Reported:	4/21/2006

Component	Chemical mol. %	Delta C-13 per mil	Delta D per mil	C-14 conc. pMC	Tritium TU
Carbon Monoxide	nd				
Hydrogen Sulfide	nd				
Helium	0.0025				
Hydrogen	0.0041				
Argon	nd				
Oxygen	0.0307				
Nitrogen	0.20				
Carbon Dioxide	3.77	-5.11			
Methane	88.65	-36.97	-173.9	< 0.4	< 12.0
Ethane	4.66				
Ethylene	nd				
Propane	1.53				
Iso-butane	0.334				
N-butane	0.365				
Iso-pentane	0.147				
N-pentane	0.106				
Hexanes +	0.201				

Total BTU/cu.ft. dry @ 60deg F & 14.7psia, calculated: 1064
Specific gravity, calculated: 0.649

nd = not detected. na = not analyzed. Isotopic composition of carbon is relative to VPDB. Isotopic composition of hydrogen is relative to VSMOW. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. % Chemical analysis based on standards accurate to within 2%

APPENDIX F

PRODUCED WATER SAMPLE ANALYTICAL RESULTS 2005

PARAGON ANALYTICS
225 Commerce Drive ◆ Fort Collins, CO 80524 ◆ (800) 443-1511 ◆ (970) 490-1511 ◆ FAX (970) 490-1522

February 13, 2006

Mr. James Hix
Cordilleran Compliance Services, Inc.
5550 Marshall Street
Arvada, CO 80002

Re: Paragon Workorder: 05-12-143
Client Project Name: Battlement Mesa
Client Project Number: E04243

Dear Mr. Hix:

One water sample was received from Cordilleran Compliance Services, Inc. on December 16, 2005. The sample was scheduled for Tritium (pages 1-57) and Gamma Spectroscopy (page 1-106) analyses.

The results for these analyses are contained in the enclosed reports.

Thank you for your confidence in Paragon Analytics. Should you have any questions, please call.

Sincerely,

Paragon Analytics
Lance Steere
Senior Project Manager

LRS/ja
Enclosure: Report

Paragon Analytics

Sample Number(s) Cross-Reference Table

Paragon OrderNum: 0512143
Client Name: Cordilleran Compliance Services, Inc.
Client Project Name: Battlement Mesa
Client Project Number: E04243
Client PO Number:

Client Sample	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
BM2642W	0512143-1		WATER	07-Dec-05	10:35

0512143

0512147 MW 12/16/05

Paragon Analytics
A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 80524
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID) 0512147

Chain-of-Custody Date _____ Page ___ of ___ **Originator:** Retain pink copy

Project Name / No.: _____ Sampler(s): _____ Turnaround (circle one): **Standard** or **Rush (Due** _____ **)** Dispose: **Date** _____ or **Return** to Client

Report To: James Hix
Phone: 303.237-2072
Fax: 303.237-2659
E-mail: jameshix@cordcomp.com
Company: Cordilleran Compliance Services
Address: 5550 Marshall Street
Arvada, CO 80002

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs SW8260B E624 E524.2	BTEX (only) SW8021B	SVOCs SW8270C E625	OC Pesticides SW8081A E608	PCBs SW8082 E608	Herbicides SW8151A	Explosives SW8330	TCLP Organics SW1311 SW8260B 8270C 8081A 8151A	TCLP Metals SW1311 SW6010B SW7471	Total Metals by ICP SW6010B 7470 7471 E200 ILMO___	Dissolved Metals by ICP SW6010B 7470 E200 ILMO___	Total Metals by ICP/MS SW6020 E200.8 ILMO___	Dissolved Metals by ICP/MS SW6020 E200.8 ILMO___	Hexavalent Chromium SW7196A Alkaline Digest? Y / N	Inorganic Anions SW9056 E300.0 (specify in comments)	Solids: Total E160.3 TDS E160.1 TSS E160.2	pH SW9040B SW9045C	TPH GRO DRO SW8015B (both)	Gross Alpha / Beta SW9310 E900.0	Actinides by Paragon SOP Pu / U / Am / Th / Cm / ___	Tritium H3 E906.0	Total Alpha-Emitting Radium SW9315 E903.0	Radium 226 E903.1 SW9320 E904.0	Strontium 89 D5811-00	Gamma Isotopes E901.1 (HW03)
BM2642W	12/7/05	1035	(1)	W	ICE ACID	2																					✓				✓

* Time Zone: EST CST MST PST Matrix Key: O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments:

Form 202r5.xls (4/6/04)

Relinquished By: (1)	Relinquished By: (2)
Signature James W. Hix	Signature
Printed Name James Hix	Printed Name
Date 12/15/05 Time	Date Time
Company Cordilleran to Fed X	Company

Received By: (1)	Received By: (2)
Signature	Signature
Printed Name Matt Workman	Printed Name
Date 12/16/05 Time 1005	Date Time
Company PA	Company

Paragon Analytics

CONDITION OF SAMPLE UPON RECEIPT FORM

Client: Cordillieran Workorder No: 0512143

Project Manager: ~~JT 12/16/05~~ LRS Initials: MW Date: 12/16/05

1.	Does this project require any **special handling** in addition to standard Paragon procedures?		YES	(NO)
2.	Is **pre-screening** required per SOP 008?		YES	~~NO~~
3.	Are custody **seals** on **shipping containers** intact?	N/A	~~YES~~	NO
4.	Are custody **seals** on **sample containers** intact?	~~N/A~~	YES	NO
5.	Is there a **COC (Chain-of-Custody) present** or other representative documents?		~~YES~~	NO
6.	Is the **COC** (if applicable) **complete and legible**?	N/A	~~YES~~	NO
7.	Are **bottle IDs legible** and in **agreement** with **COC sample IDs**?	N/A	~~YES~~	NO
8.	Is the COC in agreement with samples received? (**# of samples, # of containers, matrix**)	N/A	~~YES~~	NO
9.	Were **airbills** present and/or removable?	N/A	~~YES~~	NO
10.	Are all **aqueous samples** requiring preservation **preserved correctly**? (excluding volatile organics)	N/A	~~YES~~	NO
11.	Are all aqueous **non-preserved samples** at the **correct pH**?	N/A	~~YES~~	NO
12.	Is there **sufficient sample** for the requested analyses?		~~YES~~	NO
13.	Were all samples placed in the **proper containers** for the requested analyses?		~~YES~~	NO
14.	Are all samples within **holding times** for the requested analyses?		~~YES~~	NO
15.	Were all sample containers received **intact**? (not broken or leaking, etc.)		~~YES~~	NO
16.	Are all samples requiring no headspace (volatiles, reactive cyanide/sulfide, radon), headspace free? **Size of bubble**: ____ < green pea ____ > green pea	~~N/A~~	YES	NO
17.	Were samples checked for and free from the presence of **residual chlorine?** (Applicable when PM has indicated samples are from a chlorinated water source; note if field preservation with sodium thiosulfate was not observed.)	~~N/A~~	YES	NO
18.	Were the sample(s) **shipped on ice**?	N/A	~~YES~~	NO
19.	Were cooler temperatures measured at 0.1-6.0°C?	N/A	(YES)	NO

***IR gun used** *(circle one)*: #2 - Oakton InfraPro II, SN2922500201-0066; (#4) - Oakton InfraPro II, SN2372220101-0002

Cooler #'s 1

Temperature (°C) 1.8

No. of custody seals 1

DOT Survey/ Acceptance Information

External µR/hr reading 13

Background µR/hr reading 12

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? (YES) / NO (If no, see Form 008.)

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE EXCEPT #1 AND #2.

If applicable, was the client contacted? YES / NO / NA Contact Name:_____ Date/Time:_____

Project Manager Signature/ Date: 12/19/05

FedEx Express **US Airbill**

FedEx Tracking Number **8548 9974 1340**

From (Print) **0200**

0512143

Recipient's Copy

1 From

Date 12/15/05

Sender's Name James Hix Phone 303 231-2112

Company E.I. Hunt Construction Group, Inc.

Address 5610 Marshall Street

Dept./Floor/Suite/Room

City Arvada State CO ZIP 80002

2 Your Internal Billing Reference EC1213 / Nitro DM212

3 To

Recipient's Name Supply Receiving Phone (800) 443-1311 120 490-1311

Company Paragon Aviation

Recipient's Address 335 Commerce Drive

We cannot deliver to P.O. boxes or P.O. ZIP codes.

Dept./Floor/Suite/Room

Address

To request a package be held at a specific FedEx location, print FedEx address here.

City Fort Collins State CO ZIP 80524

4a Express Package Service To add SATURDAY Delivery, see Section 6. *Packages up to 150 lbs.* * To most locations.

- [x] FedEx Priority Overnight — Next business morning.*
- [ ] FedEx Standard Overnight — Next business afternoon.*
- [ ] FedEx First Overnight — Earliest next business morning delivery to select locations.*
- [ ] FedEx 2Day — Second business day.*
- [ ] FedEx Express Saver — Third business day.*

FedEx Envelope rate not available. Minimum charge: One-pound rate.

4b Express Freight Service To add SATURDAY Delivery, see Section 6. *Packages over 150 lbs.* ** To most locations.

- [ ] FedEx 1Day Freight* — Next business day.**
- [ ] FedEx 2Day Freight — Second business day.**
- [ ] FedEx 3Day Freight — Third business day.**

* Call for Confirmation:

5 Packaging * Declared value limit $500.

- [ ] FedEx Envelope*
- [ ] FedEx Pak* — Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak.
- [ ] FedEx Box
- [ ] FedEx Tube
- [x] Other

6 Special Handling Include FedEx address in Section 3.

- [ ] **SATURDAY Delivery** — Available ONLY for FedEx Priority Overnight, FedEx 2Day, FedEx 1Day Freight, and FedEx 2Day Freight to select ZIP codes.
- [ ] **HOLD Weekday at FedEx Location** — Not available for FedEx First Overnight.
- [ ] **HOLD Saturday at FedEx Location** — Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.

Does this shipment contain dangerous goods? One box must be checked.

- [x] No
- [ ] Yes — As per attached Shipper's Declaration
- [ ] Shipper's Declaration not required
- [ ] Dry Ice — Dry Ice, 9, UN 1845 ____ x ____ kg

Dangerous goods (including dry ice) cannot be shipped in FedEx packaging.

- [ ] Cargo Aircraft Only

7 Payment *Bill to:* Enter FedEx Acct. No. or Credit Card No. below.

- [x] Sender — Acct. No in Section 1 will be billed.
- [ ] Recipient
- [ ] Third Party
- [x] Credit Card
- [ ] Cash/Check

Obtain Recip. Acct. No. [ ]

Total Packages	Total Weight	Total Declared Value†	Total Charges
1	10	$ N/C .00	

†Our liability is limited to $100 unless you declare a higher value. See back for details.

Credit Card Auth.

8 *NEW* Residential Delivery Signature Options If you require a signature, check Direct or Indirect.

- [ ] **No Signature Required** — Package may be left without obtaining a signature for delivery.
- [ ] **Direct Signature** — Anyone at recipient's address may sign for delivery. *Fee applies.*
- [ ] **Indirect Signature** — If no one is available at recipient's address, anyone at a neighboring address may sign for delivery. *Fee applies.*

520

8548 9974 1340

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Paragon Analytics
Radiochemistry Case Narrative
Tritium

Cordilleran Compliance Services, Inc.
Battlement Mesa / E04243
Paragon WO 0512143

1. This report consists of the analytical results and supporting documentation for one water sample received by Paragon on 12/16/05.

2. This sample was prepared according to Paragon Analytics procedures SOP700R9.

3. The sample was analyzed for the presence of tritium according to Paragon Analytics procedure SOP704R7. The analyses were completed on 01/04/06.

4. The analysis results for this sample are reported in units of pCi/L. The sample was not filtered prior to analysis.

5. Three reagent blanks were prepared with batch 3H051227-1. Reagent Blank 3H051227-1CB1, had a "window 2" count rate above the upper control limit. Due to being quenched for the method of standard addition for a sample in another workorder within this prep batch, this sample is unable to be recounted. In lieu of recounting, this sample will be rejected and only two reagent blanks will be used to determine the background and "window 2" rates for this sample. Data quality is not believed to be significantly affected and is submitted without further qualification. Please refer to QASS 301208.

6. For this analysis, "Window 2" is monitored for high-energy beta contamination. Sample BM2642W (Paragon ID 0512143-1) has a "Window 2" count rate of 45.39, above the upper control limit of 43.50. This sample has measured activity less than the achieved MDC. Data quality is not believed to be significantly affected. Data is submitted without further qualification.

7. No further anomalous situations were encountered during the preparation or analysis of this sample. All remaining quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, Paragon Analytics certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Krista Bishop
Radiochemistry Instrument Technician

2/01/06
Date

Radiochemistry Final Data Review

2/3/06
Date

000001

1

PARAGON ANALYTICS, INC.
Radiochemistry Data Package

Section 1

SAMPLE RESULTS SUMMARY

Tritium Analysis By Liquid Scintillation Sample Results Summary

Client Name: Cordilleran Compliance Services, Inc.
Client Project Name: Battlement Mesa
Client Project Number: E04243

Laboratory Name: Paragon Analytics
PAI Work Order: 0512143

Reported on: Wednesday, February 01, 2006 2:46:45 PM

Lab Sample ID	Client Sample ID	Sample Type	Nuclide	Result +/- 2 s TPU	MDC	Units	Matrix	Prep Batch	Date Analyzed	Flags
0512143-1	BM2642W	Sample	H-3	130 +/- 210	340	pCi/l	WATER	3H051227-1	1/3/2006	U

Comments:

Data Package ID: *h30512143-1*

Qualifiers/Flags:

U - Result is less than the sample specific MDC.
LT - Result is less than Requested MDC, greater than sample specific MDC.
Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
Y2 - Chemical Yield outside default limits.
M - The requested MDC was not met.
M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)
MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

30000

2

PARAGON ANALYTICS, INC.

Radiochemistry Data Package

Section 2

QC RESULTS SUMMARY

Tritium Analysis By Liquid Scintillation

PAI 704 Rev 7

Method Blank Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Lab ID: 3H051227-1MB

Sample Matrix: WATER
Prep SOP: PAI 700 Rev 9
Date Collected: 27-Dec-05
Date Prepared: 27-Dec-05
Date Analyzed: 03-Jan-06

Prep Batch: 3H051227-1
QCBatchID: 3H051227-1-1
Run ID: 3H051227-1A
Count Time: 100 minutes

Final Aliquot: 10.0 ml
Result Units: pCi/l
File Name: Manual Entry

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
10028-17-8	H-3	130 +/- 210	340	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Data Package ID: *H30512143-1*

Tritium Analysis By Liquid Scintillation

PAI 704 Rev 7

Laboratory Control Sample(s)

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Lab ID: 3H051227-1LCS

Sample Matrix: WATER
Prep SOP: PAI 700 Rev 9
Date Collected: 27-Dec-05
Date Prepared: 27-Dec-05
Date Analyzed: 03-Jan-06

Prep Batch: 3H051227-1
QCBatchID: 3H051227-1-1
Run ID: 3H051227-1A
Count Time: 100 minutes

Final Aliquot: 9.90 ml
Result Units: pCi/l
File Name: Manual Entry

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
10028-17-8	H-3	7900 +/- 1200	300	8300	95.4	85 - 115	P

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.
LT - Result is less than Requested MDC, greater than sample specific MDC.
Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.
Y2 - Chemical Yield outside default limits.
L - LCS Recovery below lower control limit.
H - LCS Recovery above upper control limit.
P - LCS Recovery within control limits.
M - The requested MDC was not met.
M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)
MDC - Minimum Detectable Concentration (see PAI SOP 709)

Data Package ID: *H30512143-1*

PARAGON ANALYTICS, INC.
Radiochemistry Data Package

3

Section 3

INDIVIDUAL SAMPLE RESULTS

Tritium Analysis By Liquid Scintillation

PAI 704 Rev 7

Sample Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Field ID: BM2642W
Lab ID: 0512143-1

Sample Matrix: WATER
Prep SOP: PAI 700 Rev 9
Date Collected: 07-Dec-05
Date Prepared: 27-Dec-05
Date Analyzed: 03-Jan-06

Prep Batch: 3H051227-1
QCBatchID: 3H051227-1-1
Run ID: 3H051227-1A
Count Time: 100 minutes
Report Basis: Unfiltered

Final Aliquot: 10.0 ml
Prep Basis: Unfiltered
Moisture(%): 100.000
Result Units: pCi/l
File Name: Manual Entry

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
10028-17-8	H-3	130 +/- 210	340	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *H30512143-1*

PARAGON ANALYTICS, INC.
Radiochemistry Data Package



Section 4

RAW DATA

Tritium Analysis By Liquid Scintillation Raw Data Report

Laboratory Name: Paragon Analytics

PAI Work Order: 0512143

Prep SOP: PAI 700

Analytical SOP: PAI 704

Reported on: Friday, January 20, 2006 9:49:52 AM

Sample ID / QC Type	Nuclide Type	Sample Date/Time	Prep Batch / QCBatchID	Ingrowth Date /Time	Quench Factor / %Lum	Matrix / %Moist.	Samp Alq / Analy Alq	Inst ID / Det ID	AnRunID / File Name	Count Date/Time	GrossCPM / BkgCPM	BaseEff / ProgEff	CntDur(min) / Yield	Activity +/- / 2 s TPU	MDC / DecLev	ReportUnits / ReportBasis	DER / RPD	%Spk. Recov / Flags
0512143-1	H-3	12/7/2005	3H051227-1	NA	138.2	WATER	50 ml	LS6000	3H051227-1A	1/3/2006	13.410	22.57%	100	130	340	pCi/l	NA	
SMP	Trg. Analyte	10:35:00 AM	3H051227-1-1	NA	0.12	100	10 ml	45-03	Manual Entry	3:07 AM	12.760	NA	NA	210	NA	Unfiltered	NA	U
3H051227-1	H-3	12/27/2005	3H051227-1	NA	138.4	WATER	50 ml	LS6000	3H051227-1A	1/3/2006	13.390	22.57%	100	130	340	pCi/l	NA	
MB	Trg. Analyte	8:23:49 AM	3H051227-1-1	NA	0.16	NA	10 ml	45-09	Manual Entry	3:07 AM	12.760	NA	NA	210	NA	Unfiltered	NA	U
3H051227-1	H-3	12/27/2005	3H051227-1	NA	138	WATER	50 ml	LS6000	3H051227-1A	1/3/2006	52.040	22.57%	100	7900	300	pCi/l	NA	95.4
LCS	Trg. Analyte	8:23:49 AM	3H051227-1-1	NA	0.1	NA	9.9 ml	45-10	Manual Entry	3:07 AM	12.760	NA	NA	1200	NA	Unfiltered	NA	P

Comments:

Data Package ID: *h30512143-1*

Qualifiers/Flags:

U - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

D - DER is greater than Control Limit of 2.13

+ - Duplicate RPD not within limits.

LT - Result is less than Request MDC, greater than sample specific MDC

* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'

- Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'

M - Requested MDC not met.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

NC - Not Calculated for duplicate results less than 5 times MDC

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Notes:

1) The Tracer results are not yield corrected (i.e. activity measured not activity added).

2) Where sample time is not available, 12:00 PM (Mountain) is used for decay correction.

Abbreviations:

TR- Tracer TA - Target Analyte

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

DER - Duplicate Error Ratio

BDL - Below Detection Limit

ID: H3--1CPM GEO. 3 JAN 2006 03:07
USER: 4 COMMENT:LS 6000

PRESET TIME :	100.00						
DATA CALC :	CPM	H# :YES	SAMPLE REPEATS:	1	PRINTER	: STD
COUNT BLANK :	NO	IC# : NO	REPLICATES :	1	RS232	: OFF
TWO PHASE :	NO	AQC : NO	CYCLE REPEATS :	1		
SCINTILLATOR:	LIQUID	LUMEX:YES	LOW SAMPLE REJ:	0		
LOW LEVEL :	YES	HALF LIFE CORRECTION DATE:			none	

CHAN: 100.0 - 320.0 %ERROR: 0.00 FACTOR: 1.000000 BKG. SUB: 0
CHAN: 380.0 - 990.0 %ERROR: 0.00 FACTOR: 1.000000 BKG. SUB: 0

ALPHA-BETA DISCRIMINATION: NO

SAM NO	POS	TIME MIN	H#	WIND1 CPM	WIND1 %ERROR	WIND2 CPM	WIND2 %ERROR	LUMEX %	ELAPSED TIME
1	45-1	100.00	139.2	14.05	5.35	45.13 •	2.98	0.12	102.55
2	45-2	100.00	150.3 +	12.87	5.68	~~40.79~~ 40.68	3.14	1.10	205.62
3	45-3	100.00	138.2	13.41	5.47	45.39 •	2.97	0.12	308.27
4	45-4	100.00	139.5	13.98	5.36	45.14 •	2.98	0.13	410.93
5	45-5	100.00	137.4	13.33	5.49	44.48 •	3.00	0.15	513.62
6	45-6	100.00	139.9	12.98	5.56	41.03	3.12	0.16	616.31
7	45-7	100.00	137.8	53.16	2.74	44.45 •	3.00	0.11	718.99
8	45-8	100.00	139.5	52.39	2.77	44.86 •	2.99	0.11	821.68
9	45-9	100.00	138.4	13.39	5.48	44.37 •	3.00	0.16	924.38
10	45-10	100.00	138.0	52.04	2.77	42.02	3.09	0.10	1027.08
11	45-11	100.00	140.4	12.53	5.66	42.10	3.08	0.15	1129.76

~~A Below WIND 2~~
~~LCL of 40.79.~~
~~LLS 1/19/06~~
LLS 1/20/06

• Above WIND 2
LLS 1/20/06
VCL of ~~44.51~~ 43.50
LLS 1/19/06

+ H # above
UCL of 146.4.
LLS 1/19/06

000011

Paragon Analytics

LSC Run Log 298159

Instrument ID: LS 6000

	Date	Sample ID	CountTime (min.)	Rack & Position	Test	User #	Batch ID	Position Check	Initials	Comments
1	1/01/06	OS11212 - 6	120	20 - 8	H3_10mL	3	3HOS1216 - 5	LMS	LMS	NA
2		3HOS1216 - 5CB2		- 9						
3		OS11212 - 7MS		- 10						
4		- 8		- 11						
5		- 9		- 12						
6		OS11212 - 12		24 - 1						
7		- 12D		- 2						
8		3HOS1216 - 5LCS		- 3						
9	1/02/06	DAILY QC	10	1 - 1-4	—	1	—	LMS	LMS	NA
10		OS11212 - 7	200	28 - 1	H3_10mL	10	3HOS1216 - 5			
11		- 10		- 2						
12		- 11		- 3						
13		3HOS1216 - 5MB		- 4						
14	1/03/06	CB3	120	25 - 1	H3_10mL	120		LMS	LMS	NA
15	1/03/06	3HOS1227 - 1CB1	100	45 - 1		4	3HOS1227 - 1			
16		OS12130 - 1		- 2						
17		OS12143 - 1		- 3						
18		OS12153 - 10		- 4						
19		- 10D		- 5						
20		3HOS1227 - 1CB2		- 6						
21		OS12153 - 10MS		- 7						
22		- 10MSD		- 8						
23		3HOS1227 - 1MB		- 9						
24		- LCS		- 10						
25		- CB3		- 11						
26	1/03/05	DAILY QC	10	1 - 1-4	—	1	—	LMS	LMS	NA
27	1/03/05	OS16025 - 4	60	48 - 1	H3_5mL	5	OS16025			5mL CALIB. TRITIUM
28		- 5		- 2						
29		- 6		- 3						
30		- 10	5.60	- 4						

Reviewed by / Date LMS 1/04/06

FORM 762r4.XLS (12/24/2002)

800012

PARAGON ANALYTICS, INC.
Radiochemistry Data Package

Section 5

QUALITY ASSURANCE SUMMARY REPORTS



QUALITY ASSURANCE SUMMARY SHEET

PAI W.O. # / BATCH 3H051227-1
TEST 3H
METHOD
SOP/REV (PREP)
SOP/REV (ANAL) 704/7

Briefly document any QA or other problems or deviations associated with the analysis of samples. Problems could result from: log-in, color, odor, dilution, consistency, scheduling, equipment, or instrumentation, or may include documentation of minor deviations necessary due to unique DQO's or sample characteristics.

Three reagent blanks were prepared with batch 3H051227-1. Reagent Blank 3H051227-1CB1 had a Wind 2 count rate above the upper control limit. Due to being quenched for the method of standard additions, this sample is unable to be recounted. In lieu of recounts, this sample will be rejected and only 2 reagent blanks will be used to determine the background and window 2 rates for these samples. The count rate for the quenched sample 3H051227-1CB1 will, however still be used as the background rate for the method of standard additions. Data quality is not believed to be significantly affected.
lms 1/20/06

TECHNICIAN/ANALYST Krista Bishop DATE 1/20/06
DEPARTMENT MANAGER Chris McMenamy DATE 1/20/06

301208

PARAGON ANALYTICS, INC.
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Section 6

LABORATORY BENCH SHEETS

6

Radiochemistry Instrument Worksheet

Paragon Analytics

Prep Batch: 3H051227-1

Prep Procedure: H3

Analytical QASS / NCR? (Y) / (N) 1/19/06 301208

Prep Num	LabID	QC Type	Init Alq	Fin Alq	Units	Cnt 1 File/Inst	Cnt 1 Rack-Pos	Cnt 1 Pos Chk By	Cnt 2 File/Inst	Cnt 2 Rack-Pos	Cnt 2 Pos Chk By	Cnt 3 File/Inst	Cnt 3 Rack-Pos	Cnt 3 Pos Chk By	Notes
1	0512130-1	SMP	50	10	ml	LS 6000	45 - 2	lls	LS6000	45-1	lls			lls 1/19/06	H# high, Std. additions, recount
1	0512143-1	SMP	50	10	ml		- 3								
1	0512153-10	SMP	50	10	ml		- 4								
1	0512153-10	DUP	50	10	ml		- 5							lls 1/19/06	
1	0512153-10	MS	50	9.900990	ml		- 7								
1	0512153-10	MSD	50	9.900990	ml		- 8								
1	3H051227-1CB1	MB	50	10	ml		- 1		LS6000	3-1	lls			lls 1/19/06	Recounted for Std. Add.
1	3H051227-1CB2	MB	50	10	ml		- 6								
1	3H051227-1CB3	MB	50	10	ml		- 11								
1	3H051227-1	MB	50	10	ml		- 9							lls 1/19/06	
1	3H051227-1	LCS	50	9.900990	ml		- 10								

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	H-3	486.2613.60	1,843.698	DPM/ml	12/27/05	0.5	ml	ST-002

000016

Radiochemistry Prep Worksheet

Paragon Analytics

Prep Batch: 3H051227-1

Prep Procedure: H3

Reviewed By: KAA KAA **Review Date:** 12/27/05

Non-Routine Pre-Treatment? Y / (N) **Batch:** NA **Re-Prep?** Y / (N) **Batch:** NA **Prep QASS / NCR?** Y / (N) NA

Prep SOP: PAI 700 **Rev:** 9
Prep SOP: NONE
Matrix Class: liquid

Prep Analyst: Kimberly Arnett KAA
Prep Date: 12/27/05
Prep Dept: RS

Balance:
Balance:

Cocktail: UG LLT
Cocktail Pipet: T-002
Aliquot Pipet: RS-001

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Water Added(ml)	Moisture(%)	Analysis Vol.(ml)	Standards	Prep Notes
1	1	0512130-1	SMP		50	10	Unfiltered	0	100	10		
2	1	0512143-1	SMP		50	10	Unfiltered	0	100	10		
3	1	0512153-10	SMP		50	10	Unfiltered	0	100	10		
4	1	0512153-10	DUP		50	10	Unfiltered	0	100	10		
5	1	0512153-10	MS		50	9.900990	Unfiltered	0	100	10	S1	
6	1	0512153-10	MSD		50	9.900990	Unfiltered	0	100	10	S1	
7	1	3H051227-1CB1	MB		50	10	Unfiltered	0	100	10		
8	1	3H051227-1CB2	MB		50	10	Unfiltered	0	100	10		
9	1	3H051227-1CB3	MB		50	10	Unfiltered	0	100	10		
10	1	3H051227-1	MB		50	10	Unfiltered	0	100	10		
11	1	3H051227-1	LCS		50	9.900990	Unfiltered	0	100	10	S1	

KAA 12/27/05

Spiked By: Kimberly Arnett **Date:** 12/27/05

Witnessed By: Jeff Kujawa **Date:** 12/27/05

Relinquished By: [signature]
Date: 12/27/05
Received By: [signature]
Date: 12/31/05

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	H-3	486.2613.60	1,843.698	DPM/ml	12/27/05	0.5	ml	ST-002

00001

Comments
UG LLT LOT #97-050602

Paragon Analytics

Radiochemistry Prep Worksheet

Prep Batch: 3H051227-1

Prep Procedure: H3

Prep Batch Not Validated!!!

Reviewed By: **Review Date:**

Non-Routine Pre-Treatment? Y / (N) **Batch:** NA **Re-Prep?** Y / (N) **Batch:** NA **Prep QASS / NCR?** Y / (N) NA

Prep SOP: PAI 700 **Rev:** 9
Prep SOP: NONE
Matrix Class: liquid

Prep Analyst: Kimberly Arnett KAA
Prep Date: 12/27/05
Prep Dept: RS

Balance:
Balance:

Cocktail: UG LLT
Cocktail Pipet: T-002
Aliquot Pipet: ~~RS-007~~ RS-001 KAA 12/27/05

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Water Added(ml)	Moisture(%)	Analysis Vol.(ml)	Standards	Prep Notes
1	1	0512130-1	SMP		50	10	Unfiltered	0	100	10		
2	1	0512143-1	SMP		50	10	Unfiltered	0	100	10		
3	1	0512153-10	SMP		50	10	Unfiltered	0	100	10		
4	1	0512153-10	DUP		50	10	Unfiltered	0	100	10		
5	1	0512153-10	MS		50	9.900990	Unfiltered	0	100	10	S1	
6	1	0512153-10	MSD		50	9.900990	Unfiltered	0	100	10	S1	
7	1	3H051227-1CB1	MB		50	10	Unfiltered	0	100	10		
8	1	3H051227-1CB2	MB		50	10	Unfiltered	0	100	10		
9	1	3H051227-1CB3	MB		50	10	Unfiltered	0	100	10		
10	1	3H051227-1	MB		50	10	Unfiltered	0	100	10		
11	1	3H051227-1	LCS		50	9.900990	Unfiltered	0	100	10	S1	

Spiked By: Kimberly Arnett KAA **Date:** 12/27/05

Witnessed By: [signature] **Date:** 12/27/05

Relinquished By:
Date:
Received By:
Date:

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	H-3	486.2613.60	1,843.698	DPM/ml	12/27/05	0.5	ml	ST-002

Exp. 8/11/06

DRAFT

000018

Comments
UG LLT LOT #97-050602

TRITIUM RUN LOG

297919 Logbook/Page No. SOP 700 Rev 9 Form 1306r1.doc (3/30/2003)

Date	Workorder/ Sample Number	Column ID	Flask ID	Run No.	Comments	Technician's Initials
12/20/05	0511212-11	NA	NA	3	batch 3H051216-5, SOP754R4	JRL
12/20/05	0512134-2	A	102	2	Batch 3H051219-1	JB
↓	-4	B	103	↓	↓	↓
↓	-4D	C	602	↓	↓	↓
↓	-6	D	603	↓	↓	↓
↓	3H051219-1MB	E	T12	↓	↓	↓
↓	↓ LCS	F	T11	↓	↓	↓
12/20/05	0511212-12	NA	NA	4	Batch 3H051216-5, SOP754R4	JRL
↓	0511212-12-D	↓	↓	5	↓	↓
12/27/05	05 12130 -1	A	608	1	Batch 3H051227-1	KAA
↓	0512143 -1	B	111	↓	↓	↓
↓	0512153 -10	C	603	↓	↓	↓
↓	↓ -10Dup	D	T11	↓	↓	↓
↓	-10MS	E	C12	↓	↓	↓
↓	-10MSD	F	103	↓	↓	↓
↓	3H051227-1 -MB	A	602	2	↓	↓
↓	↓ -LCS	B	T12	↓	↓	↓
					LAST 12/27/05	

Reviewed by / Date 12/27/05

SAMPLE CONDITION FORM (LIQUID)

ANALYST: KAA

ANALYSIS DATE: 12/27/05 METHOD: 3H

WORK ORDER	SAMPLE ID	SAMPLE CONDITION		
		pH	Color	Remarks
0512130	1	0	clear	N/A sodium hydroxide added pH = 7
0512143	1	7	yellow	strong odor
0512153	10	7	yellow	N/A

KAA 12/27/05

000020

PARAGON ANALYTICS, INC.
Radiochemistry Data Package

Section 7

STANDARDS TRACEABILITY DOCUMENTS



60
PROJECT 486.2613.60 3H

Notebook No. 2613
Continued From Page

PREPARE A WORKING DILUTION AT ~2500 dpm/ml OF 3H BY DILUTING STANDARD 486.1284.85 WITH DI WATER (ACTIVITY OF 486.1284.85 = 948004.38 dpm/ml) BG 9/27/04

1.) DETERMINE DENSITY OF DI WATER:

BAL 12 MASS OF EMPTY CLASS A 100 ml VOLUMETRIC FLASK: 62.6207g

↓ MASS OF CLASS A VOLUMETRIC FLASK + 100 ml DI H_2O: 162.2711g

NET MASS OF DI H_2O: 99.6504g

$\rho = 0.9965\ g/ml$

2.) TRANSFER STANDARD 486.1284.85 TO A 500 ml AMBER BOTTLE:

BAL 26 ↓

MASS OF BOTTLE W/O LID: 256.68g

MASS OF BOTTLE + STD: 258.18g

NET MASS OF STD: 1.50g

3.) ADD DI H_2O TO FINAL DILUTION:

MASS OF BOTTLE W/O LID (FROM ABOVE): 256.68g

MASS OF BOTTLE + STD + DI H_2O: 753.4g

NET MASS OF STD + DI H_2O: 496.7g BG 9/27/04

4.) FINAL ACTIVITY CALCULATION:

$$\frac{(0.9965\ g/ml)(1.50g)(948004.38\ dpm/g)}{496.7g} = 2852.9\ dpm/ml$$

BG 9/27/04

Stnd ID: 486.2613.60 RG 10/5/04

Description: 3H
Expiration: 9/28/05
Activity: 2852.90 dpm/mL
2s Uncertainty: 95.10 dpm/mL
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 9/27/04 Prep by: AF
Matrix/Comp. DI H2O
Half Life (y): 1.24E+01

RG 10/5/04

Requires NCR for ICPT work.

RG 10/5/04

Stnd ID: 486.2613.60 RG 9/28/05

Description: 3H
Expiration: 8/11/06
Activity: 2852.90 dpm/mL
2s Uncertainty: 95.10 dpm/mL
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 9/27/04 Prep by: AF
Matrix/Comp. DI H2O
Half Life (y): 1.24E+01

RG 10/5/04 RG 9/28/05 RG 9/28/05

Continued on Page

Read and Understood By

RG 10/5/04
Signed

10/5/04
Date

Signed

10/5/04
Date

PROJECT Tritium Spike Solution 486.1284.85

Continued From Page

486.1284.85

Soln # 486.1284.85 was diluted to form a Soln approx 140 000 dpm/ml as follows:

Volt Tare	27.9711 g
Volt + Hs (486.1284.85)	42.6011 g
Final (dil w/DI H2O)	62.7170 g
dil factor	

42.6011 g
− 27.9711 g
14.63 g STD
× 10141184.6 pCi/g
14 837 521 pCi
÷ (62.7170 g − 27.9711 g)
427 029.4 pCi/g

RG 3/28/03

RG 8/17/04

Stnd ID: 486.1284.85

Description: H-3
Activity: 948004.38 dpm/ml
2s Uncertainty: 4740.02 dpm/ml
Ref. Date: 3/23/98
Ref Time: na
Prep Date: 5/3/00 Prep by: RTS
Expiration: ~~3/25/03~~ 3/25/04 RG 3/28/03
Matrix/Comp. DI H2O
Half Life (y): 1.23E+01

MAY REQUIRE NCR FOR ICPT WORK.

RG 3/28/03

RG 3/28/03

Stnd ID: 486.1284.85

Description: 3H
Expiration: 7/30/05
Activity: 948004.38 dpm/mL
2s Uncertainty: 4740.02 dpm/mL
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 7/29/04 Prep by: JLK
Matrix/Comp. DI H20
Half Life (y): 1.23E+01

RG 8/17/04

RG 8/17/04

Description: Tritium in Water Stock Solution
Activity: 427029 pCi/g or mL
Uncertainty: pCi/g or mL
Ref. Date: ~~3/30/98~~ 3/23/98 RTS 1-7-02
Ref Time: 10:00 AM 3/30/98 CEW 10/4/02
Prep Date ~~3/30/98~~ Prep by: RTS
Expiration ~~3/29/03~~ ~~3/23/98~~ CEW 10/4/02 3/29/03 CEW 10/4/02
Matrix/Comp. DI Water
Short Lived – Decay Correct with each use

RG 8/17/04

Verified 5/27/98 RTS

Standard re-verified 3/25/03. RG 3/28/03

Expires 3/25/04.

RG 8/17/04 Standard re-verified. New exp date: 7/30/05 RG 8/17/04

Continued on Page

Date entered

Signed

5/3/00

Date

Read and Understood By

RTS 5/27/98

Signed

Date

14 PROJECT Tritium Stock Solution 486.1284.84 Notebook No. WL1604

Continued From Page

PAI solution number 486.1284.84 (Analytics SRS 55543-327)

I was transferred to a 40 ml VOA vial.

Certificate not available on 3/30/98 - Will obtain

tomorrow.

Activity 51.054 uCi

Volume 50.34 grams

Matrix: H2O

RG 8/13/04

Stnd ID: 486.1284.84

Description: 3H
Expiration: 7/30/05
Activity: 1014184.00 pCi/g or ml
2s Uncertainty: 50709.00 pCi/g or ml
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 7/29/04 Prep by: JLK
Matrix/Comp. DI Water
Half Life (y): 1.23E+01

RG 8/13/04

Standard recertified on on 7/30/04. Expires 7/30/05.

RG 8/13/04

DG 7/8/03

Stnd ID: 486.1284.84

Description: H-3
Activity: 1014184.00 pCi/g or ml
2s Uncertainty: 50709.00 pCi/g or ml
Ref. Date: 3/23/98
Ref Time: 0.417
Prep Date: 3/30/98 Prep by: RTS
Expiration: 7/3/04
Matrix/Comp. DI Water
Half Life (y): 1.24E+01

DG 7/8/03

Stnd ID: 486.1284.84

Description: Tritium in Water Stock Solution
Activity: 1014184 pCi/g or mL
Uncertainty: pCi/g or mL
Ref. Date: ~~3/30/98~~ 3/23/98 1-7-02
Ref Time: 10:00
Prep Date 3/30/98 Prep by: RTS
Expiration 3/29/03
Matrix/Comp. DI Water
Short Lived – Decay Correct with each use

Verified 5/27/98 DCS

Standard re-certified on 7/3/0
expires 7/3/04 DG 7/7/03

Continued on Page

Read and Understood By

Signed 5/5/00 Date

Signed DCS Date 5/28/98

000024

ANALYTICS

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 · U.S.A.
Phone (404) 352-8677
Fax (404) 352-2837

PAT ID 486.
rec'd 3-24-98

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

55543-307

H-3 in Water 50 mL in Flame Sealed Vial

This standard radionuclide source was prepared using an aliquot measured gravimetrically from a master radionuclide solution standard. The master radionuclide solution standard was calibrated by the Department Des Applications Et De La Metrologie Des Rayonnements Ionisants (DAMRI), Paris, France, as Number 24057. The calibration was checked by liquid scintillation counting after source preparation.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

ISOTOPE:	H-3
ACTIVITY (dps):	1.889 E+06
CALIBRATION DATE:	March 23, 1998 12:00 EST
HALF-LIFE:	12.43 years
TOTAL UNCERTAINTY:	5.0%

50.34 grams of water.

P O NUMBER 21143, Item 1

PREPARED BY: M. D. Currie
M. D. Currie, Radiochemist

Q A APPROVED: CC 24 mf 3/23/98

PARAGON ANALYTICS, INC.
Radiochemistry Data Package

Section 8

CHAIN OF CUSTODY

8

Paragon Analytics

Sample Number(s) Cross-Reference Table

Paragon OrderNum: 0512143
Client Name: Cordilleran Compliance Services, Inc.
Client Project Name: Battlement Mesa
Client Project Number: E04243
Client PO Number:

Client Sample	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
BM2642W	0512143-1		WATER	07-Dec-05	10:35

05-12143

05-12143 12/16/05

Paragon Analytics
A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 80524
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID) 05-12143

Chain-of-Custody Date _____ Page ___ of ___ **Originator:** Retain pink copy

Project Name / No.: _____ Sampler(s): _____ Turnaround (circle one): **Standard** or **Rush (Due** _____ **)** Dispose: **Date** _____ or **Return** to Client

Report To: James Hix
Phone: 303.237-2072
Fax: 303.237-2659
E-mail: jameshix@cordcomp.com
Company: Cordilleran Compliance Services
Address: 5550 Marshall Street
Arvada, CO 80002

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs SW8260B E624 E524.2	BTEX (only) SW8021B	SVOCs SW8270C E625	OC Pesticides SW8081A E608	PCBs SW8082 E608	Herbicides SW8151A	Explosives SW8330	TCLP Organics SW1311 SW8260B 8270C 8081A 8151A	TCLP Metals SW1311 SW6010B SW7471	Total Metals by ICP SW6010B 7470 7471 E200 ILMO	Dissolved Metals by ICP SW6010B 7470 E200 ILMO	Total Metals by ICP/MS SW6020 E200.8 ILMO	Dissolved Metals by ICP/MS SW6020 E200.8 ILMO	Hexavalent Chromium SW7196A Alkaline Digest? Y / N	Inorganic Anions SW9056 E300.0 (specify in comments)	Solids: Total E160.3 TDS E160.1 TSS E160.2	pH SW9040B SW9045C	TPH GRO DRO SW8015B (boils)	Gross Alpha / Beta SW9310 E900.0	Actinides by Paragon SOP Pu / U / Am / Th / Cm / ___	Tritium H3 E906.0	Total Alpha-Emitting Radium SW9315 E903.0	Radium 226 E903.1 Radium 228 SW9320 E904.0	Strontium 89 D5811-00 Strontium 90 D5811-00	Gamma Isotopes E901.1 (HNO3)					
BM2642W	12/1/05	1035		W	ICE HCLp	2																				✓				✓					

* Time Zone: EST CST MST PST **Matrix Key:** O = oil S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments:

Form 202r5.xls (4/6/04)

Relinquished By: (1)	Relinquished By: (2)
Signature James W. Hix	Signature
Printed Name James Hix	Printed Name
Date 12/15/05 Time	Date Time
Company Cordilleran To Fed X	Company
Received By: (1)	**Received By:** (2)
Signature	Signature
Printed Name	Printed Name
Date 12/16/05 Time 1022	Date Time
Company	Company

820000

Paragon Analytics

CONDITION OF SAMPLE UPON RECEIPT FORM

Client: Cordillera Inc. Workorder No: 0512143

Project Manager: JT 12/16/05 LRS Initials: MW Date: 12/16/05

1.	Does this project require any **special handling** in addition to standard Paragon procedures?		YES	NO
2.	Is **pre-screening** required per SOP 008?		YES	NO
3.	Are custody **seals** on **shipping containers** intact?	N/A	YES	NO
4.	Are custody **seals** on **sample containers** intact?	N/A	YES	NO
5.	Is there a **COC (Chain-of-Custody) present** or other representative documents?		YES	NO
6.	Is the **COC** (if applicable) **complete and legible**?	N/A	YES	NO
7.	Are **bottle IDs legible** and in **agreement** with **COC sample IDs**?	N/A	YES	NO
8.	Is the COC in agreement with samples received? (**# of samples, # of containers, matrix**)	N/A	YES	NO
9.	Were **airbills** present and/or removable?	N/A	YES	NO
10.	Are all **aqueous samples** requiring preservation **preserved correctly**? (excluding volatile organics)	N/A	YES	NO
11.	Are all aqueous **non-preserved samples** at the **correct pH**?	N/A	YES	NO
12.	Is there **sufficient sample** for the requested analyses?		YES	NO
13.	Were all samples placed in the **proper containers** for the requested analyses?		YES	NO
14.	Are all samples within **holding times** for the requested analyses?		YES	NO
15.	Were all sample containers received **intact**? (not broken or leaking, etc.)		YES	NO
16.	Are all samples requiring no headspace (volatiles, reactive cyanide/sulfide, radon), headspace free? **Size of bubble**: ____ < green pea ____ > green pea	N/A	YES	NO
17.	Were samples checked for and free from the presence of **residual chlorine?** (Applicable when PM has indicated samples are from a chlorinated water source; note if field preservation with sodium thiosulfate was not observed.)	N/A	YES	NO
18.	Were the sample(s) **shipped on ice**?	N/A	YES	NO
19.	Were cooler temperatures measured at 0.1-6.0°C?	N/A	YES	NO

*IR gun used *(circle one)*: #2 - Oakton InfraPro II, SN2922500201-0066; (#4) - Oakton InfraPro II, SN2372220101-0002

Cooler #'s 1

Temperature (°C) 1.8

No. of custody seals 1

DOT Survey/ Acceptance Information

External µR/hr reading 13

Background µR/hr reading 12

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? (YES) / NO (If no, see Form 008.)

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE EXCEPT #1 AND #2.

If applicable, was the client contacted? YES / NO / NA Contact Name: _____ Date/Time: _____

Project Manager Signature/ Date: 12/19/05

Form 201r18.xls (6/26/04)

000029

FedEx Express US Airbill

FedEx Tracking Number 8548 9974 1340

Recipient's Copy

1 From

Date 12/15/05

Sender's Name [illegible] Phone 303 [illegible]

Company [illegible]

Address [illegible] Street

Dept/Floor/Suite/Room

City [illegible] State [illegible] ZIP [illegible]

2 Your Internal Billing Reference [illegible]

3 To

Recipient's Name [illegible] Phone (800) 443-1311 120 420-1311

Company [illegible]

Recipient's Address [illegible]

We cannot deliver to P.O. boxes or P.O. ZIP codes.

Dept/Floor/Suite/Room

Address

To request a package be held at a specific FedEx location, print FedEx address here.

City [illegible] State CO ZIP 80234

8548 9974 1340

4a Express Package Service To add SATURDAY Delivery, see Section 6. *Packages up to 150 lbs.* * To most locations.

- [x] FedEx Priority Overnight — Next business morning* — $ 15.75
- [ ] FedEx Standard Overnight — Next business afternoon* — $ 14.75
- [ ] FedEx First Overnight — Earliest next business morning delivery to select locations* — $ 20.75
- [ ] FedEx 2Day — Second business day* — $ 12.75
- [ ] FedEx Express Saver — Third business day* — $ 10.75

FedEx Envelope rate not available. Minimum charge: One-pound rate

4b Express Freight Service To add SATURDAY Delivery, see Section 6. *Packages over 150 lbs.* ** To most locations.

- [ ] FedEx 1Day Freight* — Next business day** — $ 16.75
- [ ] FedEx 2Day Freight — Second business day** — $ 14.75
- [ ] FedEx 3Day Freight — Third business day** — $ 12.75

* Call for Confirmation:

5 Packaging * Declared value limit $500

- [ ] FedEx Envelope* — $ 11.75
- [ ] FedEx Pak* — Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak — $ 13.75
- [ ] FedEx Box — $ 13.75
- [ ] FedEx Tube — $ 13.75
- [x] Other — $ 15.75

6 Special Handling Include FedEx address in Section 3.

- [ ] SATURDAY Delivery — Available ONLY for FedEx Priority Overnight, FedEx 2Day, FedEx 1Day Freight, and FedEx 2Day Freight to select ZIP codes — $ 3.75
- [ ] HOLD Weekday at FedEx Location — Not available for FedEx First Overnight — $ 3.75
- [ ] HOLD Saturday at FedEx Location — Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations — $ 3.75

Does this shipment contain dangerous goods? One box must be checked.

- [x] No
- [ ] Yes — As per attached Shipper's Declaration
- [ ] Shipper's Declaration not required
- [ ] Dry Ice — 9, UN 1845 ____ x ____ kg
- [ ] Cargo Aircraft Only

Dangerous goods (including dry ice) cannot be shipped in FedEx packaging.

7 Payment *Bill to:* Enter FedEx Acct. No. or Credit Card No. below.

- [ ] Sender — Acct. No. in Section 1 will be billed.
- [ ] Recipient
- [ ] Third Party
- [x] Credit Card
- [ ] Cash/Check

Obtain Recip. Acct. No. [ ]

Total Packages	Total Weight	Total Declared Value†	Total Charges
1	10	$ [illegible].00	$ [illegible]

† Our liability is limited to $100 unless you declare a higher value. See back for details.

Credit Card Auth.

8 *NEW* Residential Delivery Signature Options If you require a signature, check Direct or Indirect.

- [ ] No Signature Required — Package may be left without obtaining a signature for delivery — $ 3.75
- [ ] Direct Signature — Anyone at recipient's address may sign for delivery. *Fee applies.* — $ 3.75
- [ ] Indirect Signature — If no one is available at recipient's address, anyone at a neighboring address may sign for delivery. *Fee applies.* — $ 3.75

520

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Questions? Go to our Web site at fedex.com or call 1.800.GoFedEx 1.800.463.3339.

0000030

PARAGON ANALYTICS
Radiochemistry Data Package

Section 9

ADDITIONAL SUPPORTING DOCUMENTATION

9

Liquid Scintillation Counter

Instrument Calibration

Initial Efficiency Calibration Standards Traceability

Tritium Background Determination

As noted in QASS 288299, the background count rate is determined from the average of the reagent blanks (not the method blank) for the batch.

Control limits for reagent blanks are established from the 'Count Time Weighted Running Mean'. Limits are +/- three standard deviation from the 'Count Time Weighted Running Mean'. Reagent blanks are in control if the Count Rate (CPM) is within these control limits

Sample ID	Count Duration (m)	Count Rate (CPM)	Total Cts.	Mean
3H051227-1CB2	100	12.98	1298.00	
3H051227-1CB3	100	12.53	1253.00	12.76

Tritium "Window 2" Control Limits (LS 6000)

The background count rate is determined from the average of the reagent blanks for the batch.

Window 2 control limits are established using the average count rate from the ~~three~~ two reagent blanks associated with each prep batch +/- 3X the estimated poisson uncertainty.

cfm 2/2/02 See QA55 301208.

Sample ID	Count Duration (min.)	Sum of Count Duration (min.)	Count Rate (CPM)	Batch Average Reagent Blank	Lower Control Limit	Upper Control Limit
3H051227-1CB2	100		41.03			
3H051227-1CB3	100	300	42.10	41.57	**40.45**	**42.68**
0	0	100		41.57	**39.64**	**43.50**

Tritium Efficiency Calibration (10ml geometry)

10ml sample + 10ml Ultima Gold LLT
12/21/2005 Count Time (Min.) = 60

Beckman LS 6000
Standard used: 699.2613.19

94000.71	dpm/ml as of	9/3/1998
1/2 life =	12.23	yrs.
Current Activity =	62154.18	dpm/ml
Volume =	0.20	ml
Average Spike Activity =	12430.84	dpm

Sample ID	WIND1 cpm	WIND2 cpm	%LUMEX	H#	
0516025-1	15.63	45.17	0.08	131.6	
0516025-2	15.02	45.12	0.08	131.6	
0516025-3	14.50	43.85	0.08	131.0	
0516025-7	2790.83	41.39	0.00	131.3	
0516025-8	2835.77	45.35	0.00	130.9	
0516025-9	2836.06	45.35	0.00	131.9	
Average LCS=	2820.89	44.71	0.04	131.4	averages
Average Bckgrd=	15.05				
Net cpm=	2805.84	WIND2 *	%LUMEX	H#	
/Known dpm=	12430.84	48.50	5.00	146.4	UCL
		40.93	0.00	116.4	LCL
Efficiency=	0.2257	See Tech. Mgr.	See Tech. Mgr.	Std. Addition	Corrective Action

*WIND2 cotrol limits are based on average of blanks. CL used for calibration only.

Instrument Technician: Kristin Bishop 12/23/05
Signature & Date

Supervisory Review: Ryan Kellogg 1/4/06
Signature & Date

R:\INST\LSC\LS6000\1221EFF_H310

ID: H3-10ML GEO. 21 DEC 2005 05:04
USER:10 COMMENT:LS 6000

PRESET TIME :	60.00						
DATA CALC :	CPM	H#	:YES	SAMPLE REPEATS:	1	PRINTER	: STD
COUNT BLANK :	NO	IC#	: NO	REPLICATES :	1	RS232	: OFF
TWO PHASE :	NO	AQC	: NO	CYCLE REPEATS :	1		
SCINTILLATOR:	LIQUID	LUMEX:	YES	LOW SAMPLE REJ:	0		
LOW LEVEL :	YES	HALF LIFE CORRECTION DATE:				none	

CHAN: 100.0 - 320.0 %ERROR: 2.00 FACTOR: 1.000000 BKG. SUB: 0
CHAN: 380.0 - 990.0 %ERROR:20.00 FACTOR: 1.000000 BKG. SUB: 0

ALPHA-BETA DISCRIMINATION: NO

SAM NO	POS	TIME MIN	H#	WIND1 CPM	WIND1 %ERROR	WIND2 CPM	WIND2 %ERROR	LUMEX %	ELAPSED TIME
1	29-1	60.00	131.6	15.63	6.53	45.17	3.84	0.08	61.70
2	29-2	60.00	131.6	15.02	6.67	45.12	3.84	0.08	123.48
3	29-3	60.00	131.0	14.50	6.78	43.85	3.90	0.08	185.28
4	29-4	3.60	131.3	2790.83	2.00	41.39	16.38	0.00	189.51
5	29-5	3.55	130.9	2835.77	1.99	45.35	15.76	0.00	193.70
6	29-6	3.55	131.9	2836.06	1.99	45.35	15.76	0.00	197.90
7	29-7	60.00	132.1	53.67	3.53	43.87	3.90	0.05	259.69

UB
12/23/05

Paragon Analytics

LSC Run Log 298154

Instrument ID: LS 6000

	Date	Sample ID	CountTime (min.)	Rack & Position	Test	User #	Batch ID	Position Check	Initials	Comments
1	12/17/05	OS11224-55	90	60 - 5	H3-5mL	5	3H051202-3	MS	MS	N/A
2		-56		- 6						
3		3H051202-3MB		- 7						
4		LCS		- 8						
5	12/18/05	DAILY QC	10	1 - 1-4	-		-	MS	MS	N/A
6	12/18/05	3H051213-1 CB1	230	20 - 1	H3-10mL	3	3H051213-1			
7		OS11120-8		- 2						
8		BD		- 3						
9		9		- 4						
10		3H051213-1 CB2		- 5						
11		OS11120-12		- 6						
12		-13		- 7						
13		3H051213-1 LCS		- 8						
14		LCSD		- 9						
15	12/19/05	OS11120-10	360	21 - 1	H3-10mL	4		MS	MS	N/A
16		-11		- 2						
17		3H051213-1 MB		- 3						
18	12/21/05	CB3	230	23 - 1	H3-10mL	8	-	MS	MS	N/A
19	12/21/05	DAILY QC	10	1 - 1-4	-	1	-			
20		OS11224-54	20	9 - 1	H3-5mL	5	3H051202-3	MS	MS	N/A
21	12/21/05	OS16025-1	60	29 - 1	H3-10mL	10	OS16025			H3 10mL Calib
22		-2		- 2						
23		-3		- 3						
24		-7	3.6	- 4						
25		-8	3.55	- 5						
26		-9	3.55	- 6						
27		-13	60	- 7						
28	12/21/05	3H051213-2CB1	180	34 - 1	H3-10mL	3	3H051213-2	MS	MS	N/A
29		OS11219-1		- 2						
30		-2		- 3						

Reviewed by / Date MS 12/23/05

FORM 762r4.XLS (12/24/2002)

Paragon Analytics, Inc.

Liquid Scintillation Benchsheet

Prep Batch 16025H3.XLS

Prep Analyst: JRK
Prep Date: 4/27/2005
Prep SOP: 700R9

Non-Routine Pretreatment? Y / N
Re-extraction? Y / N

Matrix: WATER
File Name:

Lab Sample ID	Rack	Rack Pos	Matrix	Report Basis	Analysis Volume	Units	% Moisture	Water Added	Aliquot Volume	Spike Volume	Spike Standard	Spike Pipet	Remarks
0516025-1	29	1	WATER	AR	10	ML	100	0	50				
0516025-2	29	2	WATER	AR	10	ML	100	0	50				
0516025-3	29	3	WATER	AR	10	ML	100	0	50				
0516025-4			WATER	AR	5	ML	100	0	50				
0516025-5			WATER	AR	5	ML	100	0	50				
0516025-6			WATER	AR	5	ML	100	0	50				
0516025-7	29	4	WATER	AR	10	ML	100	0	49	1	699.2613.19	RS-005	
0516025-8	29	5	WATER	AR	10	ML	100	0	49	1	699.2613.19	RS-005	
0516025-9	29	6	WATER	AR	10	ML	100	0	49	1	699.2613.19	RS-005	
0516025-10			WATER	AR	5	ML	100	0	49	1	699.2613.19	RS-005	
0516025-11			WATER	AR	5	ML	100	0	49	1	699.2613.19	RS-005	
0516025-12			WATER	AR	5	ML	100	0	49	1	699.2613.19	RS-005	
0516025-13	29	7	WATER	AR	10	ML	100	0	49.5	0.5	486.2613.60	ST-002	
0516025-14			WATER	AR	5	ML	100	0	49.5	0.5	486.2613.60	ST-002	

Cocktail: UG LLT LOT# 97-050102
Balance #:

Scintillation Pipet: T-002
Aliquot Pipet: RS-007, RS-011

Spiked By: JRK on 4/27/05
Spike Witness: JLK on 4/27/05

Reviewed By: on
Received By: See Previous

r:\A-ra-sr\bench\16025H3.xls

000038

Paragon Analytics, Inc.

Liquid Scintillation Benchsheet

5mL
geo

Prep Batch 16025H3.XLS

Prep Analyst: JRK
Prep Date: 4/27/05
Prep SOP: 700R9

Non-Routine Pretreatment? Y / N
Re-extraction? Y / N

Matrix: WATER
File Name:

Lab Sample ID	Rack	Rack Pos	Matrix	Report Basis	Analisis Volume	Units	% Moisture	Water Added	Aliquot Volume	Spike Volume	Spike Standard	Spike Pipet	Remarks
0516025-1			WATER	AR	10	ML	100	0	50				
0516025-2			WATER	AR	10	ML	100	0	50				
0516025-3			WATER	AR	10	ML	100	0	50				
0516025-4	48	1	WATER	AR	5	ML	100	0	50				
0516025-5	↓	2	WATER	AR	5	ML	100	0	50				
0516025-6	↓	3	WATER	AR	5	ML	100	0	50				
0516025-7			WATER	AR	10	ML	100	0	49	1	699.2613.19	RS-005	
0516025-8			WATER	AR	10	ML	100	0	49	1	699.2613.19	RS-005	
0516025-9			WATER	AR	10	ML	100	0	49	1	699.2613.19	RS-005	
0516025-10	48	4	WATER	AR	5	ML	100	0	49	1	699.2613.19	RS-005	
0516025-11	↓	5	WATER	AR	5	ML	100	0	49	1	699.2613.19	RS-005	
0516025-12	↓	6	WATER	AR	5	ML	100	0	49	1	699.2613.19	RS-005	
0516025-13			WATER	AR	10	ML	100	0	49.5	0.5	486.2613.60	ST-002	
0516025-14	48	7	WATER	AR	5	ML	100	0	49.5	0.5	486.2613.60	ST-002	

Cocktail: UG LLT LOT# 97-050102
Balance #:

Scintillation Pipet: T-002
Aliquot Pipet: RS-007, RS-011

Spiked By: JRK on 4/27/05
Spike Witness: JLK on 4/27/05

Reviewed By: on
Received By: LWS on 4/28/05

DRAFT

000039

Paragon Analytics, Inc.

TRITIUM RUN LOG

268458 Logbook/Page No. SOP 700 Rev. 9 Form 999005r1.doc (3/30/2003)

Date	Workorder/ Sample Number	Column ID	Flask ID	Run No.	Comments	Technician's Initials
4/20/05	3H050420-1 MB	D	T5	1	Batch 3H050420-1	JK
"	3H050420-1 LCS	E	T11	"	"	"
4/25/05	0516024-1,-4	A	T5	1	Del H2O 3H Calib	JKK
	-2,-5	B	T2			
	-3,-6	C	604 ~~605~~ 11/4 4/25/05			
	0516024-7,-10	D	T10			
	-8,-11	E	T9			
	-9,-12	F	T3			
	0516024-13,-14	A	111	2		
4/27/05	0516025-1,-4	A	T1	1	DI H2O 3H Calib	JKK
	-2,-5	B	T5			
	-3,-6	C	T10			
	0516025-7,-10	D	T11			
	-8,-11	E	103			
	-9,-12	F	111			
4/28/05	0516025-13,-14	A	604	2		
4/29/05	0504235-1	A	T1	1	Batch 3H050429-1	JK
	-1-D	B	T10			
	-1-HS	C	T11			
	3H050429-1 MB	D	111			
	3H050429-1 LCS	E	604			
	5/6/05					

Reviewed by / Date LWS 5/5/05

Paragon Analytics

QUALITY ASSURANCE SUMMARY SHEET

PAI W.O. # / BATCH 25C
TEST 25C
METHOD 25C
SOP/REV (PREP) —
SOP/REV (ANAL) 704 r 7

Briefly document any QA or other problems or deviations associated with the analysis of samples. Problems could result from: log-in, color, odor, dilution, consistency, scheduling, equipment, or instrumentation, or may include documentation of minor deviations necessary due to unique DQO's or sample characteristics.

CMM 9/23/05

CMM 9/22/05

As of 9/22/05, control limits for the "Window 2" count rate are established using the average count rate from the three reagent blanks associated with each prep batch +/- 3X the estimated poisson uncertainty.

CMM 9/23/05

CMM 9/22/05

TECHNICIAN/ANALYST [signature] DATE 9/23/05

DEPARTMENT MANAGER [signature] DATE 9/23/05

293979

FORM 302r6.doc (4/22/04)

DAILY INSTRUMENT PERFORMANCE CHECKS - LS6000

Daily IPCs consist of the following standards;

Efficiency Check -

Beckman Tritium Standard		Beckman C-14 Standard		PAI Reagent Blank
Lot HMH0908		Lot CMH2803		RB 5/7/03 LLT # 97-3021
106200.00	dpm	99500.0	dpm	
4/11/2001	REF	4/11/2001	REF	
4/11/2006	EXP	4/11/2006	EXP	

The quench factor is measured on the Reagent Blank

Historical Control Limits 9/23/2005

	Decay Corrected Tritium	Carbon-14	Reagent Blank	Quench Factor
UCL	51086.9	63492.8	18.1	115.5
Mean Value	46442.7	57720.7	14.5	105.0
LCL	41798.4	51948.7	10.9	94.5

r:\inst\lsc\ls6000\prg\lsqa6000.xls

		Decay Corrected				Reagent		Quench	
Date	H-3 CPM	H-CPM		C-14 CPM		H-3 Bkg CPM		H#	
12/12/2005	35837.30	46625.49	OK	57001.3	OK	16.1	OK	105.0	OK
12/13/2005	34863.80	45365.94	OK	56113.8	OK	14.7	OK	105.3	OK
12/15/2005	35426.00	46111.71	OK	55196.3	OK	13.2	OK	105.7	OK
12/17/2005	34749.30	45244.85	OK	56779.1	OK	15.6	OK	105.5	OK
12/18/2005	35301.20	45970.54	OK	56425.2	OK	14.6	OK	105.2	OK
12/21/2005	34773.70	45304.57	OK	54559.8	OK	12.6	OK	104.6	OK
12/22/2005	35456.60	46201.40	OK	55412.6	OK	13.9	OK	105.2	OK

PROJECT 699.2613.19 3H Notebook No. 2613 19

Continued From Page

Prepare a working dilution of approx 1.75 94000 Bq/mL by diluting Std 699.2613.18 in 4M DI water

1) See Density on page 18 of logbook 2613

2) Transfer Std 699.2613.18 to a 125 mL Amber glass bottle

Mass of bottle w/o lid	94.7389 g	Bal #12
Mass of bottle + Std	96.6785 g	
Net mass of Std	1.9396 g	

3) Add DI water to final Dilution

Mass of bottle w/o lid from above	94.7389 g	Bal #10
Mass of bottle, Std, + DI water	192.4076 g	
Net mass of Std + DI water	97.6687 g	

4) Final Activity Calculation

$$\frac{(6354.7\ kBq/g)(4.815\ g)(1000\ Bq/kBq)(1000\ dps/Bq)(0.9958\ g/mL)(1.9396\ g)}{(38.5745\ g)(97.6687\ g)} = 94{,}000.71\ DPM/mL$$

SD 7/28/03 RG 8/11/04

Stnd ID: 699.2613.19

Description: ^{3}H
Expiration: 7/28/04
Activity: 94000.71 dpm/mL
2s Uncertainty: 676.81 dpm/mL
Ref. Date: 9/3/98
Ref Time: N/A
Prep Date: 7/28/03 Prep by: JRK
Matrix/Comp. DI Water
Half Life (y): 1.23E+01

SD 8/1/03

Signed 7/28/03 Date

Stnd ID: 699.2613.19

Description: 3H
Expiration: 7/30/05
Activity: 94000.71 dpm/mL
2s Uncertainty: 676.81 dpm/mL
Ref. Date: 9/3/98
Ref Time: N/A
Prep Date: 7/29/04 Prep by: JLK
Matrix/Comp. DI Water
Half Life (y): 1.23E+01

RG 8/11/04

Signed 8/1/03 Date

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PROJECT 699.2613.18 34 Notebook No. 2613

Continued From Page

Prepare a 1° dilution of Ampoule 699 by diluting with DI water.

1) Determine the density of DI water

Mass of empty class A 100mL volumetric flask	67.7957 g Bal #4
Mass of flask + 100mL of DI water	167.3715 g
Net mass of DI water	99.5758 g

$\rho = 0.9958\ g/mL$

2) Transfer contents of ampoule 699 into a 40 mL Amber glass VOA vile

Mass of VOA vile w/o lid	24.3883g Bal #6
Mass of opened ampoule before transfer	40.8432g
Mass of opened ampoule after transfer	36.0281g
Net mass of Std transferred	4.8151g

3) Add DI water to final dilution

Mass of VOA vile from above w/o lid & contents	24.3883g Bal #6
Mass of VOA vile, std + DI water	62.9648g
Net mass of Std + DI water	38.5765g

4) Final Activity Calculation

$$(634.7\ kBq/g)(4.8151g)\left(\frac{1000\ Bq}{1\ kBq}\right)\left(\frac{1\ dpm}{0.0167\ Bq}\right)\left(\frac{1}{38.5765g}\right)(0.9958\ g/mL)$$

$= 4,733,412.57\ dpm/mL$

U.S. Department of Commerce
National Institute of Standards and Technology
SRM 4927F
Hydrogen-3
<4 MBq in distilled water
CAUTION
RADIOACTIVE

Continued on Page

Read and Understood By

Signed — Date 7/29/03

Signed — Date 7/31/03

000044

National Institute of Standards & Technology

Certificate

PAF ID 0699
recal 5-09-03

Standard Reference Material 4927F
Hydrogen-3 Radioactivity Standard

This Standard Reference Material (SRM) consists of radioactive hydrogen-3, as water, in 5 mL of distilled water. The solution is contained in a flame-sealed NIST borosilicate-glass ampoule. The SRM is intended for the calibration of beta-particle counting instruments and for the monitoring of radiochemical procedures.

Radiological Hazard

The SRM ampoule contains hydrogen-3 with a total activity of approximately 3.2 MBq. Hydrogen-3 decays by beta-particle emission. None of the beta particles escape from the SRM ampoule. During the decay process no photons are emitted. Approximate unshielded dose rates at several distances (as of the reference time) are given in note [a]*. There is no detectable external radiation. The SRM should be used only by persons qualified to handle radioactive material.

Chemical Hazard

The SRM ampoule contains only distilled water. There is no chemical hazard. If the ampoule is to be opened to transfer the solution, the recommended procedure is given on page 2.

Storage and Handling

The SRM should be stored and used at a temperature between 5 and 65 °C. The solution in an unopened ampoule should remain stable and homogeneous until at least September 2008.

The ampoule (or any subsequent container) should always be clearly marked as containing radioactive material. If the ampoule is transported it should be packed, marked, labeled, and shipped in accordance with the applicable national, international, and carrier regulations. The solution in the ampoule is a dangerous good (hazardous material) because of the radioactivity.

Preparation

This Standard Reference Material was prepared in the Physics Laboratory, Ionizing Radiation Division, Radioactivity Group, L.R. Karam, Group Leader. The overall technical direction and physical measurements leading to certification were provided by L.L. Lucas and M.P. Unterweger of the Radioactivity Group.

The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program by J.W.L. Thomas.

Bert M. Coursey, Chief
Ionizing Radiation Division

Nancy M. Trahey, Chief
Standard Reference Materials Program

Gaithersburg, Maryland 20899
June 1999
Half-life and text revised October 2000

*Notes and references are on pages 5 and 6.

Recommended Procedure for Opening the SRM Ampoule

1) If the SRM solution is to be diluted, it is recommended that the diluting solution have a composition comparable to that of the SRM solution.

2) Wear eye protection, gloves, and protective clothing and work over a tray with absorbent paper in it. Work in a fume hood.

3) Shake the ampoule to wet all of the inside surface of the ampoule. Return the ampoule to the upright position.

4) Check that all of the liquid has drained out of the neck of the ampoule. If necessary, gently tap the neck to speed the process.

5) Holding the ampoule upright, score the narrowest part of the neck with a scribe or diamond pencil.

6) Lightly wet the scored line. This reduces the crack propagation velocity and makes for a cleaner break.

7) Hold the ampoule upright with a paper towel, a wiper, or a support jig. Position the scored line away from you. Using a paper towel or wiper to avoid contamination, snap off the top of the ampoule by pressing the narrowest part of the neck away from you while pulling the tip of the ampoule towards you.

8) Transfer the solution from the ampoule using a pycnometer or a pipet with dispenser handle. NEVER PIPETTE BY MOUTH.

9) Seal any unused SRM solution in a flame-sealed glass ampoule, if possible, to minimize the evaporation loss.

See also reference [4]*.

*Notes and references are on pages 5 and 6.

000646

PROPERTIES OF SRM 4927F

Certified values

Solution density	(0.998± 0.002) g·mL^{-1} at 20.0 °C [b]*
Radionuclide	Hydrogen-3
Reference time	1200 EST, 3 September 1998
Massic activity of the solution [c]	634.7 kBq·g^{-1}
Relative expanded uncertainty (k=2)	0.72% [d] [e]

Uncertified values

Physical Properties:			
Source description	Liquid in flame-sealed NIST borosilicate-glass ampoule		
Ampoule specifications	Body outside diameter Wall Thickness Barium content Lead-oxide content Other heavy elements	(16.5 ± 0.5) mm (0.60 ± 0.04) mm Less than 2.5% Less than 0.02% Trace quantities	
Solution mass	Approximately 5.0 g		
Chemical Properties:			
Solution composition	Chemical Formula	Concentration (mol·L^{-1})	Mass Fraction (g·g^{-1})
	H_2O ^3HHO	55 6×10^{-7}	1.00 1×10^{-8}
Radiological Properties:			
Radionuclidic impurities	None detected [f]		
Half lives used	Hydrogen-3: (4500 ± 8) d [g]		
Calibration method and measuring instrument(s)	4πß gas counting of SRM 4927E using the NIST length-compensated internal gas proportional counters and intercomparison of SRMs 4927E/4927F using two 4πß liquid-scintillation counting systems [h]		

*Notes and references are on pages 5 and 6.

EVALUATION OF THE UNCERTAINTY OF THE MASSIC ACTIVITY [d]*

Input Quantity x_i, the source of uncertainty (and individual uncertainty components where appropriate)	Method Used To Evaluate $u(x_i)$, the standard uncertainty of x_i (A) denotes evaluation by statistical methods (B) denotes evaluation by other methods	Relative Uncertainty Of Input Quantity, $u(x_i)/x_i$, (%) [i]	Relative Sensitivity Factor, $\lvert \partial y/\partial x_i \rvert \cdot (x_i/y)$ [j]	Relative Uncertainty Of Output Quantity, $u_i(y)/y$, (%) [k]
Massic count rate of SRM 4927E, corrected for background and decay [h]	Standard deviation of the mean for 23 sets of gas counting measurements (A)	0.18	1.0	0.18
Gram-mole measurements	Estimated (B)	0.20	1.0	0.20
Live-time [p]	Estimated (B)	0.10	1.0	0.10
Extrapolation of count-rate-versus-energy to zero energy	Estimated (B)	0.20	1.0	0.20
Half life of H-3	Standard uncertainty of the half life (A)	0.18 [m]	0.009 [n]	0.002
Liquid-scintillation intercomparison of SRM 4927F and SRM 4927E	Standard deviation of the mean for 7 sets of liquid-scintillation measurements (A)	0.06	1.0	0.06
Radionuclidic impurities	Limit of detection (B) [q]	100.	0.0005	0.05
Relative Combined Standard Uncertainty of the Output Quantity, $u_c(y)/y$, (%)				0.36
Coverage Factor, k				x 2
Relative Expanded Uncertainty of the Output Quantity, U/y, (%)				0.72

*Notes and references are on pages 5 and 6.

NOTES

[a] The Sievert is the SI unit for dose equivalent. See reference [1]. One μSv is equal to 0.1 mrem.

Distance from Ampoule (cm):	1	30	100
Approximate Dose Rate (μSv/h):	<0.1 (Not detectable)		

[b] The stated uncertainty is two times the standard uncertainty.

[c] Massic activity is the preferred name for the quantity activity divided by the total mass of the sample. See reference [1].

[d] The reported value, y, of massic activity (activity per unit mass) at the reference time was not measured directly but was derived from measurements and calculations of other quantities. This can be expressed as $y = f(x_1, x_2, x_3, \ldots x_n)$, where f is a mathematical function derived from the assumed model of the measurement process.

The value, x_i, used for each input quantity i has a standard uncertainty, $u(x_i)$, that generates a corresponding uncertainty in y, $u_i(y) \equiv |\partial y/\partial x_i| \cdot u(x_i)$, called a component of combined standard uncertainty of y.

The combined standard uncertainty of y, $u_c(y)$, is the positive square root of the sum of the squares of the components of combined standard uncertainty.

The combined standard uncertainty is multiplied by a coverage factor of $k = 2$ to obtain U, the expanded uncertainty of y.

Since it can be assumed that the possible estimated values of the massic activity are approximately normally distributed with approximate standard deviation $u_c(y)$, the unknown value of the massic activity is believed to lie in the interval $y \pm U$ with a level of confidence of approximately 95 percent.

For further information on the expression of uncertainties, see references [2] and [3].

[e] The value of each standard uncertainty component, and hence the value of the expanded uncertainty itself, is a best estimate based upon all available information, but is only approximately known. That is to say, the "uncertainty of the uncertainty" is large and not well known. This is true for uncertainties evaluated by statistical methods (e.g., the relative standard deviation of the standard deviation of the mean for the massic response is approximately 50%) and for uncertainties evaluated by other methods (which could easily be over estimated or under estimated by substantial amounts). The unknown value of the expanded uncertainty is believed to lie in the interval $U/2$ to $2U$ (i.e., within a factor of 2 of the estimated value).

[f] The estimated limit of detection for radionuclidic impurities is 300 $Bq \cdot g^{-1}$.

[g] The stated uncertainty is the standard uncertainty. See reference [5].

[h] Extensive gas-counting measurements were made on the SRM 4927E solution during 1998 and 1999. The SRM 4927F solution was intercompared with the SRM 4927E solution using liquid-scintillation counting.

[i] Relative standard uncertainty of the input quantity x_i.

000049

[j] The relative change in the output quantity y divided by the relative change in the input quantity x_i. If $|\partial y/\partial x_i| \cdot (x_i/y) = 1.0$, then a 1% change in x_i results in a 1% change in y. If $|\partial y/\partial x_i| \cdot (x_i/y) = 0.05$, then a 1% change in x_i results in a 0.05% change in y.

[k] Relative component of combined standard uncertainty of output quantity y, rounded to two significant figures or less. The relative component of combined standard uncertainty of y is given by $u_i(y)/y \equiv |\partial y/\partial x_i| \cdot u(x_i)/y = |\partial y/\partial x_i| \cdot (x_i/y) \cdot u(x_i)/x_i$. The numerical values of $u(x_i)/x_i$, $|\partial y/\partial x_i| \cdot (x_i/y)$, and $u_i(y)/y$, all dimensionless quantities, are listed in columns 3, 4, and 5, respectively. Thus, the value in column 5 is equal to the value in column 4 multiplied by the value in column 3. The input quantities are independent, or very nearly so. Hence the covariances are zero or negligible.

[m] The relative standard uncertainty of $\lambda \cdot t$ is determined by the relative standard uncertainty of λ (i.e., of the half life). The relative standard uncertainty of t is negligible.

[n] $|\partial y/\partial x_i| \cdot (x_i/y) = |\lambda \cdot t|$

[p] The live time is determined by counting the pulses from a gated crystal-controlled oscillator.

[q] The standard uncertainty for each undetected impurity that might reasonably be expected to be present is estimated to be equal to the estimated limit of detection for that impurity, i.e. $u(x_i)/x_i = 100\%$. $|\partial y/\partial x_i| \cdot (x_i/y) = \{$(response per Bq of impurity)/(response per Bq of H-3)$\} \cdot \{$(Bq of impurity)/(Bq of H-3)$\}$. Thus $u_i(y)/y$ is the relative change in y if the impurity were present with a massic activity equal to the estimated limit of detection.

REFERENCES

[1] International Organization for Standardization (ISO), *ISO Standards Handbook - Quantities and Units*, 1993. Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036, U.S.A. 1-212-642-4900.

[2] International Organization for Standardization (ISO), *Guide to the Expression of Uncertainty in Measurement*, 1993. Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036, U.S.A. 1-212-642-4900. (Listed under ISO miscellaneous publications as "ISO Guide to the Expression 1993".)

[3] B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, 1994. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20407, U.S.A.

[4] National Council on Radiation Protection and Measurements Report No. 58, *A Handbook of Radioactivity Measurements Procedures*, Second Edition, 1985. Available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, MD 20814 U.S.A.

[5] L.L. Lucas and M.P. Unterweger, *Comprehensive Review and Critical Evaluation of the Half-Life of Tritium*, J. Res. Natl. Inst. Stand. Technol. 105, 541-549 (2000).

Calibration Source Check

LS6000
Date: 12/21/2005
Nuclide: H3
Half Life: 1.223E+01 yr.

Calibration Check Source:

Spike Standard: 486.2613.60
Reference Date : 3/23/1998
Spiked DPM : 2852.9 dpm/mL
Spike Volume : 0.5 mL
Spiked into : 50.0 mL
Current Spk. Act. : 8.28 pCi/mL

Calibration Check Source Count

Sample ID	Rack	Pos	Sam. Date	Cnt. Dur.	Anal. Vol.	GrsCPM	BkgCPM	Efficiency	Activity	Units	Chem. Yield
0516025-13	29	7	4/27/2005	60	10	53.67	15.05	0.2257	8.00	pCi/mL	100%

LCS Recovery: 96.5%
PAI Limits: 85-115%

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LS0051 000051

60 PROJECT 486.2613.60 3H Notebook No. 2613

Continued From Page

PREPARE A WORKING DILUTION AT ~2500 dpm/ml OF 3H BY DILUTING STANDARD 486.1284.85 WITH DI WATER (ACTIVITY OF 486.1284.85 = 948004.38 dpm/mg) 9/27/04

1.) DETERMINE DENSITY OF DI WATER

BAL 12 MASS OF EMPTY CLASS A 100 ml VOLUMETRIC FLASK: 62.1620 g

MASS OF CLASS A VOLUMETRIC FLASK + 100 ml DI H_2O: 162.2711 g

NET MASS OF DI H_2O: 99.1504 g

$\rho = 0.9965$ g/ml

2.) TRANSFER STANDARD 486.1284.85 TO A 500 ml AMBER BOTTLE:

BAL 26

MASS OF BOTTLE W/O LID: 256.68 g

MASS OF BOTTLE + STD: 258.18 g

NET MASS OF STD: 1.50 g

3.) ADD DI H_2O TO FINAL DILUTION:

MASS OF BOTTLE W/O LID (FROM ABOVE): 256.68 g

MASS OF BOTTLE + STD + DI H_2O: 753.4 g

NET MASS OF STD DI H_2O: 496.7 g 9/27/04

4.) FINAL ACTIVITY CALCULATION: 9/27/04

$$\frac{(0.9965\ g/ml)(1.50\ g)(948004.38\ dpm/g)}{496.7\ g} = 2852.9\ dpm/ml$$

9/27/04

~~2852.9~~

RG 10/5/04

Stnd ID: 486.2613.60

Description: 3H
Expiration: 9/28/05
Activity: 2852.90 dpm/mL
2s Uncertainty: 95.10 dpm/mL
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 9/27/04 Prep by: AF
Matrix/Comp. DI H2O
Half Life (y): 1.24E+01

RG 10/5/04

Requires NCR for ICPT work.

RG 10/5/04

RG 9/29/05

Stnd ID: 486.2613.60 RG 9/29/05

Description: 3H
Expiration: 8/11/06
Activity: 2852.90 dpm/mL
2s Uncertainty: 95.10 dpm/mL
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 9/27/04 Prep by: AF
Matrix/Comp. DI H2O
Half Life (y): 1.24E+01

RG 9/29/05

RG 9/29/05

Continued on Page

Read and Understood By

Signed 10/5/04 Date

Signed 10/5/04 Date

000052

PROJECT _____ Continued From Page _____

486.1284.85

Stock 486.1284.84 was diluted to form a stock approx 100,000 dpm/mL as follows:

Wt Flask 27.9711 g

Wt + HS (486.1284.84) 42.6011 g

Final (dil w/ DI H2O) 62.7170 g

Dil Factor

42.6011 g
− 27.9711 g
14.63 g STD

x | 6141184.6 pCi/g
14 | 837 521 pCi
÷ (62.7170 g − 27.9711 g)
429 624.4 pCi/g

RG 3/28/03

Stnd ID: 486.1284.85

Description: H-3
Activity: 948004.38 dpm/ml
2s Uncertainty: 4740.02 dpm/ml
Ref. Date: 3/23/98
Ref Time: na
Prep Date: 5/3/00 Prep by: RTS
Expiration: ~~3/25/03~~ 3/25/04 RG 3/28/03
Matrix/Comp. DI H2O
Half Life (y): 1.23E+01

MAY REQUIRE NCR FOR ICPT WORK.

RG 3/28/03

RG 8/17/04

Stnd ID: 486.1284.85

Description: 3H
Expiration: 7/30/05
Activity: 948004.38 dpm/mL
2s Uncertainty: 4740.02 dpm/mL
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 7/29/04 Prep by: JLK
Matrix/Comp. DI H2O
Half Life (y): 1.23E+01

RG 8/17/2004

Description: Tritium in Water Stock Solution
Activity: 427029 pCi/g or mL
Uncertainty: pCi/g or mL
Ref. Date: ~~3/30/98~~ 3/23/98 RG 1-7-02
Ref Time: 10:00 AM ~~5/30/98~~ CEW 10/4/02
Prep Date ~~3/30/98~~ Prep by: RTS
Expiration ~~3/29/03~~ ~~3/23/05~~ CEW 10/4/02 3/29/05 CEW 10/4/02
Matrix/Comp. DI Water
Short Lived – Decay Correct with each use

RG 8/17/04

Sample 5/2/98 DCS

Standard re-verified 3/25/03 RG 3/28/03
Expires 3/25/04

Standard re-verified. New exp date: 7/30/05 RG 8/17/04 Continued on Page

Read and Understood By

Signed _____ Date 5/3/00

Signed _____ Date 5/22/98

000053

Notebook No. WE404

PROJECT Tritium Stock Solution 486.1284.84

Continued From Page

PAI solution number 486.1284.84 (Analyte: 10355543-3A7)

1 was transferred to a 40 ml VOA vial.

Certificate of BOA was available on 3/30/98 - will attach.

Activity 51.054 uCi

Volume 50.34 grams

Matrix H2O

RG 8/13/04

Stnd ID: 486.1284.84

Description: 3H
Expiration: 7/30/05
Activity: 1014184.00 pCi/g or ml
2s Uncertainty: 50709.00 pCi/g or ml
Ref. Date: 3/23/98
Ref Time: N/A
Prep Date: 7/29/04 Prep by: JLK
Matrix/Comp. DI Water
Half Life (y): 1.23E+01

RG 8/13/04

Standard received 6/22 on 7/30/04. Expires 7/30/05.

RG 8/13/04

Stnd ID: 486.1284.84

Description: H-3
Activity: 1014184.00 pCi/g or ml
2s Uncertainty: 50709.00 pCi/g or ml
Ref. Date: 3/23/98
Ref Time: 0.417
Prep Date: 3/30/98 Prep by: RTS
Expiration: 7/3/04
Matrix/Comp. DI Water
Half Life (y): 1.24E+01

Stnd ID: 486.1284.84

Description: Tritium in Water Stock Solution
Activity: 1014184 pCi/g or mL
Uncertainty: pCi/g or mL
Ref. Date: ~~3/25/98~~ 3/23/98 1-7-02
Ref Time: 10:00
Prep Date 3/30/98 Prep by: RTS
Expiration 3/29/03
Matrix/Comp. DI Water
Short Lived -- Decay Correct with each use

5/27/98

Standard re-received on 7/3/04 expires 7/3/05

Continued on Page

Read and Understood By

Signed 5/5/05 Date

Signed 5/29/98 Date

000654

ANALYTICS

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 · U.S.A.
Phone (404) 352-8677
Fax (404) 352-2837

PAID 486.
rec'd 3-24-98

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

55543-307

H-3 in Water 50 mL in Flame Sealed Vial

This standard radionuclide source was prepared using an aliquot measured gravimetrically from a master radionuclide solution standard. The master radionuclide solution standard was calibrated by the Department Des Applications Et De La Metrologie Des Rayonnements Ionisants (DAMRI), Paris, France, as Number 24057. The calibration was checked by liquid scintillation counting after source preparation.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

ISOTOPE:	H-3
ACTIVITY (dps):	1.889 E+06
CALIBRATION DATE:	March 23, 1998 12:00 EST
HALF-LIFE:	12.43 years
TOTAL UNCERTAINTY:	5.0%

50.34 grams of water.

P O NUMBER 21143, Item 1

PREPARED BY: M. D. Currie
M. D. Currie, Radiochemist

Q A APPROVED: EC Mart 3/23/98

Liquid Scintillation Counter

Quality Control Data

Daily Instrument Performance Checks

DAILY INSTRUMENT PERFORMANCE CHECKS - LS6000

Daily IPCs consist of the following standards;

Efficiency Check -

Beckman Tritium Standard		**Beckman C-14 Standard**		**PAI Reagent Blank**
Lot HMH0908		Lot CMH2803		RB 5/7/03 LLT # 97-3021
106200.00	dpm	99500.0	dpm	
4/11/2001	REF	4/11/2001	REF	
4/11/2006	EXP	4/11/2006	EXP	

The quench factor is measured on the Reagent Blank

Interim Control Limits 1/24/2006

	Decay Corrected Tritium	Carbon-14	Reagent Blank	Quench Factor
UCL	71116.6	75810.0	21.2	120.1
Mean Value	64651.4	68918.2	17.3	109.2
LCL	58186.3	62026.4	13.4	98.3

r:\inst\lsc\ls6000\prg\lsqa6000.xls

Date	Decay Corrected H-3 CPM	Decay Corrected H-CPM		C-14 CPM		Reagent H-3 Bkg CPM		Quench H#	
1/3/2006	35511.80	46359.06	OK	57372.6	OK	15.0	OK	105.2	OK
1/4/2006	34621.90	45204.31	OK	55598.8	OK	14.4	OK	105.4	OK
1/5/2006	35690.70	46606.99	OK	56784.4	OK	13.8	OK	105.8	OK
1/5/2006	35465.80	46313.30	OK	57432.4	OK	14.0	OK	105.6	OK
1/6/2006	35197.20	45969.64	OK	56167.3	OK	14.0	OK	105.5	OK
1/7/2006	35159.80	45927.87	OK	55322.0	OK	16.3	OK	105.3	OK
1/8/2006	35498.30	46377.20	OK	56038.7	OK	11.5	OK	105.8	OK

Paragon Analytics

Radiochemistry Case Narrative
Gamma Spectroscopy

Cordilleran Compliance Services, Inc.

Battlement Mesa / E04243

Paragon Work Order 0512143

1. This report consists of analysis results for one water sample received by Paragon Analytics on 12/16/05. The analysis results for this sample are reported in units of pCi/L. The sample was filtered prior to analysis.

2. This sample was prepared according to Paragon Analytics procedure PA SOP739R8 with modifications made according to QASS 305429.

3. The sample was analyzed for the presence of gamma emitting radionuclides according to Paragon Analytics procedure PA SOP713R8. The analyses were completed on 2/9/06.

4. Paragon Analytics has found there to be a significant low bias to ^{214}Pb and ^{214}Bi results when using a mixed nuclide gamma source for efficiency calibrations. The magnitude of this bias has been determined to be approximately 32% for ^{214}Bi, and 23% for ^{214}Pb. Therefore, any reported results for ^{214}Pb and ^{214}Bi are flagged with a "J" qualifier, indicating the activity values to be an estimated value. Results are reported without further qualification.

5. Technical considerations made in the creation of the gamma spectroscopy library used in this analysis are detailed in the document "Technical Comments Regarding Gamma Spectroscopy Libraries" found in Section 4.

6. Paragon Analytics follows the convention outlined in ANSI N42.23 for reporting significant digits in the TPU and MDC results. ANSI N42.23 states that the TPU result should be rounded to two significant digits and that the MDC result should be rounded to the same decimal place as the TPU result. In practice, this could result in an MDC result with a reported value of 0 for samples with significant activity, including the batch laboratory control sample.

7. There are cases where the magnitude of negative activity is greater than the 2σ TPU. Under typical conditions, where background data is normally distributed and analyzed by paired observations, this event is likely to occur at least 2.5% of the time. Review of the data does not indicate a problem with the instrument or reporting systems and results are reported without further qualification.

8. No problems were encountered with either the client sample or the associated quality control samples. All quality control criteria were met.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, Paragon Analytics certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Radiochemistry Instrument Technician — Date: 2/9/06

Radiochemistry Final Data Review — Date: 2/10/06

1

PARAGON ANALYTICS
Radiochemistry Data Package

Section 1

SAMPLE RESULTS SUMMARY

Due to the nature of gamma spectroscopy data a summary report is not provided.

Please refer to the individual sample results in Section 3.

2

PARAGON ANALYTICS

Radiochemistry Data Package

Section 2

QC RESULTS SUMMARY

Gamma Spectroscopy Results

PAI 713 Rev 8

Method Blank Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Lab ID: GS060119-3MB
Library: FANP

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 19-Jan-06
Date Prepared: 19-Jan-06
Date Analyzed: 09-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 295 minutes

Final Aliquot: 1000 ml
Result Units: pCi/l
File Name: 060418d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
14331-83-0	Ac-228	-2 +/- 30	51	U
14391-76-5	Ag-110m	-4.7 +/- 5.1	9.5	U
14682-66-7	Al-26	4.2 +/- 6.5	10.9	U
14596-10-2	Am-241	-1.1 +/- 5.9	10.1	U
13966-02-4	Be-7	-13 +/- 36	64	U
14913-49-6	Bi-212	-4 +/- 64	114	U
14733-03-0	Bi-214	-4 +/- 16	27	U,J
13982-30-4	Ce-139	1.3 +/- 2.9	4.9	U
14762-78-8	Ce-144	11 +/- 19	32	U
14093-03-9	Co-56	4.5 +/- 9.2	15.6	U
13981-50-5	Co-57	1.2 +/- 2.4	4.0	U
13981-38-9	Co-58	-5.8 +/- 5.1	9.6	U
10198-40-0	Co-60	4.8 +/- 6.1	10.0	U
14392-02-0	Cr-51	14 +/- 32	54	U
13967-70-9	Cs-134	-1.9 +/- 5.0	8.8	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *GSW0512143-1*

Gamma Spectroscopy Results

PAI 713 Rev 8

Method Blank Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Lab ID: GS060119-3MB
Library: FANP

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 19-Jan-06
Date Prepared: 19-Jan-06
Date Analyzed: 09-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 295 minutes

Final Aliquot: 1000 ml
Result Units: pCi/l
File Name: 060418d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
10045-97-3	Cs-137	1.6 +/- 5.5	9.4	U
14683-23-9	Eu-152	1 +/- 30	54	U
15585-10-1	Eu-154	-8 +/- 32	58	U
14391-16-3	Eu-155	3.9 +/- 9.0	15.0	U
14596-12-4	Fe-59	6 +/- 11	18	U
10043-66-0	I-131	-2.9 +/- 4.2	7.6	U
13966-00-2	K-40	-21 +/- 89	158	U
13966-31-9	Mn-54	-3.6 +/- 5.2	9.6	U
13966-32-0	Na-22	4.0 +/- 6.1	10.1	U
14681-63-1	Nb-94	0.7 +/- 5.4	9.3	U
13967-76-5	Nb-95	-1.6 +/- 4.5	8.1	U
15100-28-4	Pa-234m	-200 +/- 1000	1800	U
15092-94-1	Pb-212	4.7 +/- 7.5	12.4	U
15067-28-4	Pb-214	3 +/- 12	20	U,J
13967-48-1	Ru-106	-36 +/- 49	89	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *GSW0512143-1*

Gamma Spectroscopy Results

PAI 713 Rev 8

Method Blank Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Lab ID: GS060119-3MB
Library: FANP

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 19-Jan-06
Date Prepared: 19-Jan-06
Date Analyzed: 09-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 295 minutes

Final Aliquot: 1000 ml
Result Units: pCi/l
File Name: 060418d07

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
14683-10-4	Sb-124	1.2 +/- 4.9	8.3	U
14234-35-6	Sb-125	0 +/- 12	21	U
13967-63-0	Sc-46	-1.6 +/- 5.1	9.3	U
15623-47-9	Th-227	-35 +/- 27	48	U
15065-10-8	Th-234	1 +/- 56	94	U
14913-50-9	Tl-208	-7.3 +/- 7.4	13.1	U
15117-96-1	U-235	18 +/- 21	34	U
13982-39-3	Zn-65	-2 +/- 12	22	U

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 6 halflives.

M - Requested MDC not met.

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *GSW0512143-1*

000008

Gamma Spectroscopy Results

PAI 713 Rev 8

Laboratory Control Sample(s)

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Lab ID: GS060119-3LCS
Library: ANALYTICAL

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 19-Jan-06
Date Prepared: 19-Jan-06
Date Analyzed: 09-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 30 minutes

Final Aliquot: 1000 ml
Result Units: pCi/l
File Name: 060422d07

CASNO	Target Nuclide	Results +/- 2s TPU	MDC	Spike Added	% Rec	Control Limits	Lab Qualifier
14596-10-2	Am-241	99000 +/- 12000	0	97800	101	85 - 115	P
10198-40-0	Co-60	45900 +/- 5400	200	46300	99.1	85 - 115	P
10045-97-3	Cs-137	37800 +/- 4500	300	37700	100	85 - 115	P,M3

Comments:

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

LT - Result is less than Requested MDC, greater than sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS Recovery within control limits.

M - The requested MDC was not met.

M3 - The requested MDC was not met, but thereported activity is greater than the reported MDC.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

Data Package ID: *GSW0512143-1*

PARAGON ANALYTICS
Radiochemistry Data Package

3

Section 3

INDIVIDUAL SAMPLE RESULTS

Gamma Spectroscopy Results

PAI 713 Rev 8

Sample Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Field ID: BM2642W
Lab ID: 0512143-1
Library: FANP

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 07-Dec-05
Date Prepared: 19-Jan-06
Date Analyzed: 08-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 60 minutes
Report Basis: Filtered

Final Aliquot: 970 ml
Prep Basis: Filtered
Moisture(%): NA
Result Units: pCi/l
File Name: 060426d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
14331-83-0	Ac-228	16 +/- 22	37	U
14391-76-5	Ag-110m	1.5 +/- 5.8	9.9	U
14682-66-7	Al-26	1.4 +/- 6.4	11.3	U
14596-10-2	Am-241	-24 +/- 24	43	U
13966-02-4	Be-7	-48 +/- 88	161	U
14913-49-6	Bi-212	64 +/- 86	142	U
14733-03-0	Bi-214	4 +/- 17	29	U,J
13982-30-4	Ce-139	0.5 +/- 6.0	10.3	U
14762-78-8	Ce-144	-9 +/- 33	57	U
14093-03-9	Co-56	5 +/- 19	32	U
13981-50-5	Co-57	4.8 +/- 5.1	8.3	U
13981-38-9	Co-58	-13.5 +/- 9.0	17.8	U
10198-40-0	Co-60	0.5 +/- 6.0	10.7	U
14392-02-0	Cr-51	90 +/- 190	330	U
13967-70-9	Cs-134	-2.7 +/- 10	18	U

Comments: This sample was filtered prior to analysis.

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

G - Sample density differs by more than 15% of LCS density.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *GSW0512143-1*

Gamma Spectroscopy Results

PAI 713 Rev 8

Sample Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Field ID: BM2642W
Lab ID: 0512143-1
Library: FANP

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 07-Dec-05
Date Prepared: 19-Jan-06
Date Analyzed: 08-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 60 minutes
Report Basis: Filtered

Final Aliquot: 970 ml
Prep Basis: Filtered
Moisture(%): NA
Result Units: pCi/l
File Name: 060426d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
10045-97-3	Cs-137	-2.1 +/- 5.6	10.0	U
14683-23-9	Eu-152	-5 +/- 29	52	U
15585-10-1	Eu-154	-11 +/- 32	58	U
14391-16-3	Eu-155	2 +/- 19	33	U
14596-12-4	Fe-59	19 +/- 25	42	U
10043-66-0	I-131	400 +/- 1100	1900	U
13966-00-2	K-40	152 +/- 96	146	
13966-31-9	Mn-54	-3.9 +/- 7.6	13.6	U
13966-32-0	Na-22	-3.7 +/- 6.3	11.8	U
14681-63-1	Nb-94	-1.5 +/- 5.6	9.9	U
13967-76-5	Nb-95	-0.9 +/- 9.9	17.5	U
15100-28-4	Pa-234m	160 +/- 990	1720	U
15092-94-1	Pb-212	1 +/- 11	18	U
15067-28-4	Pb-214	2 +/- 16	27	U,J
13967-48-1	Ru-106	-26 +/- 61	108	U

Comments: This sample was filtered prior to analysis.

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

G - Sample density differs by more than 15% of LCS density.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *GSW0512143-1*

Gamma Spectroscopy Results

PAI 713 Rev 8

Sample Results

Lab Name: Paragon Analytics
Work Order Number: 0512143
Client Name: Cordilleran Compliance Services, Inc.
ClientProject ID: Battlement Mesa E04243

Field ID: BM2642W
Lab ID: 0512143-1
Library: FANP

Sample Matrix: WATER
Prep SOP: PAI 739 Rev 8
Date Collected: 07-Dec-05
Date Prepared: 19-Jan-06
Date Analyzed: 08-Feb-06

Prep Batch: GS060119-3
QCBatchID: GS060119-3-1
Run ID: GS060119-3A
Count Time: 60 minutes
Report Basis: Filtered

Final Aliquot: 970 ml
Prep Basis: Filtered
Moisture(%): NA
Result Units: pCi/l
File Name: 060426d10

CASNO	Target Nuclide	Result +/- 2 s TPU	MDC	Lab Qualifier
14683-10-4	Sb-124	-12 +/- 16	28	U
14234-35-6	Sb-125	16 +/- 15	24	U
13967-63-0	Sc-46	1.9 +/- 8.8	15.4	U
15623-47-9	Th-227	-5 +/- 40	69	U
15065-10-8	Th-234	-81 +/- 95	167	U
14913-50-9	Tl-208	4.0 +/- 6.8	11.3	U
15117-96-1	U-235	23 +/- 34	55	U
13982-39-3	Zn-65	-8 +/- 15	28	U

Comments: This sample was filtered prior to analysis.

Qualifiers/Flags:

U - Result is less than the sample specific MDC or less than the associated TPU

Y1 - Chemical Yield is in control at 100-110%. Quantitative Yield is assumed.

Y2 - Chemical Yield outside default limits.

LT - Result is less than Requested MDC, greater than sample specific MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

M - The requested MDC was not met.

SQ - Spectral quality prevents accurate quantitation.

SI - Nuclide identification and/or quantitation is tentative.

TI - Nuclide identification is tentative.

R - Nuclide has exceeded 8 halflives.

G - Sample density differs by more than 15% of LCS density.

Abbreviations:

TPU - Total Propagated Uncertainty (see PAI SOP 743)

MDC - Minimum Detectable Concentration (see PAI SOP 709)

BDL - Below Detection Limit

Data Package ID: *GSW0512143-1*

PARAGON ANALYTICS
Radiochemistry Data Package



Section 4

RAW DATA

060426D10.SPC Analyzed by MC

****

SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

****

Geo 1 / Water

Sample ID: 0512143-1 GS060119-3

Sampling Start:	12/07/2005 12:00:00	Counting Start:	02/08/2006 14:39:47
Sampling Stop:	12/07/2005 12:00:00	Decay Time.	1.51E+003 Hrs
Buildup Time.	0.00E+000 Hrs	Live Time	3600 Sec
Sample Size	9.70E-001 L	Real Time	3690 Sec
Collection Efficiency	1.0000	Spc. File	.060426D10.SPC

Detector #: 10 (Detector 10)

Energy(keV)= -1.28 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 02/08/2006

FWHM(keV) = 0.88 + 0.017*En + 8.12E-04*En^2 + 0.00E+00*En^3 10/03/2005

Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
1	46.84	96.02	28	39	31	175	0.90	a	NET< CL
2	63.46	129.18	49	35	27	143	0.87	a	
3	66.52	135.28	80	37	27	143	0.81	b	
4	75.19	152.58	48	25	17	69	0.54	a	
5	77.26	156.72	80	34	24	114	0.81	b	
6	92.73	187.60	74	37	27	130	1.03	a	
7	139.97	281.87	53	34	25	132	0.94	a	
8	186.16	374.03	57	32	24	117	0.93	a	
9	198.53	398.71	101	39	27	137	1.26	a	
10	239.19	479.85	62	38	28	149	1.26	a	
11	242.16	485.78	41	31	23	112	0.92	b	
12	295.44	592.09	74	34	24	114	1.08	a	
13	352.23	705.40	199	40	23	97	1.34	a	
14	511.21	1022.65	295	54	34	157	2.91	a	Wide Pk
15	558.89	1117.80	60	26	17	56	1.50	a	
16	583.67	1167.24	47	27	19	60	1.97	a	
17	609.69	1219.17	159	38	23	98	1.69	a	
18	1460.78	2917.48	121	29	16	37	2.77	a	
19	1764.55	3523.64	28	19	13	24	2.95	a	

060426D10.SPC Analyzed by

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SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Vers. 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Background File:. . . . . DET100203.BKG (0614013-10 WEEKLY BKGD)

Bkg.File Detector #: 10

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
1	46.84	28	39	31	-35	44	37	NET<CL
2	63.46	49	35	27	-7	41	34	NET<CL
3	66.52	80	37	27	33	41	33	NET<CL
4	75.19	48	25	17	-18	31	27	NET<CL
5	77.26	80	34	24	-10	39	33	NET<CL
6	92.73	74	37	27	-36	41	35	NET<CL
7	139.97	53	34	25	19	36	29	NET<CL
8	186.16	57	32	24	-27	37	32	NET<CL
9	198.53	101	39	27	52	42	32	
10	239.19	62	38	28	3	41	34	NET<CL
11	242.16	41	31	23	-9	35	29	NET<CL
12	295.44	74	34	24	-34	38	33	NET<CL
13	352.23	199	40	23	6	44	36	NET<CL
14	511.21	295	54	34	4	60	49	NET<CL
15	558.89	60	26	17	20	28	22	NET<CL
16	583.67	47	27	19	18	29	23	NET<CL
17	609.69	159	38	23	10	42	34	NET<CL
18	1460.78	121	29	16	50	31	23	
19	1764.55	28	19	13	-11	21	18	NET<CL

060426D10.SPC Analyzed by

SEEKER F I N A L A C T I V I T Y R E P O R T Version 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

Geo 1 / Water

Sample ID: 0512143-1 GS060119-3

Sampling Start: 12/07/2005 12:00:00	Counting Start: 02/08/2006 14:39:47
Sampling Stop: 12/07/2005 12:00:00	Decay Time. . . . . 1.51e+003 Hrs
Buildup Time. . . . . 0.00e+000 Hrs	Live Time . . . . . 3600 Sec
Sample Size . . . . . 9.70e-001 L	Real Time . . . . . 3690 Sec
Collection Efficiency 1.0000	Spectrum File 060426D10.SPC
Cr. Level Confidence Interval: 95 %	Det. Limit Confidence Interval: 95 %

Detector #: 10 (Detector 10)

Efficiency File: (D10)(Sh01).EFF (Geo 1 Eff Cal)
Eff.=1/[3.02E-02*En^-2.41E+00 + 3.34E+01*En^6.62E-01] 10/03/2005

Library File: . . . . . .FANP.LIB (FANP (Fiss. Act. and Nat. Products))

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	NET	Concentration (pCi/L)		MDA	Critical Level	Halflife (hrs)
Th-234	92.50	N	-8.14E+01	9.41E+01	1.67E+02	8.06E+01	3.92E+13
Pb-212	238.63	N	8.10E-01	1.08E+01	1.85E+01	8.87E+00	1.67E+04
Pb-214	351.99	N	2.06E+00	1.56E+01	2.65E+01	1.28E+01	1.40E+07
Tl-208	583.14	N	4.02E+00	6.74E+00	1.13E+01	5.33E+00	1.67E+04
Bi-214	609.32	N	3.87E+00	1.71E+01	2.90E+01	1.39E+01	1.40E+07
K-40	1460.75		1.52E+02	9.39E+01	1.46E+02	6.88E+01	1.12E+13
Am-241	59.54	N	-2.41E+01	2.35E+01	4.27E+01	2.04E+01	3.80E+06
Eu-155	105.31	N	1.79E+00	1.91E+01	3.27E+01	1.56E+01	4.35E+04
Co-57	122.07	N	4.77E+00	5.07E+00	8.27E+00	3.95E+00	6.48E+03
Ce-144	133.53	N	-8.63E+00	3.25E+01	5.72E+01	2.72E+01	6.82E+03
U-235	143.76	N	2.35E+01	3.35E+01	5.54E+01b	2.65E+01	6.17E+12
Ce-139	165.85	N	4.94E-01	6.03E+00	1.03E+01	4.94E+00	3.30E+03
Th-227	236.00	N	-5.25E+00	4.03E+01	6.95E+01R	3.36E+01	1.90E+05
Cr-51	320.07	N	8.81E+01	1.94E+02	3.26E+02	1.55E+02	6.65E+02
I-131	364.48	N	3.53E+02	1.12E+03	1.90E+03	9.01E+02	1.93E+02
Sb-125	427.95	N	1.61E+01	1.49E+01	2.41E+01	1.13E+01	2.43E+04
Be-7	477.56	N	-4.83E+01	8.83E+01	1.61E+02	7.57E+01	1.28E+03
Sb-124	602.71	N	-1.20E+01	1.58E+01	2.80E+01B	1.35E+01	1.44E+03
Cs-134	604.66	N	-2.67E+00	1.04E+01	1.80E+01R	8.74E+00	1.81E+04
Ru-106	621.84	N	-2.59E+01	6.06E+01	1.09E+02	5.13E+01	8.84E+03
Ag-110M	657.75	N	1.49E+00	5.75E+00	9.92E+00	4.62E+00	6.00E+03
Cs-137	661.62	N	-2.06E+00	5.55E+00	1.00E+01	4.71E+00	2.64E+05
Nb-94	702.50	N	-1.47E+00	5.58E+00	9.92E+00	4.68E+00	1.78E+08
Bi-212	727.17	N	6.43E+01	8.58E+01	1.42E+02	6.62E+01	1.67E+04
Nb-95	765.82	N	-8.60E-01	9.88E+00	1.75E+01	8.19E+00	1.54E+03

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060426D10.SPC Analyzed by

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	NET	Concentration (pCi/L)	MDA	Critical Level	Halflife (hrs)
Co-58	810.75	N	-1.35E+01 +- 8.90E+00	1.77E+01	8.30E+00	1.70E+03
Mn-54	834.81	N	-3.88E+00 +- 7.59E+00	1.36E+01	6.46E+00	7.49E+03
Sc-46	889.26	N	1.92E+00 +- 8.84E+00	1.53E+01	7.13E+00	2.01E+03
Ac-228	911.07	N	1.63E+01 +- 2.22E+01	3.67E+01	1.71E+01	5.04E+04
Pa-234m	1001.03	N	1.56E+02 +- 9.88E+02	1.72E+03	8.01E+02	3.92E+13
Eu-154	1004.80	N	-1.07E+01 +- 3.19E+01	5.80E+01	2.70E+01	7.45E+04
Fe-59	1099.22	N	1.89E+01 +- 2.52E+01	4.15E+01	1.90E+01	1.08E+03
Zn-65	1115.52	N	-8.11E+00 +- 1.50E+01	2.75E+01	1.29E+01	5.85E+03
Co-56	1238.28	N	5.35E+00 +- 1.87E+01	3.21E+01	1.50E+01	1.86E+03
Na-22	1274.54	N	-3.74E+00 +- 6.30E+00	1.18E+01	5.48E+00	2.28E+04
Co-60	1332.51	N	5.34E-01 +- 6.03E+00	1.07E+01	4.91E+00	4.62E+04
Eu-152	1408.08	N	-5.20E+00 +- 2.85E+01	5.21E+01	2.39E+01	1.17E+05
Al-26	1808.65	N	1.41E+00 +- 6.38E+00	1.13E+01	5.11E+00	6.31E+09

MEASURED TOTAL: 9.17E+02 +- 2.70E+03 pCi/L

UNKNOWN,SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	46.84	96.02	-35	44	37	175	0.90	Deleted
2	63.46	129.18	-7	41	34	143	0.87	Deleted
3	66.52	135.28	33	41	33	143	0.81	Deleted
4	75.19	152.58	-18	31	27	69	0.54	Deleted
5	77.26	156.72	-10	39	33	114	0.81	Deleted
7	139.97	281.87	19	36	29	132	0.94	Deleted
8	186.16	374.03	-27	37	32	117	0.93	Deleted
9	198.53	398.71	52	42	32	137	1.26	Unknown
11	242.16	485.78	-9	35	29	112	0.92	Deleted
12	295.44	592.09	-34	38	33	114	1.08	Deleted
14	511.21	1022.65	4	60	49	157	2.91	Deleted
15	558.89	1117.80	20	28	22	56	1.50	Deleted
19	1764.55	3523.64	-11	21	18	24	2.95	Deleted

c:\SEEKER\BIN\060426d10.res Analysis Results Saved.

060418D07.SPC Analyzed by MC

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: GS060119-3MB GS060119-3

Sampling Start:	02/09/2006 00:00:00	Counting Start:	02/09/2006 00:38:06
Sampling Stop:	02/09/2006 00:00:00	Decay Time.	6.35E-001 Hrs
Buildup Time.	0.00E+000 Hrs	Live Time	17700 Sec
Sample Size	1.00E+000 L	Real Time	17748 Sec
Collection Efficiency	1.0000	Spc. File	.060418D07.SPC

Detector #: 7 (Detector 7)

Energy(keV)= -2.35 + 0.501*Ch +-1.08E-07*Ch^2 + 7.78E-11*Ch^3 02/08/2006
FWHM(keV) = 0.77 + 0.008*En + 7.04E-04*En^2 + 0.00E+00*En^3 12/04/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
1	46.37	97.23	106	41	29	191	0.73	a	
2	63.20	130.81	120	58	45	366	0.94	a	
3	66.36	137.11	114	52	39	305	0.83	b	
4	74.91	154.18	37	48	38	298	0.83	a	NET< CL
5	84.59	173.49	41	32	24	145	0.46	a	
6	92.57	189.42	154	56	41	311	1.04	a	
7	139.54	283.15	75	44	33	223	0.87	a	
8	175.68	355.28	46	71	58	410	1.97	a	NET< CL Wide Pk
9	185.77	375.41	126	53	39	263	1.08	a	
10	193.27	390.39	32	52	42	276	1.25	a	NET< CL
11	198.45	400.72	94	36	25	138	0.73	b	
12	209.74	423.25	37	42	33	199	1.03	a	
13	238.58	480.82	35	48	38	247	1.11	a	NET< CL
14	511.06	1024.59	373	61	39	201	2.27	a	Wide Pk
15	558.48	1119.20	94	36	25	108	1.41	a	
16	596.37	1194.80	76	43	32	148	2.16	a	
17	802.76	1606.53	39	25	18	58	1.66	a	
18	1461.06	2918.27	25	18	12	29	1.75	a	

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060418D07.SPC Analyzed by

SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Vers. 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

Background File:. . . . . DET070203.BKG (0614013-7 WEEKLY BKGD)

Bkg.File Detector #: 7

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
1	46.37	106	41	29	-20	67	56	NET<CL
2	63.20	120	58	45	-15	75	62	NET<CL
3	66.36	114	52	39	59	79	64	NET<CL
4	74.91	37	48	38	-8	66	54	NET<CL
5	84.59	41	32	24	11	52	43	NET<CL
6	92.57	154	56	41	1	73	60	NET<CL
7	139.54	75	44	33	28	68	55	NET<CL
9	185.77	126	53	39	63	72	57	
11	198.45	94	36	25	64	46	35	
13	238.58	35	48	38	-22	60	50	NET<CL
14	511.06	373	61	39	25	90	74	NET<CL
15	558.48	94	36	25	52	45	35	
16	596.37	76	43	32	62	60	48	
17	802.76	39	25	18	11	35	28	NET<CL
18	1461.06	25	18	12	-6	28	23	NET<CL

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060418D07.SPC Analyzed by

SEEKER F I N A L A C T I V I T Y R E P O R T Version 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

Geo 1 / Water

Sample ID: GS060119-3MB GS060119-3

Sampling Start: 02/09/2006 00:00:00	Counting Start: 02/09/2006 00:38:06
Sampling Stop: 02/09/2006 00:00:00	Decay Time. . . . . 6.35e-001 Hrs
Buildup Time. . . . . 0.00e+000 Hrs	Live Time . . . . . 17700 Sec
Sample Size . . . . . 1.00e+000 L	Real Time . . . . . 17748 Sec
Collection Efficiency 1.0000	Spectrum File 060418D07.SPC
Cr. Level Confidence Interval: 95 %	Det. Limit Confidence Interval: 95 %

Detector #: 7 (Detector 7)

Efficiency File: (D07)(Sh01).EFF (Geo 1 Eff CaL)
Eff.=1/[1.72E-01*En^-1.65E+00 + 1.63E+02*En^9.06E-01] 12/13/2005

Library File: . . . . . .FANP.LIB (FANP (Fiss. Act. and Nat. Products))

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	NET	Concentration (pCi/L)		MDA	Critical Level	Halflife (hrs)
Th-234	92.50	N	7.81E-01	+- 5.56E+01	9.35E+01	4.57E+01	3.92E+13
U-235	143.76	N	1.80E+01	+- 2.08E+01	3.41E+01	1.64E+01	6.17E+12
	185.72		I.D.	. . . .	. . . .	. . . .	6.17E+12
K-40	1460.75	N	-2.07E+01	+- 8.90E+01	1.58E+02	7.46E+01	1.12E+13
Am-241	59.54	N	-1.11E+00	+- 5.86E+00	1.01E+01B	4.86E+00	3.80E+06
Eu-155	105.31	N	3.87E+00	+- 8.94E+00	1.50E+01	7.21E+00	4.35E+04
Co-57	122.07	N	1.17E+00	+- 2.41E+00	4.03E+00	1.94E+00	6.48E+03
Ce-144	133.53	N	1.07E+01	+- 1.89E+01	3.15E+01	1.52E+01	6.82E+03
Ce-139	165.85	N	1.28E+00	+- 2.94E+00	4.93E+00	2.37E+00	3.30E+03
Th-227	236.00	N	-3.53E+01	+- 2.66E+01	4.77E+01	2.31E+01	1.90E+05
Pb-212	238.63	N	4.69E+00	+- 7.45E+00	1.24E+01	5.96E+00	1.67E+04
Cr-51	320.07	N	1.39E+01	+- 3.21E+01	5.40E+01	2.58E+01	6.65E+02
Pb-214	351.99	N	2.89E+00	+- 1.18E+01	2.00E+01	9.64E+00	1.40E+07
I-131	364.48	N	-2.94E+00	+- 4.23E+00	7.58E+00	3.62E+00	1.93E+02
Sb-125	427.95	N	3.88E-01	+- 1.21E+01	2.08E+01	9.90E+00	2.43E+04
Be-7	477.56	N	-1.34E+01	+- 3.60E+01	6.40E+01	3.04E+01	1.28E+03
Tl-208	583.14	N	-7.27E+00	+- 7.31E+00	1.31E+01	6.30E+00	1.67E+04
Sb-124	602.71	N	1.19E+00	+- 4.88E+00	8.34E+00b	3.95E+00	1.44E+03
Cs-134	604.66	N	-1.91E+00	+- 4.95E+00	8.78E+00	4.17E+00	1.81E+04
Bi-214	609.32	N	-3.64E+00	+- 1.58E+01	2.72E+01	1.31E+01	1.40E+07
Ru-106	621.84	N	-3.56E+01	+- 4.89E+01	8.88E+01	4.21E+01	8.84E+03
Ag-110M	657.75	N	-4.68E+00	+- 5.12E+00	9.45E+00	4.48E+00	6.00E+03
Cs-137	661.62	N	1.56E+00	+- 5.49E+00	9.38E+00	4.42E+00	2.64E+05
Nb-94	702.50	N	7.41E-01	+- 5.42E+00	9.34E+00	4.42E+00	1.78E+08
Bi-212	727.17	N	-4.26E+00	+- 6.40E+01	1.14E+02	5.30E+01	1.67E+04

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060418D07.SPC Analyzed by

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	NET	Concentration (pCi/L)		MDA	Critical Level	Halflife (hrs)
Nb-95	765.82	N	-1.57E+00	+- 4.46E+00	8.08E+00	3.78E+00	1.54E+03
Co-58	810.75	N	-5.82E+00	+- 5.02E+00	9.58E+00	4.51E+00	1.70E+03
Mn-54	834.81	N	-3.60E+00	+- 5.21E+00	9.61E+00	4.52E+00	7.49E+03
Sc-46	889.26	N	-1.57E+00	+- 5.14E+00	9.29E+00	4.34E+00	2.01E+03
Ac-228	911.07	N	-2.29E+00	+- 2.96E+01	5.14E+01	2.45E+01	5.04E+04
Pa-234m	1001.03	N	-2.24E+02	+- 1.00E+03	1.79E+03	8.39E+02	3.92E+13
Eu-154	1004.80	N	-8.48E+00	+- 3.23E+01	5.81E+01	2.72E+01	7.45E+04
Fe-59	1099.22	N	6.31E+00	+- 1.08E+01	1.82E+01	8.43E+00	1.08E+03
Zn-65	1115.52	N	-2.01E+00	+- 1.23E+01	2.20E+01	1.03E+01	5.85E+03
Co-56	1238.28	N	4.48E+00	+- 9.22E+00	1.57E+01	7.22E+00	1.86E+03
Na-22	1274.54	N	4.04E+00	+- 6.06E+00	1.01E+01	4.63E+00	2.28E+04
Co-60	1332.51	N	4.85E+00	+- 6.10E+00	1.00E+01	4.57E+00	4.62E+04
Eu-152	1408.08	N	1.35E+00	+- 3.01E+01	5.37E+01	2.46E+01	1.17E+05
Al-26	1808.65	N	4.17E+00	+- 6.48E+00	1.09E+01	4.86E+00	6.31E+09

MEASURED TOTAL: 8.64E+01 +- 2.58E+02 pCi/L

UNKNOWN,SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	46.37	97.23	-20	67	56	191	0.73	Deleted
2	63.20	130.81	-15	75	62	366	0.94	Deleted
3	66.36	137.11	59	79	64	305	0.83	Deleted
4	74.91	154.18	-8	66	54	298	0.83	Deleted
5	84.59	173.49	11	52	43	145	0.46	Deleted
7	139.54	283.15	28	68	55	223	0.87	Deleted
8	175.68	355.28	46	71	58	410	1.97	Deleted
10	193.27	390.39	32	52	42	276	1.25	Deleted
11	198.45	400.72	64	46	35	138	0.73	Unknown
12	209.74	423.25	37	42	33	199	1.03	Unknown
13	238.58	480.82	-22	60	50	247	1.11	Deleted
14	511.06	1024.59	25	90	74	201	2.27	Deleted
15	558.48	1119.20	52	45	35	108	1.41	Unknown
16	596.37	1194.80	62	60	48	148	2.16	Unknown
17	802.76	1606.53	11	35	28	58	1.66	Deleted

c:\SEEKER\BIN\060418d07.res Analysis Results Saved.

060422D07.SPC Analyzed by MC

SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

Geo 1 / Water

Sample ID: GS060119-3LCS GS060119-3

Sampling Start: 02/09/2006 06:00:00	Counting Start: 02/09/2006 06:51:54
Sampling Stop: 02/09/2006 06:00:00	Decay Time. . . . . 8.65E-001 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 1800 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 1889 Sec
Collection Efficiency 1.0000	Spc. File 060422D07.SPC

Detector #: 7 (Detector 7)

Energy(keV)= -2.36 + 0.501*Ch + 4.44E-07*Ch^2 +-6.57E-11*Ch^3 02/09/2006
FWHM(keV) = 0.77 + 0.008*En + 7.04E-04*En^2 + 0.00E+00*En^3 12/04/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	44.03	92.66	365	258	210	8121	1.05 a	Wide Pk
2	49.34	103.27	8150	661	523	27544	2.60 b	
3	51.80	108.17	3669	616	497	27404	2.29 c	
4	54.07	112.71	762	409	333	17604	1.31 d	
5	59.45	123.45	76787	600	190	7242	0.88 a	
6	67.33	139.20	1046	342	276	8894	2.10 a	Wide Pk
7	70.18	144.89	562	403	330	10947	2.68 b	
8	87.96	180.39	27704	370	132	3237	0.90 a	
9	121.93	248.22	5360	189	98	1792	0.94 a	
10	136.38	277.08	609	128	97	1733	0.92 a	
11	145.78	295.84	64	100	81	1332	0.88 a	NET< CL
12	165.76	335.74	613	131	100	1694	1.11 a	
13	185.33	374.81	62	99	81	1311	0.79 a	NET< CL
14	331.26	666.07	51	80	65	842	0.83 a	NET< CL
15	391.62	786.52	177	96	76	1137	1.08 a	
16	587.96	1178.18	44	55	44	439	0.85 a	NET< CL
17	661.65	1325.13	19049	288	69	820	1.43 a	
18	897.90	1796.21	95	80	64	843	1.24 a	
19	1173.28	2345.20	16132	260	47	435	1.88 a	
20	1332.46	2662.54	14484	242	23	94	2.01 a	HiResid
21	1835.42	3665.59	74	21	10	16	2.20 a	

060422D07.SPC Analyzed by

****

SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Vers. 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

****

Background File:. . . . . DET070203.BKG (0614013-7 WEEKLY BKGD)

Bkg.File Detector #: 7

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
3	51.80	3669	616	497	3667	617	497	
6	67.33	1046	342	276	1041	342	276	
13	185.33	62	99	81	55	99	81	NET<CL
16	587.96	44	55	44	43	55	44	NET<CL

060422D07.SPC Analyzed by

SEEKER F I N A L A C T I V I T Y R E P O R T Version 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

Geo 1 / Water

Sample ID: GS060119-3LCS GS060119-3

Sampling Start: 02/09/2006 06:00:00	Counting Start: 02/09/2006 06:51:54
Sampling Stop: 02/09/2006 06:00:00	Decay Time. . . . . 8.65e-001 Hrs
Buildup Time. . . . . 0.00e+000 Hrs	Live Time . . . . . 1800 Sec
Sample Size . . . . . 1.00e+000 L	Real Time . . . . . 1889 Sec
Collection Efficiency 1.0000	Spectrum File 060422D07.SPC
Cr. Level Confidence Interval: 95 %	Det. Limit Confidence Interval: 95 %

Detector #: 7 (Detector 7)

Efficiency File: (D07)(Sh01).EFF (Geo 1 Eff CaL)
Eff.=1/[1.72E-01*En^-1.65E+00 + 1.63E+02*En^9.06E-01] 12/13/2005

Library File: . . . .ANALYTICAL.LIB (Analytical)

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	N E T	Concentration (pCi/L)	MDA	Critical Level	Halflife (hrs)
Am-241	59.54		9.90E+04 +- 7.74E+02	4.92E+02	2.44E+02	3.79E+06
Cd-109	88.02		3.18E+05 +- 4.24E+03	3.07E+03	1.52E+03	1.11E+04
Co-57	122.07		2.80E+03 +- 9.89E+01	1.04E+02	5.15E+01	6.50E+03
Ce-139	165.85		4.05E+02 +- 8.65E+01	1.34E+02	6.59E+01	3.30E+03
Sn-113	391.68		2.88E+02 +- 1.57E+02	2.53E+02	1.24E+02	2.76E+03
Cs-137	661.62		3.78E+04 +- 5.72E+02	2.78E+02	1.36E+02	2.64E+05
Y-88	Average:x		2.99E+02 +- 8.02E+01	. . . .	. . . .	2.56E+03
	898.02		2.26E+02 +- 1.91E+02	3.12E+02	1.53E+02	2.56E+03
	1836.01		3.15E+02 +- 8.83E+01	9.34E+01	4.09E+01	2.56E+03
Co-60	Average:x		4.59E+04 +- 5.33E+02	. . . .	. . . .	4.62E+04
	1173.21		4.57E+04 +- 7.38E+02	2.77E+02	1.34E+02	4.62E+04
	1332.48		4.60E+04 +- 7.70E+02	1.52E+02	7.17E+01	4.62E+04
Hg-203	279.18		MDA	1.77E+02	8.72E+01	1.12E+03

MEASURED TOTAL: 5.04E+05 +- 6.54E+03 pCi/L

UNKNOWN,SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	44.03	92.66	365	258	210	8121	1.05	Unknown
2	49.34	103.27	8150	661	523	27544	2.60	Unknown
3	51.80	108.17	3667	617	497	27404	2.29	Unknown

000025

060422D07.SPC Analyzed by

UNKNOWN,SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
4	54.07	112.71	762	409	333	17604	1.31	Unknown
6	67.33	139.20	1041	342	276	8894	2.10	Unknown
7	70.18	144.89	562	403	330	10947	2.68	Unknown
10	136.38	277.08	609	128	97	1733	0.92	Unknown
11	145.78	295.84	64	100	81	1332	0.88	Deleted
13	185.33	374.81	55	99	81	1311	0.79	Deleted
14	331.26	666.07	51	80	65	842	0.83	Deleted
16	587.96	1178.18	43	55	44	439	0.85	Deleted

c:\SEEKER\BIN\060422d07.res Analysis Results Saved.

Paragon Analytics

Gamma Spectrometer Run Log

Date: 2/8/06 Reviewed By/Date: JP 2/9/06

Sample ID	Ver[1]	Det. No.	Geo[2]	Count Dur. (min.)[3]	Start Time	Analyst	File ID/Comments	Saved?
GS060208-10MB	JP	7	7*	60	11:45	JP	060408D07.SPC	JP
0602073-1	JP	2	9↑	60	12:06	JP	060343D02.SPC	JP
0602071-2D	JP	10	7*	60	12:10	JP	060424D10.SPC	JP
GS051212-8MB	JP	8	18/27	120	12:14	JP	060433D08.SPC	JP
0602073-2	JP	4	9↑	60	12:46	JP	060315D04.SPC	JP
↓ -4	JP	6	9↑	60	↓	↓	060422D06.SPC	JP
GS060208-10LCS	JP	7	7*	~~60~~ 30	12:49	JP	060409D07.SPC	JP JP 2/8/06
0602073-5	JP	2	9↑	60	13:35	JP	060344D02.SPC	JP
0601021-1	JP	10	1	60	13:36	JP	060425D10.SPC	JP
GS060208-11LCS	JP	4	9↑	30	13:49	JP	060316D04.SPC	JP
↓ -11MB	JP	6	9↑	60	↓	JP	060423D06.SPC	JP
0511011-1	JP	7	18/27	60	13:52	JP	060410D07.SPC	JP
↓ -2	JP	8	↓	60	14:19	JP	060434D08.SPC	JP
0602042-11	JP	4	7*	1000	14:22	JP	060317D04.SPC	JP
↓ -38	JP	2	↓	↓	14:38	JP	060345D02.SPC	JP
0512143-1	JP	10	1	60	14:39	JP	060426D10.SPC	JP
0601047-7	JP	6	11	75	14:51	JP	060425D06.SPC	JP
0511011-3	JP	7	18/27	75	14:57	JP	060413D07.SPC	JP
↓ -1D	JP	8	↓	60	15:24	JP	060436D08.SPC	JP
0601021-2	JP	10	1	60	15:44	JP	060427D10.SPC	JP
0511011-5	MC	7	18/27	↓	16:20	JP	060414D07.SPC	MC
0601047-12	JP	6	11	40	16:09	JP	060426D06.SPC	JP
0511011-4	MC	8	18/27	90	16:29	JP	060438D08.SPC	MC
0601021-3	MC	10	1	60	16:47	JP	060428D10.SPC	MC

1 Analyst will verify the position, detector, and geometry when the sample is removed from the detector.

2 Calibration geometry.

3 Count duration.

KEY: * sample was counted on a puck
↑ sample was counted with air flow arrow pointing up
↓ sample was counted with air flow arrow pointing down

303193 B

Gamma Spectrometer Run Log

Date: 2/8/06 Reviewed By/Date: MC 2/9/06

Sample ID	Ver[1]	Det. No.	Geo[2]	Count Dur. (min.)[3]	Start Time	Analyst	File ID/Comments	Saved?
0601047-3	MC	6	11	75	16:52	JP	060427D06.SPC	MC
0511011-6	↓	7	18/27	90	17:35	MC	060416D07.SPC	↓
0601021-4	MC	10	1	60	17:57	↓	060429D10.SPC	MC
0601047-13	↓	6	11	75	18:16	MC	060428D06.SPC	↓
0511011-8	MC	8	18/27	60	18:21	↓	060439D08.SPC	MC
0613003-5 (798)	↓	5	1	↓	18:25	MC	060004D05.SPC	↓
0613004-5 (798)	↓	↓	↓	↓	↓	↓	↓	↓
0601021-5	MC	10	1	60	18:59	MC	060430D10.SPC	MC
0613003-1 (796)	↓	1	11	↓	19:02	↓	060006D01.SPC	↓
0613008-1 (796)	MC	↓	↓	↓	↓	↓	↓	↓
0601021-1B	↓	7	1	295	19:30	MC	060417D07.SPC	MC
0512120-1	MC	8	1	↓	↓	↓	060440D08.SPC	↓
0614013-5		5	NA	1000	19:57	MC	060005D05SPC	JP
0512120-2	MC	6	1	285	19:40	↓	060429D06.SPC	MC
0601021-6	↓	10	↓	75	20:02	MC	060431D10.SPC	MC
0613003-1 (796)	MC	1	11	45	20:07	MC	060007D01.SPC	MC
0613008-1 (796)	↓	↓	↓	↓	↓	↓	↓	↓
0614013-1	〃	1	NA	1000	00:38	MC	———	〃
0511145-3	JP	10	11	300		↓	060432D10.SPC	JP
GS060119-3MB	JP	7	1	295		MC	060418D07SPC	JP
GS060116-5MB	JP	6	↓	295		↓	060430D06.SPC	JP
0512120-5	JP	8	1	↓		↓	060441D08.SPC	JP
———				MC	2/8/06		———	
———							———	

1 Analyst will verify the position, detector, and geometry when the sample is removed from the detector.

2 Calibration geometry.

3 Count duration.

KEY: * sample was counted on a puck
↑ sample was counted with air flow arrow pointing up
↓ sample was counted with air flow arrow pointing down

0 COUNTS IN PROGRESS.
MC 2/9/06

309194 B

Gamma Spectrometer Run Log

Date: 2/9/06 Reviewed By/Date: MC 2/9/06

Sample ID	Ver[1]	Det. No.	Geo[2]	Count Dur. (min.)[3]	Start Time	Analyst	File ID/Comments	Saved?
0601034-1	JP	6	17/26	30	6:11	JP	060432D06.SPC	JP
0511011-7	JP	8	18/27	60	↓	↓	060443D08SPC	JP
0601034-2	JP	6	17/26	60	6:46	JP	060434D06.SPC	JP
GS060119-3LCS	JP	7	1	30	6:51	JP	060422D07.SPC	JP
0511011-9	JP	8	18/27	75	~~7:27~~ 7:16	JP	060445D08.SPC	JP JP 2/9/06
↓ -10	JP	7	↓	↓	7:25	JP	060423D07.SPC	JP
↓ -11	JP	10	18/27	90	7:40	JP	060438D10.SPC	JP
0601034-3	JP	4	17/26	30	7:32	JP	060319D04.SPC	JP
0601047-15	JP	6	11	45	7:54	JP	060435D06.SPC	JP
↓ -14	JP	4	11	60	8:05	JP	060320D04.SPC	JP
0511011-12	JP	2	18/27	60	8:11	JP	060348D02.SPC	JP
0601047-17	JP	6	11	45	8:42	JP	060436D06.SPC	JP
0511011-14	JP	7	18/27	90	8:48	JP	060425D07.SPC	JP
↓ -15	JP	8	↓	105	↓	↓	060447D08.SPC	JP
0601047-16	JP	4	11	45	9:12	JP	060321D04.SPC	JP
0511011-11D	JP	2	18/27	120	9:18	JP	060351D02.SPC	JP
↓ -13	JP	10	↓	75	↓	↓	060439D10.SPC	JP
GS060118-1MB	JP	6	11	75	9:30	JP	060437D06.SPC	JP
↓ LCS	JP	4	11	30	10:00	JP	060322D04.SPC	JP
GS051212-5MB	JP	7	18/27	120	10:29	JP	060426D07.SPC	JP
0601034-1D	JP	4	17/26	30	10:33	JP	060323D04.SPC	JP
GS051212-5LCS	JP	10	18	30	10:39	JP	060440D10.SPC	JP
↓ -5ALCS	JP	8	27	30	10:43	JP	060448D08.SPC	JP
0601034-4	JP	6	17/26	60	10:53	JP	060438D06.SPC	JP

1 Analyst will verify the position, detector, and geometry when the sample is removed from the detector.

2 Calibration geometry.

3 Count duration.

KEY: * sample was counted on a puck
↑ sample was counted with air flow arrow pointing up
↓ sample was counted with air flow arrow pointing down

Technical Comments Regarding Analysis using the FANP Gamma Spectroscopic Library

Analysis using the **FANP** (**F**ission, **A**ctivation, and **N**atural **P**roducts) library is limited to the list of gamma emitting radionuclides specified by Paragon Analytics. Paragon Analytics specifies all values assigned to the nuclides in this library. In cases where multiple gamma emissions are used to quantify activity, the most abundant emission is used for quantification in the absence of any supporting gamma emissions. It should be noted that the current software program used for gamma spectroscopic analysis is limited to a +/- 2.0 keV photo-peak resolution tolerance. Thus, any gamma emissions occurring within the same +/- 2.0 keV range will suffer interference, consequently preventing accurate quantification. Nuclide specific information regarding analysis using the FANP library is as follows:

Nuclide: ^{228}Ac Energy: various Photon Abundance: various

All activity values for ^{228}Ac are calculated using the half-life, $t_{1/2}$=5.75 years, of the long-lived ^{228}Ra parent. It is assumed that secular equilibrium is achieved between the ^{228}Ra parent and the ^{228}Ac progeny.

Nuclide: ^{212}Bi, ^{212}Pb, ^{208}Tl Energy: various Photon Abundance: various

All activity values for ^{212}Bi, ^{212}Pb, and ^{208}Tl are calculated using the half-life, $t_{1/2}$=1.91 years, of the long-lived ^{228}Th parent. It is assumed that secular equilibrium is achieved between the ^{228}Th parent and the ^{212}Bi, ^{212}Pb, ^{208}Tl progeny.

Nuclide: ^{214}Bi, ^{214}Pb Energy: various Photon Abundance: various

All activity values for ^{214}Bi and ^{214}Pb are calculated using the half-life, $t_{1/2}$=1600 years, of the long-lived ^{226}Ra parent. It is assumed that secular equilibrium is achieved between the ^{226}Ra parent and the ^{214}Bi and ^{214}Pb progeny.

Nuclide: ^{56}Co Energy: 1175.13 keV Photon Abundance: 0.0228

This emission for this nuclide suffers from possible resolution interference due to the ^{60}Co gamma emission occurring at 1173.23 keV (0.9997, abundance). Therefore, this emission will be used as an identifier only and not in the activity calculations for this nuclide.

Nuclides: ^{57}Co Energy: 122.07 Photon Abundance: 0.8560

The most abundant gamma emission specified for quantification of this nuclide suffers from possible resolution interference due to the ^{152}Eu gamma emission occurring at 121.78 keV (0.2050, abundance). Therefore, a possibility of a high bias to the ^{57}Co results may occur in the presence of elevated ^{152}Eu activity.

Nuclide: ^{134}Cs Energy: 604.66 Photon Abundance: 0.9762

The most abundant gamma emission specified for quantification of this nuclide suffers from possible resolution interference due to the ^{124}Sb gamma emission occurring at 602.71 keV (0.9826, abundance). Therefore, a possibility of a high bias to the ^{134}Cs results may occur in the presence of elevated ^{124}Sb activity.

Other gamma emissions used for quantification of this nuclide suffer from possible resolution interference due to multiple gamma emissions of ^{228}Ac. Therefore, a possible high bias to the ^{134}Cs activity results may occur in the presence of elevated ^{228}Ac activity.

Nuclide: ^{137}Cs Energy: 661.62 keV Photon Abundance: 0.8512

Cesium-137 does not emit any gamma photons useful for quantification. However, it can be assumed to be in secular equilibrium with the short-lived ^{137m}Ba daughter product. Therefore, the activity for ^{137}Cs is determined from the 661.62 keV gamma emission of the ^{137m}Ba daughter product. The calculated gamma photon abundance used in the library is the product of the 0.8998 abundance of the 661.62 keV ^{137m}Ba photon and the 0.946 branching ratio between ^{137}Ba and ^{137m}Ba.

Nuclide: ^{155}Eu Energy: 105.31 Photon Abundance: 0.2120

The only gamma emission useful for quantification of this nuclide suffers from possible resolution interference due to the ^{235}U gamma emission occurring at 105 keV (0.0210, abundance). Therefore, a possibility of a high bias to the ^{155}Eu results may occur in the presence of elevated ^{235}U activity.

Nuclide: ^{40}K Energy: 1460.75 Photon Abundance: 0.1100

The only gamma emission useful for quantification of this nuclide suffers from possible resolution interference due to the ^{228}Ac gamma emission occurring at 1459.2 keV (0.0104, abundance). Therefore, a possibility of a high bias to the ^{40}K results may occur in the presence of elevated ^{228}Ac activity.

Nuclide: ^{54}Mn Energy: 834.81 Photon Abundance: 0.9997

The only gamma emission useful for quantification of this nuclide suffers from possible resolution interference due to the ^{228}Ac gamma emission occurring at 835.6 keV (0.0182, abundance). Therefore, a possibility of a high bias to the ^{54}Mn results may occur in the presence of elevated ^{228}Ac activity.

Nuclide: ^{95}Nb Energy: 765.82 Photon Abundance: 0.9999

All activity values for ^{95}Nb are calculated using the half-life, $t_{1/2}$=64.02 days, of the ^{95}Zr parent. It is assumed that a transient equilibrium is achieved between the ^{95}Zr parent and the ^{95}Nb progeny.

The only gamma emission useful for quantification of this nuclide suffers from possible resolution interference due to the ^{234m}Pa gamma emission occurring at 766.6 keV (0.0020, abundance). Therefore, a possibility of a high bias to the ^{95}Nb results may occur in the presence of elevated ^{234m}Pa activity.

Nuclide: ^{234m}Pa Energy: 1001.03 Photon Abundance: 0.0059

All activity values for ^{234m}Pa are calculated using the half-life, $t_{1/2}$=4.468E+09 yrs, of the long-lived ^{238}U parent. It is assumed that secular equilibrium is achieved between the ^{238}U parent and the ^{234m}Pa progeny.

Nuclide: ^{106}Ru Energy: various Photon Abundance: various

Ru-106 does not emit any gamma photons. Therefore, all activity values for ^{106}Ru are calculated using the gamma emissions of the short-lived ^{106}Rh daughter. The half-life, $t_{1/2}$=368.2 days, of the ^{106}Ru parent is used in the activity calculations. It is assumed that a secular equilibrium is achieved between the ^{106}Ru parent and the ^{106}Rh progeny.

Nuclide: ^{124}Sb Energy: 602.71 Photon Abundance: 0.9826

The most abundant gamma emission specified for quantification of this nuclide suffers from possible resolution interference due to the ^{134}Cs gamma emission occurring at 604.66 keV (0.9762, abundance). Therefore, a possibility of a high bias to the ^{124}Sb results may occur in the presence of elevated ^{134}Cs activity.

Nuclide: ^{125}Sb Energy: 600.77 Photon Abundance: 0.1786

The gamma emission specified for quantification of this nuclide that occurs at 600.77 keV suffers from possible resolution interference due to the ^{124}Sb gamma emission occurring at 602.71 keV (0.9826, abundance). Therefore, this photo-peak will be used as an identifier only and not in the activity calculations for this nuclide.

Nuclide: ^{227}Th Energy: 236.00 Photon Abundance: 0.1230

All activity values for ^{227}Th are calculated using the half-life, $t_{1/2}$=21.7 yrs, of the long-lived ^{227}Ac parent. It is assumed that secular equilibrium is achieved between the ^{227}Ac parent and the ^{227}Th progeny.

Nuclide: ^{234}Th Energy: 92.50 Photon Abundance: 0.0553

The 92.50 keV photo-peak used in this library for Th-234 quantification is actually two separate photo-peaks, occurring at 92.4 keV and 92.8 keV. The current software used for gamma spectroscopic analysis cannot resolve two photo-peaks that occur within the 2-keV resolution tolerance. Therefore, these two photopeaks are observed as a single photo-peak. Therefore, the average of the two photo-peak energies is used in this library. Also, the sum of the two photo-peak abundances, 0.0553, is used in the activity calculations for this observed 'single' photo-peak.

All activity values for ^{234}Th are calculated using the half-life, $t_{1/2}$=4.468E+09 yrs, of the long-lived ^{238}U parent. It is assumed that secular equilibrium is achieved between the ^{238}U parent and the ^{234}Th progeny.

Nuclide: ^{235}U Energy: 185.70 Photon Abundance: 0.5720

Quantifying ^{235}U activity using the 185.70 keV photo-peak is vulnerable to a significant high bias due to interference from gamma emissions from ^{226}Ra occurring at 186.21 keV (0.0328, abundance). Therefore, this emission will be used as an identifier only and not in the activity calculations for this nuclide.

Gamma Spectroscopist — Date: 2-23-05
Radiochemistry Instrumentation Laboratory

Radiochemistry Manager — Date: 2/23/05

Library File: FANP.lib
File I.D.: FANP (Fiss. Act. and Nat. Products)

OK JB 2/23/05

Pk. #	Energy (keV)	Isotope Name	2ndary Pk #	Type	Gamma Fraction	Halflife
24	338.40	Ac-228	61	QUANT	0.1127	5.7500E+00 yrs
61	911.07	Ac-228	63	NET	0.2580	5.7500E+00 yrs
63	968.90	Ac-228	24	QUANT	0.1580	5.7500E+00 yrs
41	657.75	Ag-110M	43	NET	0.9314	2.4990E+02 dys
43	677.71	Ag-110M	46	QUANT	0.1054	2.4990E+02 dys
46	706.67	Ag-110M	49	QUANT	0.1646	2.4990E+02 dys
49	763.93	Ag-110M	59	QUANT	0.2198	2.4990E+02 dys
59	884.67	Ag-110M	62	QUANT	0.7163	2.4990E+02 dys
62	937.48	Ag-110M	84	QUANT	0.3375	2.4990E+02 dys
84	1384.27	Ag-110M	87	QUANT	0.2394	2.4990E+02 dys
87	1505.00	Ag-110M	41	QUANT	0.1289	2.4990E+02 dys
90	1808.65	Al-26	0	NET	0.9973	7.2000E+05 yrs
1	59.54	Am-241	0	NET	0.3590	4.3310E+02 yrs
30	477.56	Be-7	0	NET	0.1052	5.3440E+01 dys
48	727.17	Bi-212	0	NET	0.0658	1.9100E+00 yrs
38	609.32	Bi-214	73	NET	0.4609	1.6000E+03 yrs
73	1120.28	Bi-214	38	QUANT	0.1510	1.6000E+03 yrs
11	165.85	Ce-139	0	NET	0.8035	1.3766E+02 dys
7	133.53	Ce-144	44	NET	0.1109	2.8414E+02 dys
44	696.49	Ce-144	7	QUANT	0.0130	2.8414E+02 dys
56	846.81	Co-56	67	QUANT	0.9999	7.7300E+01 dys
67	1037.83	Co-56	76	QUANT	0.1400	7.7300E+01 dys
76	1175.13	Co-56	77	ID	0.0228	7.7300E+01 dys
77	1238.28	Co-56	81	NET	0.6760	7.7300E+01 dys
81	1360.22	Co-56	89	QUANT	0.0429	7.7300E+01 dys
89	1771.49	Co-56	56	QUANT	0.1570	7.7300E+01 dys
6	122.07	Co-57	8	NET	0.8560	2.7000E+02 dys
8	136.43	Co-57	6	QUANT	0.1068	2.7000E+02 dys
54	810.75	Co-58	0	NET	0.9945	7.0780E+01 dys
75	1173.23	Co-60	80	QUANT	0.9997	5.2721E+00 yrs
80	1332.51	Co-60	75	NET	0.9998	5.2721E+00 yrs
23	320.07	Cr-51	0	NET	0.1000	2.7700E+01 dys
31	563.26	Cs-134	32	QUANT	0.0835	2.0623E+00 yrs
32	569.29	Cs-134	37	QUANT	0.1538	2.0623E+00 yrs
37	604.66	Cs-134	52	NET	0.9762	2.0623E+00 yrs
52	795.76	Cs-134	53	QUANT	0.8553	2.0623E+00 yrs
53	801.84	Cs-134	74	QUANT	0.0869	2.0623E+00 yrs
74	1167.86	Cs-134	82	QUANT	0.0180	2.0623E+00 yrs
82	1365.13	Cs-134	31	QUANT	0.0304	2.0623E+00 yrs
42	661.62	Cs-137	0	NET	0.8512	3.0104E+01 yrs
25	344.30	Eu-152	51	QUANT	0.2650	1.3330E+01 yrs
51	778.90	Eu-152	69	QUANT	0.1294	1.3330E+01 yrs
69	1085.80	Eu-152	71	QUANT	0.1021	1.3330E+01 yrs
71	1112.07	Eu-152	85	QUANT	0.1364	1.3330E+01 yrs
85	1408.08	Eu-152	25	NET	0.2100	1.3330E+01 yrs
18	248.04	Eu-154	34	QUANT	0.0660	8.5019E+00 yrs
34	591.70	Eu-154	58	QUANT	0.0460	8.5019E+00 yrs
58	873.20	Eu-154	64	QUANT	0.1227	8.5019E+00 yrs
64	996.30	Eu-154	66	QUANT	0.1030	8.5019E+00 yrs
66	1004.80	Eu-154	18	NET	0.1801	8.5019E+00 yrs
4	105.31	Eu-155	0	NET	0.2120	4.9600E+00 yrs

Pk. #	Energy (keV)	Isotope Name	2ndary Pk #	Type	Gamma Fraction	Halflife
14	192.34	Fe-59	70	QUANT	0.0308	4.5100E+01 dys
70	1099.22	Fe-59	79	NET	0.5650	4.5100E+01 dys
79	1291.56	Fe-59	14	QUANT	0.4320	4.5100E+01 dys
20	284.29	I-131	27	QUANT	0.0614	8.0405E+00 dys
27	364.48	I-131	20	NET	0.8170	8.0405E+00 dys
86	1460.75	K-40	0	NET	0.1100	1.2800E+09 yrs
55	834.81	Mn-54	0	NET	0.9997	3.1220E+02 dys
78	1274.54	Na-22	0	NET	0.9994	2.6000E+00 yrs
45	702.50	Nb-94	0	NET	0.9790	2.0300E+04 yrs
50	765.82	Nb-95	0	NET	0.9999	6.4020E+01 dys
65	1001.03	Pa-234m	0	NET	0.0059	4.4680E+09 yrs
5	115.18	Pb-212	17	QUANT	0.0059	1.9100E+00 yrs
17	238.63	Pb-212	22	NET	0.4330	1.9100E+00 yrs
22	300.09	Pb-212	5	QUANT	0.0327	1.9100E+00 yrs
21	295.22	Pb-214	26	QUANT	0.1920	1.6000E+03 yrs
26	351.99	Pb-214	21	NET	0.3710	1.6000E+03 yrs
39	621.84	Ru-106	68	NET	0.0981	3.6820E+02 dys
68	1050.47	Ru-106	39	QUANT	0.0173	3.6820E+02 dys
36	602.71	Sb-124	40	NET	0.9826	6.0200E+01 dys
40	645.84	Sb-124	47	QUANT	0.0745	6.0200E+01 dys
47	713.82	Sb-124	83	QUANT	0.0238	6.0200E+01 dys
83	1368.21	Sb-124	88	QUANT	0.0251	6.0200E+01 dys
88	1691.04	Sb-124	36	QUANT	0.4779	6.0200E+01 dys
12	176.29	Sb-125	28	QUANT	0.0682	2.7702E+00 yrs
28	427.95	Sb-125	29	NET	0.3000	2.7702E+00 yrs
29	463.51	Sb-125	35	QUANT	0.1049	2.7702E+00 yrs
35	600.77	Sb-125	12	ID	0.1786	2.7702E+00 yrs
60	889.26	Sc-46	0	NET	0.9998	8.3850E+01 dys
16	236.00	Th-227	0	NET	0.1230	2.1700E+01 yrs
2	63.29	Th-234	3	QUANT	0.0390	4.4680E+09 yrs
3	92.50	Th-234	2	NET	0.0553	4.4680E+09 yrs
19	277.36	Tl-208	33	QUANT	0.0631	1.9100E+00 yrs
33	583.14	Tl-208	57	NET	0.8450	1.9100E+00 yrs
57	860.47	Tl-208	19	QUANT	0.1242	1.9100E+00 yrs
9	143.76	U-235	10	NET	0.1096	7.0379E+08 yrs
10	163.35	U-235	13	QUANT	0.0508	7.0379E+08 yrs
13	185.72	U-235	15	ID	0.5720	7.0379E+08 yrs
15	205.31	U-235	9	QUANT	0.0501	7.0379E+08 yrs
72	1115.52	Zn-65	0	NET	0.5060	2.4380E+02 dys

PARAGON ANALYTICS
Radiochemistry Data Package

Section 5

QUALITY ASSURANCE SUMMARY REPORTS

5

Paragon Analytics

QUALITY ASSURANCE SUMMARY SHEET

PAI W.O. # / BATCH 0512143, 0601021, GS060119-3

TEST Gamma

METHOD Prep

SOP/REV (PREP) 739/8

SOP/REV (ANAL) _____

Briefly document any QA or other problems or deviations associated with the analysis of samples. Problems could result from: log-in, color, odor, dilution, consistency, scheduling, equipment, or instrumentation, or may include documentation of minor deviations necessary due to unique DQO's or sample characteristics.

Due to presence of Sediment, Samples 0512143-1 and ~~0602~~ mm 1/20/06 0601021-3, 0601021-4 were filtered through qualitative fluted filter paper per SOP 721.

The pH of Sample 0512143 was above 2. Therefore 2mL HNO_3 was added to Sample and allowed to sit for minimum of 16 hrs. It was then rechecked as less than 2 before being aliquotted. mm 1/20/06

TECHNICIAN/ANALYST Matt McNeil DATE 1/20/06

DEPARTMENT MANAGER Lindsay Barnhill DATE 1/20/06

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FORM 302r6.doc (4/22/04)

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PARAGON ANALYTICS
Radiochemistry Data Package

Section 6

LABORATORY BENCH SHEETS

6

Radiochemistry Instrument Worksheet

Paragon Analytics

Prep Batch: GS060119-3

Prep Procedure: GAMMASCAN

Analytical QASS / NCR? Y (N) N/A

Prep Num	Lab ID Collection Date	QC Type	Init Alq	Fin Alq	Units Geo.	Cnt 1 File Cnt Dur (min)	Cnt 1 Inst/Det	Cnt 1 Count Date	Cnt 2 File Cnt Dur (min)	Cnt 2 Inst/Det	Cnt 2 Count Date	Cnt 3 File Cnt Dur (min)	Cnt 3 Inst/Det	Cnt 3 Count Date	Notes
1	0512143-1 12/07/05 10:35	SMP	970	970	ml 01	60	10	2/8/06							
1	0601021-1 01/04/06 15:50	SMP	1000	1000	ml 01	60	10	2/8/06							
1	0601021-1 01/04/06 15:50	DUP	1000	1000	ml 01	295	7	2/8/06							CT DUP
1	0601021-2 01/04/06 15:50	SMP	1000	1000	ml 01	60	10	2/8/06							
1	0601021-3 01/04/06 15:52	SMP	1000	1000	ml 01		10	2/8/06							
1	0601021-4 01/04/06 13:48	SMP	1000	1000	ml 01		↓								
1	0601021-5 01/04/06 14:45	SMP	1000	1000	ml 01		10								
1	0601021-6 12/21/05	SMP	1000	1000	ml 01	~~75~~	↓								
1	GS060119-3 01/19/06 07:22	MB	1000	1000	ml 01	295	7								
1	GS060119-3 01/19/06 07:22	LCS	1000	1000	ml 01	30	7	2/9/06							

1/31
2/3

CT TIME = 90 MIN.
MC 2/8/06

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	AM-241	718	217.046	DPM/ml	01/19/06	1000	ml	
S1	CO-60	718	103.529	DPM/ml	01/19/06	1000	ml	
S1	CS-137	718	83.746	DPM/ml	01/19/06	1000	ml	

60003600

Radiochemistry Prep Worksheet

Paragon Analytics

Prep Batch: GS060119-3

Prep Procedure: GAMMASCAN

Reviewed By: tde TE **Review Date:** 1/23/06 1/23/2006

Non-Routine Pre-Treatment? (Y) / N **Batch:** See QASS **Re-Prep?** Y / (N) **Batch:** NA **Prep QASS / NCR?** (Y) / N 305429

Prep SOP: PAI 739 **Rev:** 8
Prep SOP: NONE
Matrix Class: liquid

Prep Analyst: Mark McNeal
Prep Date: 1/19/2006
Prep Dept: GM

Balance:
Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Geometry	Standards	Prep Notes
1	1	0512143-1	SMP		970	970	Filtered	01		Diluted to 1000ml w/DI water
2	1	0601021-1	SMP		1000	1000	Unfiltered	01		
3	1	0601021-1	DUP		1000	1000	Unfiltered	01		Count Dup, Insuff Sample
4	1	0601021-2	SMP		1000	1000	Unfiltered	01		
5	1	0601021-3	SMP		1000	1000	Filtered	01		
6	1	0601021-4	SMP		1000	1000	Filtered	01		
7	1	0601021-5	SMP		1000	1000	Unfiltered	01		
8	1	0601021-6	SMP		1000	1000	Unfiltered	01		
9	1	GS060119-3	MB		1000	1000	Unfiltered	01		
10	1	GS060119-3	LCS		1000	1000	Unfiltered	01	S1	

TE 1/23/06

Spiked By: N/A **Date:** N/A

Witnessed By: N/A **Date:** N/A

Relinquished By: TE
Date: 1/20/06
Received By: MC
Date: 1/23/06

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	AM-241	718	217.046	DPM/ml	01/19/06	1000	ml	
S1	CO-60	718	103.529	DPM/ml	01/19/06	1000	ml	
S1	CS-137	718	83.746	DPM/ml	01/19/06	1000	ml	

050040

Comments

Radiochemistry Prep Worksheet

Paragon Analytics

Prep Batch: GS060119-3

Prep Procedure: GAMMASCAN

Reviewed By: mhm mm 1/20/06 **Review Date:** 1/20/2006

Non-Routine Pre-Treatment? (Y) / N **Batch:** _____ **Re-Prep?** Y / (N) **Batch:** _____ **Prep QASS / NCR?** (Y) N _____

Prep SOP: PAI 739 **Rev:** 8
Prep SOP: NONE
Matrix Class: liquid

Prep Analyst: Mark McNeamm 1/20/06
Prep Date: 1/19/2006
Prep Dept: GM

Balance:
Balance:

Samp Num	Prep Num	LabID	QC Type	Dish No.	Init Alq ml	Fin Alq ml	Prep Basis	Geometry	Standards	Prep Notes
1	1	0512143-1	SMP	970	~~1000~~	~~1000~~	Unfiltered	01		30 ml DIH2O was added to 970ml of sample to bring volume up to 1000ml
2	1	0601021-1	SMP		1000	1000	Unfiltered	01		
3	1	0601021-1	DUP		1000	1000	Unfiltered	01		Count Dup
4	1	0601021-2	SMP		1000	1000	Unfiltered	01		
5	1	0601021-3	SMP		1000	1000	Unfiltered	01		
6	1	0601021-4	SMP		1000	1000	Unfiltered	01		
7	1	0601021-5	SMP		1000	1000	Unfiltered	01		
8	1	0601021-6	SMP		1000	1000	Unfiltered	01		
9	1	GS060119-3	MB		1000	1000	Unfiltered	01		mm 1/20/06
10	1	GS060119-3	LCS		1000	1000	Unfiltered	01	S1	

Spiked By: N/A **Date:** N/A

Witnessed By: N/A **Date:** N/A

Relinquished By: _____ 1/23/06
Date: 1/20/06
Received By: _____
Date: _____

Spike Solution Information

Soln #	Nuclide	SolnID	Prep Conc	Units	Prep Date	Aliquot	Units	Pipet ID
S1	AM-241	718	217.046	DPM/ml	01/19/06	1000	ml	
S1	CO-60	718	103.529	DPM/ml	01/19/06	1000	ml	
S1	CS-137	718	83.746	DPM/ml	01/19/06	1000	ml	

1400041

Comments

SAMPLE CONDITION FORM (LIQUID)

ANALYST: Mark McNeal

ANALYSIS DATE: 1/19/06 METHOD: Prep

WORK ORDER	SAMPLE ID	SAMPLE CONDITION pH	Color	Remarks
0512143	-1	<2	yellow	Sediment, filter
0601021	-1	1.3	clear	no sediment
	-2	1.0	clear	"
	-3	1.0	Yellow	Sediment + - filter
	-4	1.0	Yellow	Sediment + - filter
	-5	1.3	Clear	no sediment
	-6	1.3	Clear	"

MM 1/19/06

PARAGON ANALYTICS
Radiochemistry Data Package

Section 7

STANDARDS TRACEABILITY DOCUMENTS



ANALYTICS

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 · U.S.A.

Phone (404) 352-8677
Fax (404) 352-2837

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

66352-307

PAI I.D 2718
recd 8-20S-03

1.0 Liter Solid in 138G GA-MA Beaker

This standard radionuclide source was prepared using aliquots measured gravimetrically from master radionuclide solution sources. The Am-241 was calibrated by 4 pi alpha liquid scintillation counting. All other radionuclides were calibrated using a germanium gamma spectrometer system. Calibration and purity were checked using a germanium gamma spectrometer system. At the time of calibration no interfering gamma-ray emitting impurities were detected. The gamma-ray emission rates for the most intense gamma-ray lines are given. Analytics maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Rev. 1, February, 1979.

US Patent 4,430,258; UK Patent GB2,149,194B; CA Patent 1,196,776.
Density of solid matrix 1.15 g/cc.

Calibration date: July 1, 2003 12:00 EST

ISOTOPE	GAMMA-RAY ENERGY	HALF-LIFE		GAMMA-RAYS PER SECOND	TOTAL UNCERTAINTY %
Am-241	59.5	432	y	1304	3.0
Cd-109	88	462.6	d	1862	3.3
Co-57	122	271.79	d	1032	2.8
Ce-139	166	137.6	d	1419	2.8
Hg-203	279	46.61	d	3194	2.7
Sn-113	392	115.1	d	1960	2.6
Cs-137	662	30.07	y	1260	3.0
Y-88	898	106.6	d	5060	2.6
Co-60	1173	5.2714	y	2402	2.7
Co-60	1332	5.2714	y	2427	2.6
Y-88	1836	106.6	d	5287	2.6

P O NUMBER EW060303, Item 2

SOURCE PREPARED BY: M. D. Currie
M. D. Currie, Radiochemist

Q A APPROVED: J.M. Mutty 8-1-03

This standard will expire one year after the calibration date.

PARAGON ANALYTICS
Radiochemistry Data Package

Section 8

CHAIN OF CUSTODY



Paragon Analytics

Sample Number(s) Cross-Reference Table

Paragon OrderNum: 0512143
Client Name: Cordilleran Compliance Services, Inc.
Client Project Name: Battlement Mesa
Client Project Number: E04243
Client PO Number:

Client Sample	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
BM2642W	0512143-1		WATER	07-Dec-05	10:35

Date Printed: Friday, December 16, 2005

05 12 143

Paragon Analytics
A Division of DataChem Laboratories, Inc.

225 Commerce Drive Fort Collins, CO 80524
800-443-1511 or (970) 490-1511 (970) 490-1522 Fax

Accession Number (LAB ID) 05 12 143

Chain-of-Custody Date _____ Page ___ of ___ **Originator:** Retain pink copy

Project Name / No.: _____ Sampler(s): _____ Turnaround (circle one): **Standard** or **Rush** (Due _____) Dispose: **Date** _____ or **Return** to Client

Report To: James Hix
Phone: 303.237-2072
Fax: 303.237-2659
E-mail: jameshix@cordcomp.com
Company: Cordilleran Compliance Services
Address: 5550 Marshall Street
Arvada, CO 80002

Circle method (right); provide additional information as needed (comments).

Sample ID	Date	Time *	Lab ID	Matrix	Preservative (indicate type)	No. of Containers	VOCs SW8260B E624 E524.2	BTEX (only) SW8021B	SVOCs SW8270C E625	OC Pesticides SW8081A E608	PCBs SW8082 E608	Herbicides SW8151A	Explosives SW8330	TCLP Organics SW1311 SW8260B 8270C 8081A 8151A	TCLP Metals SW1311 SW6010B SW7471	Total Metals by ICP SW6010B 7470 7471 E200 ILMO___	Dissolved Metals by ICP SW6010B 7470 E200 ILMO___	Total Metals by ICP/MS SW6020 E200.8 ILMO___	Dissolved Metals by ICP/MS SW6020 E200.8 ILMO___	Hexavalent Chromium SW7196A Alkaline Digest? Y / N	Inorganic Anions SW9056 E300.0 (specify in comments)	Solids: Total E160.3 TDS E160.1 TSS E160.2	pH SW9040B SW9045C	TPH GRO DRO SW8015B (both)	Gross Alpha / Beta SW9310 E900.0	Actinides by Paragon SOP Pu / U / Am / Th / Cm /___	Tritium H3 E906.0	Total Alpha-Emitting Radium SW9315 E903.0	Radium 226 E903.1 SW9320 E904.0	Strontium 89 D5811-00 Strontium 90 D5811-00	Gamma Isotopes E901.1 (HW03)
BM2642W	12/7/05	1035	1	W	ICE HCl	2																					✓				✓

* Time Zone: EST CST MST PST **Matrix Key:** O = oil, S = soil, NS = non-soil solid, W = water, L = liquid, E = extract, F = filter

Comments:

Form 202r5.xls (4/6/04)

Relinquished By: (1)	Relinquished By: (2)
Signature James W. Hix	Signature
Printed Name James Hix	Printed Name
Date 12/15/05 Time	Date Time
Company Cordilleran To Fed X	Company
Received By: (1)	**Received By:** (2)
Signature	Signature
Printed Name	Printed Name
Date 12/16/05 Time 1000	Date Time
Company PA	Company

000041

Paragon Analytics

CONDITION OF SAMPLE UPON RECEIPT FORM

Client: Cordillerar Workorder No: 05 12 143

Project Manager: JT 12/16/05 LRS Initials: MW Date: 12/16/05

1.	Does this project require any **special handling** in addition to standard Paragon procedures?		YES	NO
2.	Is **pre-screening** required per SOP 008?		YES	NO
3.	Are custody **seals** on **shipping containers** intact?	N/A	YES	NO
4.	Are custody **seals** on **sample containers** intact?	N/A	YES	NO
5.	Is there a **COC (Chain-of-Custody) present** or other representative documents?		YES	NO
6.	Is the **COC** (if applicable) **complete and legible**?	N/A	YES	NO
7.	Are **bottle IDs legible** and in **agreement** with **COC sample IDs**?	N/A	YES	NO
8.	Is the COC in agreement with samples received? (**# of samples, # of containers, matrix**)	N/A	YES	NO
9.	Were **airbills** present and/or removable?	N/A	YES	NO
10.	Are all **aqueous samples** requiring preservation **preserved correctly**? (excluding volatile organics)	N/A	YES	NO
11.	Are all aqueous **non-preserved samples** at the **correct pH**?	N/A	YES	NO
12.	Is there **sufficient sample** for the requested analyses?		YES	NO
13.	Were all samples placed in the **proper containers** for the requested analyses?		YES	NO
14.	Are all samples within **holding times** for the requested analyses?		YES	NO
15.	Were all sample containers received **intact**? (not broken or leaking, etc.)		YES	NO
16.	Are all samples requiring no headspace (volatiles, reactive cyanide/sulfide, radon), headspace free? **Size of bubble:** ____ < green pea ____ > green pea	N/A	YES	NO
17.	Were samples checked for and free from the presence of **residual chlorine?** (Applicable when PM has indicated samples are from a chlorinated water source; note if field preservation with sodium thiosulfate was not observed.)	N/A	YES	NO
18.	Were the sample(s) **shipped on ice**?	N/A	YES	NO
19.	Were cooler temperatures measured at 0.1-6.0°C?	N/A	YES	NO

*IR gun used *(circle one)*: #2 - Oakton InfraPro II, SN2922500201-0066; (#4) - Oakton InfraPro II, SN2372220101-0002

Cooler #'s 1

Temperature (°C) 1.8

No. of custody seals 1

DOT Survey/ Acceptance Information

External µR/hr reading 13

Background µR/hr reading 12

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? (YES) NO (If no, see Form 008.)

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE EXCEPT #1 AND #2.

If applicable, was the client contacted? YES / NO / NA Contact Name:_____ Date/Time:_____

Project Manager Signature/ Date: 12/19/05

FedEx Express **US Airbill**

FedEx Tracking Number 8548 9974 1340

Recipient's Copy

1 From

Date 12/15/05

Sender's Name Tom Hix Phone 303 321 3412

Company [illegible]

Address [illegible] Dept/Floor/Suite/Room

City [illegible] State [illegible] ZIP [illegible]

2 Your Internal Billing Reference [illegible]

3 To

Recipient's Name [illegible] Phone (800) 443-1111

Company [illegible]

Recipient's Address [illegible] Dept/Floor/Suite/Room

We cannot deliver to P.O. boxes or P.O. ZIP codes.

Address

To request a package be held at a specific FedEx location, print FedEx address here.

City [illegible] State CO ZIP 80024

4a Express Package Service To add SATURDAY Delivery, see Section 6. *Packages up to 150 lbs.* * To most locations.

- [x] FedEx Priority Overnight — Next business morning.*
- [ ] FedEx Standard Overnight — Next business afternoon.*
- [ ] FedEx First Overnight — Earliest next business morning delivery to select locations.*
- [ ] FedEx 2Day — Second business day.*
- [ ] FedEx Express Saver — Third business day.*

FedEx Envelope rate not available. Minimum charge: One-pound rate

4b Express Freight Service To add SATURDAY Delivery, see Section 6. *Packages over 150 lbs.* ** To most locations.

- [ ] FedEx 1Day Freight* — Next business day.**
- [ ] FedEx 2Day Freight — Second business day.**
- [ ] FedEx 3Day Freight — Third business day.**

* Call for Confirmation:

5 Packaging * Declared value limit $500

- [ ] FedEx Envelope*
- [ ] FedEx Pak* — Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak
- [ ] FedEx Box
- [ ] FedEx Tube
- [x] Other

6 Special Handling Include FedEx address in Section 3.

- [ ] SATURDAY Delivery — Available ONLY for FedEx Priority Overnight, FedEx 2Day, FedEx 1Day Freight, and FedEx 2Day Freight to select ZIP codes.
- [ ] HOLD Weekday at FedEx Location — Not available for FedEx First Overnight.
- [ ] HOLD Saturday at FedEx Location — Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.

Does this shipment contain dangerous goods? One box must be checked.

- [x] No
- [ ] Yes — As per attached Shipper's Declaration.
- [ ] Shipper's Declaration not required.
- [ ] Dry Ice — Box 9, UN 1845 ____ x ____ kg

Dangerous goods (including dry ice) cannot be shipped in FedEx packaging. [ ] Cargo Aircraft Only

7 Payment *Bill to:* Enter FedEx Acct. No. or Credit Card No. below. Obtain Recip. Acct. No. [ ]

- [ ] Sender — Acct. No. in Section 1 will be billed.
- [ ] Recipient
- [ ] Third Party
- [x] Credit Card
- [ ] Cash/Check

Total Packages	Total Weight	Total Declared Value	Total Charges
1	10	$ [illegible] .00	

† Our liability is limited to $100 unless you declare a higher value. See back for details.

Credit Card Auth.

8 *NEW* Residential Delivery Signature Options If you require a signature, check Direct or Indirect.

- [ ] No Signature Required — Package may be left without obtaining a signature for delivery.
- [ ] Direct Signature — Anyone at recipient's address may sign for delivery. Fee applies.
- [ ] Indirect Signature — If no one is available at recipient's address, anyone at a neighboring address may sign for delivery. Fee applies.

520

L 8548 9974 1340

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Questions? Go to our Web site at fedex.com or call 1.800.GoFedEx 1.800.463.3339.

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PARAGON ANALYTICS
Radiochemistry Data Package

Section 9

ADDITIONAL SUPPORTING DOCUMENTATION

9

Gamma Spectroscopy

Initial Calibration
Standards Traceability

ANALYTICS

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 · U.S.A.

Phone (404) 352-8677
Fax (404) 352-2837

RSO# 781
Rec'd 1/24/05
DCB

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

69747-307

500 Grams of Sand in 16 Ounce PP MRP Jar

This standard radionuclide source was prepared using aliquots measured gravimetrically from master radionuclide solution sources. The Am-241 was calibrated by 4 pi alpha liquid scintillation counting. All other radionuclides were calibrated using a germanium gamma spectrometer system. Calibration and purity were checked using a germanium gamma spectrometer system. At the time of calibration no interfering gamma-ray emitting impurities were detected. The gamma-ray emission rates for the most intense gamma-ray lines are given. Analytics maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Rev. 1, February, 1979.

Calibration date: January 1, 2005 12:00 EST

ISOTOPE	GAMMA-RAY ENERGY	HALF-LIFE		GAMMA-RAYS PER SECOND	TOTAL UNCERTAINTY %
Am-241	59.5	432	y	1375	3.0
Cd-109	88	462.6	d	1874	3.3
Co-57	122	271.79	d	1025	3.0
Ce-139	166	137.6	d	1450	2.8
Hg-203	279	46.61	d	3334	2.7
Sn-113	392	115.1	d	1986	2.6
Cs-137	662	30.07	y	1280	3.0
Y-88	898	106.6	d	5053	2.6
Co-60	1173	5.2714	y	2419	2.7
Co-60	1332	5.2714	y	2440	2.6
Y-88	1836	106.6	d	5280	2.6

275 mL of customer supplied sand (to customer's mark).
P O NUMBER 71239, 11/18/04 Rel., Item 2

SOURCE PREPARED BY: M. D. Currie
M. D. Currie, Radiochemist

Q A APPROVED: 1-14-05

This standard will expire one year after the calibration date.

ANALYTICS

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 · U.S.A.

Phone (404) 352-8677
Fax (404) 352-2837

RSO # 798
Rec'd 8/5/05
D-53

CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

71035A-307

1.0 Liter Solid in 138G GA-MA Beaker

This standard radionuclide source was prepared using aliquots measured gravimetrically from master radionuclide solution sources. The Am-241 was calibrated by 4 pi alpha liquid scintillation counting. All other radionuclides were calibrated using a germanium gamma spectrometer system. Calibration and purity were checked using a germanium gamma spectrometer system. At the time of calibration no interfering gamma-ray emitting impurities were detected. The gamma-ray emission rates for the most intense gamma-ray lines are given. Analytics maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Rev. 1, February, 1979.

US Patent 4,430,258; UK Patent GB2,149,194B; CA Patent 1,196,776.
Density of solid matrix 1.15 g/cc.

Calibration date: July 1, 2005 12:00 EST

ISOTOPE	GAMMA-RAY ENERGY	HALF-LIFE		GAMMA-RAYS PER SECOND	TOTAL UNCERTAINTY %
Am-241	59.5	432	y	1353	3.0
Cd-109	88	462.6	d	1912	3.3
Co-57	122	271.79	d	1048	3.0
Ce-139	166	137.6	d	1426	2.8
Hg-203	279	46.61	d	3260	2.7
Sn-113	392	115.1	d	2038	2.6
Cs-137	662	30.07	y	1268	3.0
Y-88	898	106.6	d	5008	2.6
Co-60	1173	5.2714	y	2475	2.7
Co-60	1332	5.2714	y	2499	2.6
Y-88	1836	106.6	d	5224	2.6

P O NUMBER 71239, Rel. 5/20/05, Item 1

SOURCE PREPARED BY: M Tarkaeva for
M. D. Currie, Radiochemist

Q A APPROVED: 8-1-05

This standard will expire one year after the calibration date.

000053

051845D07.SPC Analyzed by MC

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 13 / Solid

Sample ID: 0515007-7 FWHM (781)

Sampling Start:	01/01/2005 12:00:00	Counting Start:	12/04/2005 11:27:46
Sampling Stop:	01/01/2005 12:00:00	Decay Time.	8.09E+003 Hrs
Buildup Time.	0.00E+000 Hrs	Live Time	3600 Sec
Sample Size	5.00E+002 g	Real Time	3736 Sec
Collection Efficiency	1.0000	Spc. File	.051845D07.SPC

Detector #: 7 (Detector 7)

Energy(keV) = -2.30 + 0.501*Ch + 1.97E-07*Ch^2 + 0.00E+00*Ch^3 12/04/2005
FWHM(keV) = 0.72 + 0.010*En + 6.77E-04*En^2 + 0.00E+00*En^3 12/03/2004
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	49.37	103.20	2925	539	435	27910	1.45 a	Wide Pk
2	59.49	123.41	107180	737	279	15705	0.87 a	
3	66.50	137.41	1673	579	472	27416	1.91 a	Wide Pk
4	68.37	141.14	1070	538	439	25131	1.85 b	
5	88.01	180.36	101933	719	271	13588	0.90 a	
6	121.97	248.19	38299	441	167	5642	0.89 a	HiResid
7	136.37	276.95	4584	248	171	5416	0.93 a	
8	165.78	335.67	20364	357	176	5270	1.07 a	HiResid
9	168.45	341.01	10	117	96	2259	0.48 b	NET< CL HiResid
10	199.08	402.16	147	164	134	3598	0.78 a	
11	255.09	513.99	435	188	151	3897	1.07 a	
12	262.65	529.09	90	142	115	2683	0.82 a	NET< CL
13	279.08	561.91	1353	186	141	3380	1.14 a	
14	355.31	714.08	78	139	114	2385	0.92 a	NET< CL
15	391.57	786.47	10446	247	114	2565	1.22 a	
16	510.90	1024.65	262	198	161	3645	2.14 a	Wide Pk
17	661.61	1325.40	31838	380	107	1998	1.43 a	
18	814.15	1629.73	210	111	88	1591	1.24 a	
19	897.93	1796.84	10661	248	113	2367	1.64 a	
20	1173.18	2345.74	34021	379	72	995	1.88 a	
21	1325.85	2650.09	366	141	111	1146	5.93 a	HiResid Wide Pk
22	1332.40	2663.16	30640	354	45	382	2.01 b	HiResid

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051845D07.SPC Analyzed by

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
23	1835.95	3666.45	6314	161	22	79	2.44	a

000055

051845D07.SPC Analyzed by

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SEEKER C A L I B R A T I O N R E S U L T S Version 2.0.4

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Sample ID: 0515007-7 FWHM (781)
Stds. Match Tolerance: 2.00 keV

Detector Number: 07 Calibration Date. . . 12/04/2005 11:27:46

FWHM(keV) = 0.77 + 0.008*En + 7.04e-04*En^2 + 0.00e+00*En^3
(Where En = SQR(Energy in keV))

Pk. #	Energy (kev)	Measured FWHM(keV)	% Diff.	Calculated FWHM(keV)	% Diff.	Prev.Calc. FWHM(kev)
1	59.50	0.871	0.98	0.879	-4.90	0.838
2	88.04	0.901	1.37	0.913	-4.40	0.875
3	122.06	0.894	6.06	0.951	-3.94	0.915
4	165.85	1.072	-7.46	0.997	-3.49	0.964
5	279.00	1.144	-3.20	1.109	-2.68	1.080
6	391.68	1.217	-0.29	1.213	-2.17	1.188
7	661.64	1.431	1.51	1.453	-1.47	1.432
8	898.02	1.636	1.10	1.654	-1.15	1.635
9	1173.21	1.877	0.36	1.883	-0.94	1.866
10	1332.48	2.012	0.13	2.014	-0.86	1.997
11	1836.01	2.436	-0.62	2.421	-0.74	2.403

Calibration Results Saved.

000056

051691D10.SPC Analyzed by MC

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: 0515007-10 FWHM CAL (798)

Sampling Start: 07/01/2005 12:00:00	Counting Start: 10/03/2005 09:08:53
Sampling Stop: 07/01/2005 12:00:00	Decay Time. . . . . 2.25E+003 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 3600 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 4124 Sec
Collection Efficiency 1.0000	Spc. File 051691D10.SPC

Detector #: 10 (Detector 10)

Energy(keV)= -1.28 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 10/03/2005
FWHM(keV) = 0.96 + 0.003*En + 1.13E-03*En^2 + 0.00E+00*En^3 10/04/2004
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	49.27	100.93	1589	736	601	61703	1.13 a	Wide Pk
2	51.05	104.48	2467	1131	927	105776	2.02 b	
3	59.53	121.40	149813	1072	610	63391	1.09 a	HiResid
4	66.51	135.34	4871	1132	924	105072	1.90 a	Wide Pk
5	68.80	139.92	12199	1603	1306	157608	2.99 b	
6	70.93	144.17	9438	832	665	70048	1.26 c	
7	72.95	148.19	14623	920	730	78804	1.44 d	
8	83.78	169.81	28435	1730	1396	166177	3.20 a	HiResid Wide Pk
9	86.95	176.16	47381	1107	837	91397	1.77 b	HiResid
10	88.10	178.45	359662	1356	519	49853	1.04 c	HiResid
11	122.06	246.25	227001	1146	524	46866	1.13 a	HiResid
12	136.49	275.06	30359	742	539	45953	1.29 a	
13	165.92	333.82	250028	1154	473	41405	1.31 a	HiResid
14	255.26	512.19	9368	551	424	31326	1.40 a	
15	279.33	560.23	190147	996	396	27255	1.42 a	HiResid
16	310.71	622.89	366	395	323	19308	1.34 a	
17	391.89	784.98	232712	1045	330	18948	1.55 a	HiResid
18	511.39	1023.55	5042	551	438	26211	2.70 a	Wide Pk
19	662.01	1324.27	191626	958	319	17926	1.85 a	HiResid
20	814.15	1628.02	2235	346	273	13254	2.07 a	
21	822.16	1644.02	793	413	337	17332	2.73 b	
22	898.31	1796.06	302295	1158	299	15906	2.11 a	HiResid
23	1173.45	2345.37	229398	1006	252	10451	2.43 a	HiResid

000057

051691D10.SPC Analyzed by

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
24	1332.58	2663.09	210073	972	266	11240	2.55 a	HiResid
25	1835.50	3667.18	204226	929	177	4463	3.14 a	HiResid

000058

051691D10.SPC Analyzed by

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SEEKER C A L I B R A T I O N R E S U L T S Version 2.0.4

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Sample ID: 0515007-10 FWHM CAL (798)
Stds. Match Tolerance: 2.00 keV

Detector Number: 10 Calibration Date. . . 10/03/2005 09:08:53

FWHM(keV) = 0.88 + 0.017*En + 8.12e-04*En^2 + 0.00e+00*En^3
(Where En = SQR(Energy in keV))

Pk. #	Energy (kev)	Measured FWHM(keV)	% Diff.	Calculated FWHM(keV)	% Diff.	Prev.Calc. FWHM(kev)
1	59.50	1.086	-2.64	1.058	-0.18	1.056
2	88.04	1.035	6.77	1.110	-1.47	1.094
3	122.06	1.131	3.05	1.167	-2.50	1.138
4	165.85	1.311	-6.19	1.234	-3.36	1.194
5	279.00	1.419	-1.93	1.392	-4.32	1.335
6	391.68	1.546	-0.52	1.538	-4.42	1.472
7	661.64	1.854	0.30	1.860	-3.48	1.797
8	898.02	2.109	0.79	2.125	-2.27	2.078
9	1173.21	2.428	-0.17	2.423	-0.84	2.403
10	1332.48	2.555	1.44	2.592	-0.05	2.590
11	1836.01	3.138	-0.87	3.111	2.16	3.180

Calibration Results Saved.

051901D07.SPC Analyzed by MC

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: 0515008-7 GEO 1 EFF CAL (798)

Sampling Start: 07/01/2005 12:00:00	Counting Start: 12/13/2005 17:12:48
Sampling Stop: 07/01/2005 12:00:00	Decay Time. . . . . 3.97E+003 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 3600 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 3918 Sec
Collection Efficiency 1.0000	Spc. File 051901D07.SPC

Detector #: 7 (Detector 7)

Energy(keV)= -2.54 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 12/13/2005
FWHM(keV) = 0.77 + 0.008*En + 7.04E-04*En^2 + 0.00E+00*En^3 12/04/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
1	49.33	103.46	9660	822	656	59698	1.60	a	Wide Pk
2	51.14	107.06	8135	1197	974	95517	2.60	b	
3	57.80	120.34	5357	1056	861	82092	2.33	a	Wide Pk
4	59.39	123.51	157589	900	349	24565	0.88	b	
5	66.83	138.36	10928	803	638	45106	2.23	a	HiResid Wide Pk
6	70.49	145.66	12596	762	599	41884	2.11	b	HiResid
7	72.71	150.07	9678	618	482	32218	1.62	c	HiResid
8	74.84	154.32	7601	795	638	45106	2.25	d	HiResid
9	78.21	161.05	9827	938	754	54771	2.71	e	HiResid
10	82.23	169.07	11803	851	677	48328	2.48	f	HiResid
11	85.19	174.97	13525	810	638	45106	2.37	g	HiResid
12	87.94	180.46	196703	991	364	22553	1.09	h	HiResid
13	121.93	248.25	81450	636	231	10746	0.85	a	HiResid
14	136.37	277.04	10256	356	241	10715	0.95	a	
15	165.79	335.72	64163	573	221	9026	0.97	a	
16	186.73	377.49	370	251	204	7680	1.06	a	
17	199.16	402.28	1109	258	205	7744	1.07	a	
18	203.67	411.27	286	282	230	9035	1.13	b	
19	255.13	513.91	1888	260	202	6955	1.07	a	
20	279.19	561.88	19116	344	168	5197	1.02	a	HiResid
21	391.76	786.40	38140	428	144	4089	1.15	a	HiResid
22	511.11	1024.42	868	332	269	8233	2.95	a	Wide Pk
23	549.84	1101.68	111	117	94	2026	0.76	a	

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051901D07.SPC Analyzed by

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
24	661.92	1325.20	40466	444	154	4111	1.42	a	
25	814.39	1629.28	684	147	113	2621	1.28	a	
26	898.25	1796.54	40334	437	141	3684	1.60	a	HiResid
27	1132.96	2264.64	100	122	99	1962	1.61	a	
28	1173.37	2345.23	44549	438	95	1752	1.84	a	HiResid
29	1325.42	2648.49	1040	165	125	1974	3.77	a	HiResid Wide Pk
30	1332.50	2662.60	40348	412	75	1030	1.99	b	HiResid
31	1835.42	3665.63	23150	309	42	303	2.35	a	HiResid

051901D07.SPC Analyzed by

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SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Version 1.8.2

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Background File:. . . . . DET071209.BKG (0524004-17 WEEKLY BKGD)

Bkg.File Detector #: 7

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
5	66.83	10928	803	638	10916	803	638	
6	70.49	12596	762	599	12593	762	599	
8	74.84	7601	795	638	7596	795	638	
9	78.21	9827	938	754	9821	938	754	
11	85.19	13525	810	638	13521	810	638	
16	186.73	370	251	204	351	251	204	
17	199.16	1109	258	205	1097	258	205	
22	511.11	868	332	269	793	333	270	

051901D07.SPC Analyzed by

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SEEKER C A L I B R A T I O N R E S U L T S Version 2.0.4

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Sample ID: 0515008-7 GEO 1 EFF CAL (798)
Stds. Match Tolerance: 2.00 keV

Detector Number: 07 Calibration Date. . . 12/13/2005 17:12:48
Geometry File (D07)(Sh01).EFF ID. Geo 1 Eff CaL
Amount of Std. in Calib. Source: 1.000000 gm

Eff = 1 / [1.72e-01*En^-1.65e+00 + 1.63e+02*En^ 9.06e-01]
(Where En = Energy in MeV)) (Exponential)

Pk. #	Energy (kev)	Measured Efficiency	% Difference	Calculated Efficiency	% Difference	Prev.Calc. Efficiency
1	59.50	3.24e-02	0.17	3.24e-02	-0.88	3.22e-02
2	88.04	3.66e-02	-0.89	3.63e-02	-0.99	3.59e-02
3	122.06	3.29e-02	1.91	3.35e-02	1.15	3.39e-02
4	165.85	2.87e-02	-1.62	2.83e-02	3.06	2.92e-02
5	279.00	1.90e-02	-0.34	1.90e-02	4.35	1.98e-02
6	391.68	1.41e-02	0.73	1.42e-02	4.10	1.48e-02
7	661.64	8.96e-03	-0.80	8.89e-03	2.82	9.14e-03
8	898.02	6.55e-03	2.94	6.75e-03	1.82	6.87e-03
9	1173.21	5.31e-03	-0.10	5.30e-03	0.86	5.35e-03
10	1332.48	4.76e-03	-0.75	4.72e-03	0.38	4.74e-03
11	1836.01	3.61e-03	-2.00	3.53e-03	-0.85	3.50e-03

Calibration Results Saved.

Geometry 01 Calibration Verification: Gamma Mixed Nuclide Source														
Std. #	718	Detector	7											
				REF DATE :	7/1/2003					count date		12/14/2005		
FROM CALIBRATION CERTIFICATE				FROM ANALYTICS.LIB			EXPECTED ACTIVITY							
					Mass of									# of half-lives
Isotope	KeV	Half Life(y)	Gammas/Sec.	Gamma Fraction:	Standard			DPS	pCi/L	Activity	Recovery	Pass/Fail	expired
Am-241	59.9	432.0000	1304	0.3590	1	L	Am-241	3632.3	98170.6	99500	101%	Pass	0.01
Cd-109	88	1.2666	1862	0.0361			Cd-109	51578.9	1394025.6	1330000	95%	Pass	1.94
Co-57	122	0.7441	1032	0.8551			Co-57	1206.9	32618.3	33000	101%	Pass	3.30
Ce-139	166	0.3768	1419	0.8035			Ce-139	1766.0	47730.4	51100	107%	Pass	6.52
Hg-203	279	0.1276	3194	0.7730			Hg-203	4132.0	111674.4	>5 h-lives	>5 h-lives	>5 h-lives	19.25
Sn-113	392	0.3151	1960	0.6490			Sn-113	3020.0	81622.5	>5 h-lives	>5 h-lives	>5 h-lives	7.79
Cs-137	662	30.0000	1260	0.8512			Cs-137	1480.3	40007.1	39800	99%	Pass	0.08
Y-88	898	0.2919	5060	0.9340			Y-88	5417.6	146420.5	>5 h-lives	>5 h-lives	>5 h-lives	8.41
Co-60	1173	5.2714	2402	1.0000			Co-60	2402.0	64918.9	64100	99%	Pass	0.47
Co-60	1332	5.2714	2427	1.0000			Co-60	2427.0	65594.6	64200	98%	Pass	0.47
Y-88	1836	0.2919	5287	0.9938			Y-88	5320.0	143783.3	>5 h-lives	>5 h-lives	>5 h-lives	8.41
											R:\inst\gamma\st718.xls		

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051911D07.SPC Analyzed by MC

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: 0515008-7A GEO 1 CAL VER (718)

Sampling Start: 07/01/2003 12:00:00	Counting Start: 12/14/2005 17:40:57
Sampling Stop: 07/01/2003 12:00:00	Decay Time. . . . . 2.15E+004 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 1800 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 1853 Sec
Collection Efficiency 1.0000	Spc. File 051911D07.SPC

Detector #: 7 (Detector 7)

Energy(keV)= -2.37 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 12/14/2005
FWHM(keV) = 0.77 + 0.008*En + 7.04E-04*En^2 + 0.00E+00*En^3 12/04/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
1	43.11	90.73	319	254	207	7899	0.96	a	
2	49.52	103.51	4570	510	405	22678	1.66	a	HiResid Wide Pk
3	59.53	123.48	76878	601	191	7317	0.89	a	
4	66.43	137.26	810	298	241	7557	1.78	a	Wide Pk
5	68.89	142.16	1403	408	330	10992	2.67	b	
6	88.07	180.43	30418	387	139	3552	0.90	a	
7	122.10	248.32	6350	203	103	1961	0.90	a	
8	136.49	277.01	810	129	96	1691	1.02	a	
9	165.97	335.83	845	124	90	1502	1.06	a	
10	391.81	786.37	280	97	75	1114	1.19	a	
11	484.62	971.53	46	58	46	523	0.65	a	
12	662.04	1325.49	18949	287	65	743	1.45	a	
13	898.37	1796.96	149	91	72	1005	1.46	a	
14	1173.49	2345.83	16375	262	47	429	1.86	a	HiResid
15	1332.60	2663.24	14620	244	25	116	2.03	a	
16	1835.44	3666.41	80	23	12	27	1.67	a	

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051911D07.SPC Analyzed by

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SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Vers. 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Background File:. . . . . DET071209.BKG (0524004-17 WEEKLY BKGD)

Bkg.File Detector #: 7

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
4	66.43	810	298	241	804	298	241	
5	68.89	1403	408	330	1401	408	330	

051911D07.SPC Analyzed by

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SEEKER F I N A L A C T I V I T Y R E P O R T Version 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: 0515008-7A GEO 1 CAL VER (718)

Sampling Start: 07/01/2003 12:00:00	Counting Start: 12/14/2005 17:40:57
Sampling Stop: 07/01/2003 12:00:00	Decay Time. . . . . 2.15e+004 Hrs
Buildup Time. . . . . 0.00e+000 Hrs	Live Time . . . . . 1800 Sec
Sample Size . . . . . 1.00e+000 L	Real Time . . . . . 1853 Sec
Collection Efficiency 1.0000	Spectrum File 051911D07.SPC
Cr. Level Confidence Interval: 95 %	Det. Limit Confidence Interval: 95 %

Detector #: 7 (Detector 7)

Efficiency File: (D07)(Sh01).EFF (Geo 1 Eff CaL)
Eff.=1/[1.72E-01*En^-1.65E+00 + 1.63E+02*En^9.06E-01] 12/13/2005

Library File: . . . .ANALYTICAL.LIB (Analytical)

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	NET	Concentration (pCi/L)		MDA	Critical Level	Halflife (hrs)
Am-241	59.54		9.95E+04	+- 7.78E+02	4.97E+02	2.47E+02	3.79E+06
Cd-109	88.02		1.33E+06	+- 1.70E+04	1.23E+04	6.07E+03	1.11E+04
Co-57	122.07		3.30E+04	+- 1.05E+03	1.08E+03	5.35E+02	6.50E+03
Ce-139	165.85		5.11E+04	+- 7.51E+03	1.11E+04	5.46E+03	3.30E+03
Sn-113	391.68		1.01E+05	+- 3.53E+04	5.55E+04	2.72E+04	2.76E+03
Cs-137	661.62		3.98E+04	+- 6.01E+02	2.80E+02	1.37E+02	2.64E+05
Co-60	Average:x		6.41E+04	+- 7.41E+02	. . . .	. . . .	4.62E+04
	1173.21		6.41E+04	+- 1.03E+03	3.80E+02	1.85E+02	4.62E+04
	1332.48		6.42E+04	+- 1.07E+03	2.32E+02	1.10E+02	4.62E+04
Hg-203	279.18		MDA	. . . .	1.12E+08	5.52E+07	1.12E+03
Y-88	898.02		MDA	. . . .	7.90E+04r	3.84E+04	2.56E+03

MEASURED TOTAL: 1.72E+06 +- 6.29E+04 pCi/L

UNKNOWN, SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	43.11	90.73	319	254	207	7899	0.96	Unknown
2	49.52	103.51	4570	510	405	22678	1.66	Unknown
4	66.43	137.26	804	298	241	7557	1.78	Unknown
5	68.89	142.16	1401	408	330	10992	2.67	Unknown
8	136.49	277.01	810	129	96	1691	1.02	Unknown

051911D07.SPC Analyzed by

UNKNOWN, SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
11	484.62	971.53	46	58	46	523	0.65	Unknown
13	898.37	1796.96	149	91	72	1005	1.46	Unknown
16	1835.44	3666.41	80	23	12	27	1.67	Unknown

051691D10.SPC Analyzed by MC

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

GEO 1 MC 10/4/05

Sample ID: 0515008-10 EFF CAL (798)

Sampling Start: 07/01/2005 12:00:00	Counting Start: 10/03/2005 09:08:53
Sampling Stop: 07/01/2005 12:00:00	Decay Time. . . . . 2.25E+003 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 3600 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 4124 Sec
Collection Efficiency 1.0000	Spc. File 051691D10.SPC

Detector #: 10 (Detector 10)

Energy(keV)= -1.28 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 10/03/2005
FWHM(keV) = 0.88 + 0.017*En + 8.12E-04*En^2 + 0.00E+00*En^3 10/03/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	49.27	100.92	1588	736	601	61703	1.13 a	Wide Pk
2	51.05	104.47	2468	1131	927	105776	2.02 b	
3	59.53	121.40	149813	1072	610	63391	1.09 a	HiResid
4	66.50	135.32	4725	1131	924	105072	1.88 a	Wide Pk
5	68.80	139.91	12459	1680	1370	166364	3.06 b	
6	70.94	144.17	9320	831	665	70048	1.26 c	
7	72.95	148.19	14602	920	730	78804	1.44 d	
8	83.92	170.09	29724	1732	1396	166177	3.29 a	HiResid Wide Pk
9	87.00	176.25	46726	1036	774	83088	1.61 b	HiResid
10	88.11	178.47	354824	1348	519	49853	1.03 c	HiResid
11	122.06	246.25	227002	1146	524	46866	1.13 a	HiResid
12	136.49	275.05	30301	699	499	45994	1.28 a	
13	165.91	333.80	253491	1216	561	51756	1.28	
14	255.26	512.19	9368	551	424	31326	1.40 a	
15	279.33	560.23	190147	996	396	27255	1.42 a	HiResid
16	391.89	784.98	232972	1036	310	18704	1.55 a	HiResid
17	511.39	1023.55	5042	551	438	26211	2.70 a	Wide Pk
18	662.01	1324.27	191656	951	305	17886	1.85 a	HiResid
19	814.15	1628.02	2235	346	273	13254	2.07 a	
20	822.16	1644.02	793	413	337	17332	2.73 b	
21	898.31	1796.06	302295	1158	299	15906	2.11 a	HiResid
22	1173.45	2345.37	229398	1006	252	10451	2.43 a	HiResid
23	1332.58	2663.09	210073	972	266	11240	2.55 a	HiResid

051691D10.SPC Analyzed by

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
24	1835.50	3667.19	203763	931	187	4984	3.13	a	HiResid

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051691D10.SPC Analyzed by

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SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Version 1.8.2

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Background File:. . . . . DET100930.BKG (0521001-50 WEEKLY BKGD)

Bkg.File Detector #: 10

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
4	66.50	4725	1131	924	4682	1131	924	
6	70.94	9320	831	665	9282	832	666	
8	83.92	29724	1732	1396	29705	1732	1396	
9	87.00	46726	1036	774	46693	1036	775	
17	511.39	5042	551	438	4753	551	439	
21	898.31	302295	1158	299	302285	1158	300	

051691D10.SPC Analyzed by

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SEEKER C A L I B R A T I O N R E S U L T S Version 2.0.4

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Sample ID: 0515008-10 EFF CAL (798)
Stds. Match Tolerance: 2.00 keV

Detector Number: 10 Calibration Date. . . 10/03/2005 09:08:53
Geometry File (D10)(Sh01).EFF ID. Geo 1 Eff Cal
Amount of Std. in Calib. Source: 1.000000 gm

Eff = 1 / [3.02e-02*En^-2.41e+00 + 3.34e+01*En^ 6.62e-01]
(Where En = Energy in MeV)) (Exponential)

Pk. #	Energy (kev)	Measured Efficiency	% Difference	Calculated Efficiency	% Difference	Prev.Calc. Efficiency
1	59.50	3.08e-02	1.44	3.12e-02	4.17	3.26e-02
2	88.04	5.93e-02	-1.79	5.83e-02	4.95	6.13e-02
3	122.06	7.65e-02	0.07	7.65e-02	4.36	8.00e-02
4	165.85	7.93e-02	1.33	8.03e-02	3.34	8.31e-02
5	279.00	6.55e-02	1.68	6.67e-02	2.11	6.81e-02
6	391.68	5.59e-02	-2.06	5.48e-02	1.72	5.57e-02
7	661.64	4.22e-02	-7.70	3.92e-02	1.42	3.98e-02
8	898.02	3.09e-02	3.79	3.21e-02	1.31	3.25e-02
9	1173.21	2.66e-02	1.03	2.69e-02	1.23	2.72e-02
10	1332.48	2.42e-02	2.37	2.47e-02	1.19	2.50e-02
11	1836.01	2.00e-02	0.28	2.00e-02	1.10	2.02e-02

Calibration Results Saved.

Geometry 01 Calibration Verification: Gamma Mixed Nuclide Source; Geometry 01

Std. #	718	Detector	10										
				REF DATE :	7/1/2003				count date		10/4/2005		
FROM CALIBRATION CERTIFICATE				FROM ANALYTICS.LIB			EXPECTED ACTIVITY						
Isotope	KeV	Half Life(y)	Gammas/Sec.	Gamma Fraction:	Mass of Standard			DPS	pCi/L	Activity	Recovery	Pass/Fail	# of half-lives expired
Am-241	59.9	432.0000	1304	0.3590	1	L	Am-241	3632.3	98170.6	98600	100%	Pass	0.01
Cd-109	88	1.2666	1862	0.0361			Cd-109	51578.9	1394025.6	1520000	109%	Pass	1.79
Co-57	122	0.7441	1032	0.8551			Co-57	1206.9	32618.3	33000	101%	Pass	3.04
Ce-139	166	0.3768	1419	0.8035			Ce-139	1766.0	47730.4	45100	94%	Pass	6.00
Hg-203	279	0.1276	3194	0.7730			Hg-203	4132.0	111674.4	>5 h-lives	>5 h-lives	>5 h-lives	17.73
Sn-113	392	0.3151	1960	0.6490			Sn-113	3020.0	81622.5	85200	104%	Pass	7.18
Cs-137	662	30.0000	1260	0.8512			Cs-137	1480.3	40007.1	42000	105%	Pass	0.08
Y-88	898	0.2919	5060	0.9340			Y-88	5417.6	146420.5	>5 h-lives	>5 h-lives	>5 h-lives	7.75
Co-60	1173	5.2714	2402	1.0000			Co-60	2402.0	64918.9	62900	97%	Pass	0.43
Co-60	1332	5.2714	2427	1.0000			Co-60	2427.0	65594.6	62800	96%	Pass	0.43
Y-88	1836	0.2919	5287	0.9938			Y-88	5320.0	143783.3	>5 h-lives	>5 h-lives	>5 h-lives	7.75
											R:\lnst\gamma\stdverif.xls		

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051699D10.SPC Analyzed by

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: 0515008-10A GEO 1 CAL VER (718)

Sampling Start: 07/01/2003 12:00:00	Counting Start: 10/04/2005 12:19:34
Sampling Stop: 07/01/2003 12:00:00	Decay Time. . . . . 1.98E+004 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 1800 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 1879 Sec
Collection Efficiency 1.0000	Spc. File 051699D10.SPC

Detector #: 10 (Detector 10)

Energy(keV)= -1.13 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 10/04/2005
FWHM(keV) = 0.88 + 0.017*En + 8.12E-04*En^2 + 0.00E+00*En^3 10/03/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
1	50.33	102.75	2647	670	545	31312	2.39	a	Wide Pk
2	59.60	121.27	73401	628	262	12646	1.06	a	HiResid
3	66.92	135.88	451	302	246	9597	1.26	a	
4	88.11	178.20	62203	563	215	7872	1.08	a	
5	122.10	246.06	17401	333	167	4743	1.09	a	
6	136.54	274.89	2197	219	162	4878	1.26	a	
7	165.93	333.58	3030	206	143	4040	1.18	a	
8	352.19	705.51	78	184	150	3933	1.54	a	NET< CL
9	391.92	784.84	1396	187	141	3848	1.42	a	
10	511.30	1023.23	152	161	131	3182	1.62	a	
11	642.40	1285.02	122	125	101	2152	1.53	a	
12	661.96	1324.08	88798	613	118	2679	1.75	a	HiResid
13	898.35	1796.10	1161	183	140	3598	1.95	a	
14	1173.32	2345.18	83752	594	109	2028	2.36	a	HiResid
15	1332.43	2662.90	76784	568	101	1673	2.52	a	HiResid
16	1835.27	3666.99	838	77	42	265	2.86	a	

051699D10.SPC Analyzed by

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SEEKER B A C K G R O U N D S U B T R A C T R E S U L T S Vers. 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Background File:. . . . . DET100930.BKG (0521001-50 WEEKLY BKGD)

Bkg.File Detector #: 10

BACKGROUND SUBTRACT RESULTS

PK#	ENERGY (keV)	OLD NET COUNTS	OLD UN-CERTAINTY	OLD CR.LEVEL	NEW NET COUNTS	NEW UN-CERTAINTY	NEW CR.LEVEL	FLAG
3	66.92	451	302	246	429	302	246	
4	88.11	62203	563	215	62187	563	215	
8	352.19	78	184	150	-25	184	152	NET<CL
10	511.30	152	161	131	7	162	133	NET<CL
13	898.35	1161	183	140	1156	183	140	

051699D10.SPC Analyzed by

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SEEKER F I N A L A C T I V I T Y R E P O R T Version 2.2.1

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Geo 1 / Water

Sample ID: 0515008-10A GEO 1 CAL VER (718)

Sampling Start: 07/01/2003 12:00:00	Counting Start: 10/04/2005 12:19:34
Sampling Stop: 07/01/2003 12:00:00	Decay Time. . . . . 1.98e+004 Hrs
Buildup Time. . . . . 0.00e+000 Hrs	Live Time . . . . . 1800 Sec
Sample Size . . . . . 1.00e+000 L	Real Time . . . . . 1879 Sec
Collection Efficiency 1.0000	Spectrum File 051699D10.SPC
Cr. Level Confidence Interval: 95 %	Det. Limit Confidence Interval: 95 %

Detector #: 10 (Detector 10)

Efficiency File: (D10)(Sh01).EFF (Geo 1 Eff Cal)
Eff.=1/[3.02E-02*En^-2.41E+00 + 3.34E+01*En^6.62E-01] 10/03/2005

Library File: . . . .ANALYTICAL.LIB (Analytical)

MEASURED or MDA CONCENTRATIONS

Nuclide	ENERGY (keV)	N E T	Concentration (pCi/L)	MDA	Critical Level	Halflife (hrs)
Am-241	59.54		9.86E+04 +- 8.44E+02	7.06E+02	3.51E+02	3.79E+06
Cd-109	88.02		1.52E+06 +- 1.38E+04	1.06E+04	5.27E+03	1.11E+04
Co-57	122.07		3.30E+04 +- 6.31E+02	6.38E+02	3.16E+02	6.50E+03
Ce-139	165.85		4.51E+04 +- 3.06E+03	4.30E+03	2.13E+03	3.30E+03
Sn-113	391.68		8.52E+04 +- 1.14E+04	1.73E+04	8.58E+03	2.76E+03
Cs-137	661.62		4.20E+04 +- 2.90E+02	1.13E+02	5.58E+01	2.64E+05
Y-88	Average:x		1.33E+05 +- 1.05E+04	. . . .	. . . .	2.56E+03
	898.02		1.24E+05 +- 1.97E+04	3.03E+04	1.50E+04	2.56E+03
	1836.01		1.36E+05 +- 1.25E+04	1.39E+04	6.75E+03	2.56E+03
Co-60	Average:x		6.28E+04 +- 3.22E+02	. . . .	. . . .	4.62E+04
	1173.21		6.29E+04 +- 4.46E+02	1.66E+02	8.19E+01	4.62E+04
	1332.48		6.28E+04 +- 4.64E+02	1.67E+02	8.25E+01	4.62E+04
Hg-203	279.18		MDA	1.99E+07	9.88E+06	1.12E+03

MEASURED TOTAL: 2.02E+06 +- 4.09E+04 pCi/L

UNKNOWN,SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	50.33	102.75	2647	670	545	31312	2.39	Unknown
3	66.92	135.88	429	302	246	9597	1.26	Unknown
6	136.54	274.89	2197	219	162	4878	1.26	Unknown

051699D10.SPC Analyzed by

UNKNOWN, SUM or ESCAPE PEAKS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
8	352.19	705.51	-25	184	152	3933	1.54	Deleted
10	511.30	1023.23	7	162	133	3182	1.62	Deleted
11	642.40	1285.02	122	125	101	2152	1.53	Unknown

Gamma Spectroscopy

Quality Control Data

Weekly Background Calibrations

Paragon Analytics

Gamma Spectrometer Calibration Log

Date: 2/3/06 Reviewed By/Date: JP 2/3/06

Det. No.	Out Of Service	Background		Source Check			Repeat Source Check			
		Started	OK	Started	OK	Failed Parameter(s)	OK	Failed Parameter(s)	Corrective Action Taken **	Removed from Service
1.	JP	/	/	/	/					
2.		MC	JP	JP	JP					
3.	JP	/	/	/	/					
4.		MC	JP	JP	JP					
5.	JP	/	/	/	/					
6.		MC	JP	JP	JP					
7.		|	JP	JP	JP					
8.		|	JP	JP	/	1332 Centroid	JP		Gain Adjustment	
9.	JP	/	/	/	/			/		
10.		MC	JP	JP	JP					
11.										
12.										

** Corrective Action:

060373D07.SPC Analyzed by JP

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SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

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Weekly Background Check

Sample ID: 0614013-7 WEEKLY BKGD

Sampling Start:	02/03/2006 19:00:00	Counting Start:	02/03/2006 19:18:47
Sampling Stop:	02/03/2006 19:00:00	Decay Time.	3.13E-001 Hrs
Buildup Time.	0.00E+000 Hrs	Live Time	60000 Sec
Sample Size	1.00E+000 L	Real Time	60239 Sec
Collection Efficiency	1.0000	Spc. File	.060373D07.SPC

Detector #: 7 (Detector 7)

Energy(keV)= -2.39 + 0.501*Ch + 0.00E+00*Ch^2 + 0.00E+00*Ch^3 02/03/2006
FWHM(keV) = 0.77 + 0.008*En + 7.04E-04*En^2 + 0.00E+00*En^3 12/04/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	46.44	97.40	426	90	66	799	0.91 a	
2	53.21	110.90	64	60	47	498	0.74 a	
3	63.30	131.02	456	81	57	646	0.80 a	
4	66.34	137.09	188	102	81	1033	1.26 b	
5	72.83	150.04	63	73	59	702	0.85 a	
6	74.85	154.07	150	76	59	702	0.78 b	
7	77.00	158.36	189	87	68	842	0.91 c	
8	84.41	173.14	100	70	55	613	0.84 a	
9	92.61	189.49	517	80	54	585	0.89 a	
10	139.95	283.92	159	88	69	755	1.27 a	
11	185.85	375.47	214	82	63	680	1.15 a	
12	198.40	400.51	104	47	35	307	0.52 a	
13	238.74	480.99	194	62	45	417	0.82 a	
14	295.40	594.01	87	74	59	553	1.27 a	
15	338.54	680.05	40	71	57	516	1.32 a	NET< CL
16	352.20	707.30	112	49	36	302	0.84 a	
17	374.31	751.40	57	59	47	409	1.37 a	
18	511.37	1024.80	1180	113	74	701	2.45 a	Wide Pk
19	558.76	1119.32	145	46	32	218	1.05 a	
20	583.72	1169.13	95	50	38	271	1.39 a	
21	588.94	1179.53	31	31	23	136	0.69 b	
22	598.07	1197.75	49	72	58	500	1.92 a	NET< CL
23	609.49	1220.52	108	56	43	343	1.38 a	
24	803.28	1607.08	93	41	30	185	1.27 a	

000080

060373D07.SPC Analyzed by

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
25	911.55	1823.05	49	40	31	177	1.65 a	
26	962.05	1923.79	33	26	19	93	0.86 a	
27	1014.51	2028.43	40	40	31	169	1.72 a	
28	1460.55	2918.15	108	36	24	109	1.89 a	

060373D07.SPC Analyzed by

****

SEEKER B A C K G R O U N D Q. C. A N A L Y S I S Version 2.2.2

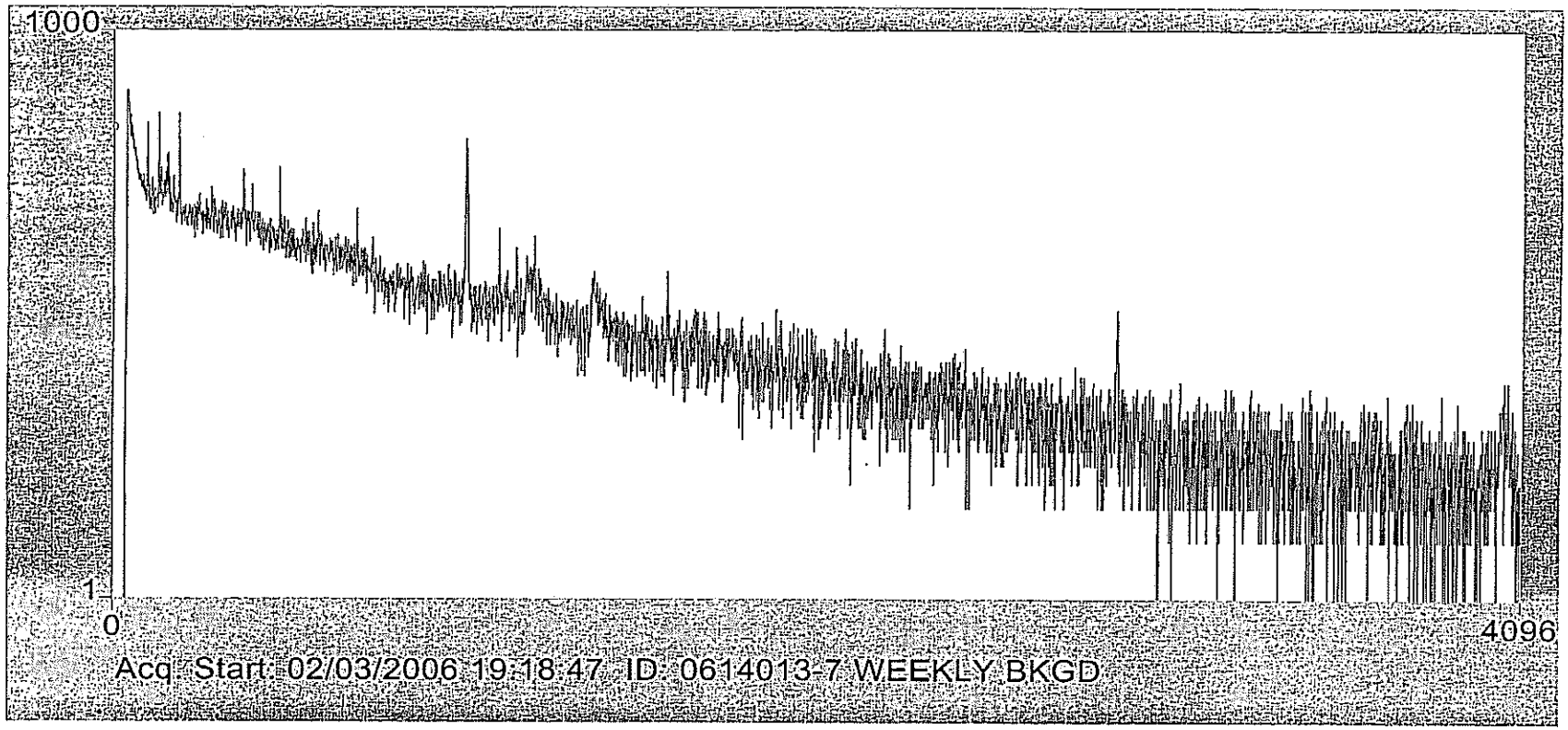
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ID: 0614013-7 WEEKLY BKGD

Detector # 7 Background Q.C. Analysis for 02/03/2006 19:18:47

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
10	50-> 150 keV Bkg	24.812	Pass	Pass	N.A.
11	150-> 250 keV Bkg	18.936	Pass	Pass	N.A.
12	250-> 500 keV Bkg	28.169	Pass	Pass	N.A.
13	500->1000 keV Bkg	28.654	Pass	Pass	N.A.
14	1000->2000 keV Bkg	16.519	Pass	Pass	N.A.
15	40-> 50 keV Bkg	3.316	Pass	Pass	N.A.

Q.C. Results Saved.


1000
1
0
4096
Acq. Start: 02/03/2006 19:18:47 ID: 0614013-7 WEEKLY BKGD

060381D10.SPC Analyzed by JP

****

SEEKER G A M M A A N A L Y S I S R E S U L T S PS Version 1.8.4

Paragon Analytics, Div. of DataChem Lab
GammaScan

****

Weekly Background Check

Sample ID: 0614013-10 WEEKLY BKGD

Sampling Start: 02/03/2006 19:00:00	Counting Start: 02/03/2006 19:18:53
Sampling Stop: 02/03/2006 19:00:00	Decay Time. . . . . 3.15E-001 Hrs
Buildup Time. . . . . 0.00E+000 Hrs	Live Time . . . . . 60000 Sec
Sample Size . . . . . 1.00E+000 L	Real Time . . . . . 60239 Sec
Collection Efficiency 1.0000	Spc. File 060381D10.SPC

Detector #: 10 (Detector 10)

Energy(keV)= -1.27 + 0.501*Ch +-1.44E-07*Ch^2 + 7.46E-11*Ch^3 02/03/2006
FWHM(keV) = 0.88 + 0.017*En + 8.12E-04*En^2 + 0.00E+00*En^3 10/03/2005
Where En = Sqrt(Energy in keV)

Search Sensitivity: 1.00 | Sigma Multiplier: 2.00 | Search Start/End: 80/4000

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)	FLAG
1	46.60	95.57	1051	168	127	2765	1.14 a	
2	48.09	98.54	465	193	155	3555	1.42 b	
3	53.67	109.68	152	106	84	1580	0.63 c	
4	63.35	129.01	933	171	131	2739	1.30 a	Wide Pk
5	66.37	135.03	789	155	119	2396	1.13 b	
6	72.09	146.45	540	333	271	6504	3.09 c	
7	74.90	152.06	1103	159	119	2396	1.17 d	
8	77.08	156.42	1496	164	119	2396	1.17 e	
9	84.44	171.11	224	155	125	2484	1.28 a	
10	87.16	176.53	438	129	100	1863	1.02 b	
11	89.91	182.04	220	111	88	1553	0.85 c	
12	92.66	187.52	1836	162	113	2174	1.23 d	
13	139.81	281.65	561	117	88	1631	1.00 a	
14	143.50	289.02	154	134	108	2175	1.28 b	
15	170.34	342.61	52	129	105	2055	1.27 a	NET< CL
16	185.89	373.66	1388	149	106	2066	1.31 a	
17	198.46	398.74	810	131	97	1844	1.23 a	
18	209.61	421.01	67	104	84	1506	0.94 a	NET< CL
19	238.70	479.10	990	128	91	1648	1.15 a	
20	241.87	485.42	825	135	101	1883	1.30 b	
21	259.21	520.05	67	73	58	838	0.72 a	
22	277.81	557.19	60	93	75	1203	0.94 a	NET< CL
23	295.20	591.90	1800	140	92	1565	1.35 a	
24	338.64	678.63	195	101	80	1258	1.22 a	

000034

060381D10.SPC Analyzed by

PEAK SEARCH RESULTS

PK. #	ENERGY (keV)	ADDRESS CHANNEL	NET/MDA COUNTS	UN-CERTAINTY	C.L. COUNTS	BKG COUNTS	FWHM (keV)		FLAG
25	352.00	705.31	3212	155	87	1406	1.31	a	
26	486.20	973.26	60	60	48	567	0.83	a	
27	511.12	1022.99	4846	207	126	2157	2.81	a	Wide Pk
28	558.54	1117.67	660	95	65	881	1.31	a	
29	570.04	1140.63	231	98	76	1135	1.55	a	
30	583.38	1167.26	485	104	77	1102	1.70	a	
31	597.71	1195.88	393	148	117	2026	2.48	a	
32	600.77	1201.99	342	175	141	2812	2.67	b	
33	609.49	1219.40	2485	158	101	1886	1.59	a	
34	617.75	1235.88	82	111	90	1503	1.66	a	NET< CL
35	670.07	1340.33	83	68	54	681	1.14	a	
36	693.76	1387.61	248	139	111	1900	2.80	a	
37	727.75	1455.47	84	65	52	621	1.15	a	
38	768.39	1536.58	334	120	94	1307	2.96	a	
39	785.39	1570.51	111	90	72	914	2.16	a	
40	803.12	1605.90	479	86	61	738	1.62	a	
41	806.41	1612.46	111	61	47	517	1.14	b	
42	835.57	1670.65	276	136	108	1526	3.58	a	Wide Pk
43	839.21	1677.92	238	105	83	1166	2.33	b	
44	859.95	1719.31	55	67	54	649	1.23	a	
45	898.62	1796.48	224	108	86	1125	2.83	a	
46	911.31	1821.80	303	72	52	572	1.41	a	
47	934.19	1867.44	132	64	49	506	1.55	a	
48	962.37	1923.67	301	108	84	1043	2.97	a	
49	969.31	1937.52	165	79	61	695	1.96	b	
50	1000.74	2000.22	91	55	43	403	1.31	a	
51	1062.91	2124.25	114	102	82	995	2.88	a	
52	1120.37	2238.86	578	85	57	605	2.04	a	
53	1238.22	2473.85	218	81	62	630	2.52	a	
54	1280.96	2559.05	74	62	49	439	2.04	a	
55	1377.75	2751.94	131	69	54	476	2.44	a	
56	1461.05	2917.92	1184	93	52	438	2.51	a	
57	1509.58	3014.58	63	58	46	374	2.10	a	
58	1661.00	3316.04	41	51	40	277	2.30	a	
59	1728.48	3450.32	25	161	132	1160	9.00	a	NET< CL Wide Pk
60	1730.25	3453.85	90	51	39	274	2.08	b	
61	1765.05	3523.09	656	82	52	393	3.05	a	

060381D10.SPC Analyzed by

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SEEKER B A C K G R O U N D Q. C. A N A L Y S I S Version 2.2.2

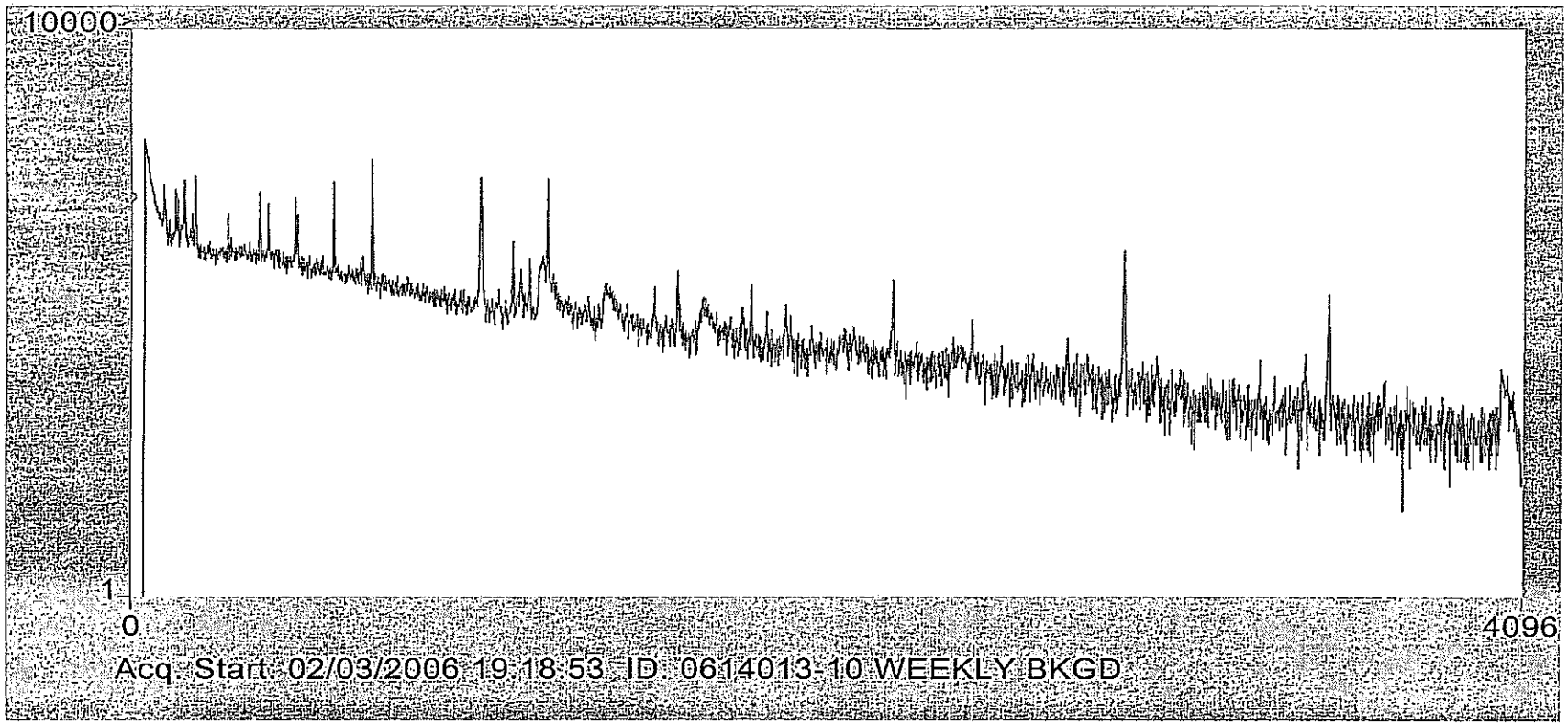
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ID: 0614013-10 WEEKLY BKGD

Detector # 10 Background Q.C. Analysis for 02/03/2006 19:18:53

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
10	50-> 150 keV Bkg	68.392	Pass	Pass	N.A.
11	150-> 250 keV Bkg	54.094	Pass	Pass	N.A.
12	250-> 500 keV Bkg	86.127	Pass	Pass	N.A.
13	500->1000 keV Bkg	103.464	Pass	Pass	N.A.
14	1000->2000 keV Bkg	64.010	Pass	Pass	N.A.
15	40-> 50 keV Bkg	10.662	Pass	Pass	N.A.

Q.C. Results Saved.


10000
1
0
4096
Acq. Start: 02/03/2006 19:18:53 ID: 0614013-10 WEEKLY BKGD

000037

Gamma Spectroscopy

Quality Control Data

Daily Instrument Performance Checks

ATD. 0126

Analytics, Inc.
1380 Seaboard Industrial Boulevard
Atlanta, Georgia 30318
404 352-8677

recd 12-29-94

ANALYTICS

CERTIFICATE OF CALIBRATION
Standard Radionuclide Source

49500-307

50 mL Liquid in Flame Sealed Vial

This standard radionuclide source was prepared using aliquots measured gravimetrically from master radionuclide solution sources. The Am-241 was calibrated by 4 pi alpha liquid scintillation counting. All other radionuclides were calibrated using a germanium gamma spectrometer system. Calibration and purity were checked using a germanium gamma spectrometer system. At the time of calibration no interfering gamma-ray emitting impurities were detected. The gamma-ray emission rates for the most intense gamma-ray lines are given. Analytics maintains traceability to the National Institute of Standards and Technology through a Measurements Assurance Program as described in USNRC Regulatory Guide 4.15, Rev. 1, February, 1979.

Calibration date: October 1, 1994 12:00 EST

ISOTOPE	GAMMA-RAY ENERGY	HALF-LIFE		GAMMA-RAYS PER SECOND	TOTAL UNCERTAINTY %
Am-241	59.5	432	y	1759	5.0
Cd-109	88	462.6	d	2622	4.5
Co-57	122	271.79	d	1472	4.2
Ce-139	166	137.64	d	2037	4.6
Hg-203	279	46.595	d	3978	4.5
Sn-113	392	115.09	d	2862	4.7
Cs-137	662	30.0	y	1735	4.7
Y-88	898	106.63	d	7290	4.4
Co-60	1173	5.2714	y	3347	4.3
Co-60	1332	5.2714	y	3355	4.8
Y-88	1836	106.63	d	7630	4.3

50.8520 grams solution 4M HCl.
P O NUMBER 45864, Item 1

SOURCE PREPARED BY: M. D. Currie
M. D. Currie, Radiochemist

Q A APPROVED: D. M. Montgomery 12-23-94

This standard will expire one year after the calibration date.

000039

ATL ID 0126

ANALYTICS

Analytics, Inc.
1680 Seaboard Industrial Boulevard
Atlanta, Georgia 30318
404 352-8677

ANALYSIS OF UNCERTAINTY

BATCH 70 MIXED GAMMA STANDARDS WITH Am-241
CALIBRATION DATE: October 1, 1994 12:00 EST

GAMMA RAY ENERGY (keV)	RANDOM ERROR % (99 % CL)	SYSTEMATIC ERROR %	TOTAL %
59.5	2.0	3.0	5.0
88	1.5	3.0	4.5
122	1.6	2.6	4.2
166	2.1	2.5	4.6
279	1.5	3.0	4.5
392	1.9	2.8	4.7
662	1.9	2.8	4.7
898	1.4	3.0	4.4
1173	1.5	2.8	4.3
1332	2.0	2.8	4.8
1836	1.2	3.1	4.3

The systematic error includes the error in calibration standards, weighing error, and estimated counting corrections. All uncertainties are stated at the 99% confidence level.

No interfering gamma emitting impurities were detected during calibration. Depending on the resolution and energy dispersion (kev/channel) of the measuring system, the following spectral conflicts may occur: (1) between the 80 keV gamma-ray and the X-rays emitted in the decay of Hg-203, (2) between the 1333 keV gamma-ray and the 1325 keV single escape peak from the 1836 keV gamma-ray.

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards & Technology
Gaithersburg, MD 20899

Certificate of Participation

Analytics, Incorporated
Atlanta, Georgia

is a participant for the period January 1, 1994, through December 31, 1994, in a radioactivity measurements assurance program conducted by the National Institute of Standards and Technology, in cooperation with the U.S. Council for Energy Awareness. Continued participation is evidenced by dated Reports of Traceability issued for particular radionuclides, which indicate the deviation of the participant's reported value from that measured by the National Institute of Standards and Technology. The significance of these Reports is addressed on the back of this certificate.

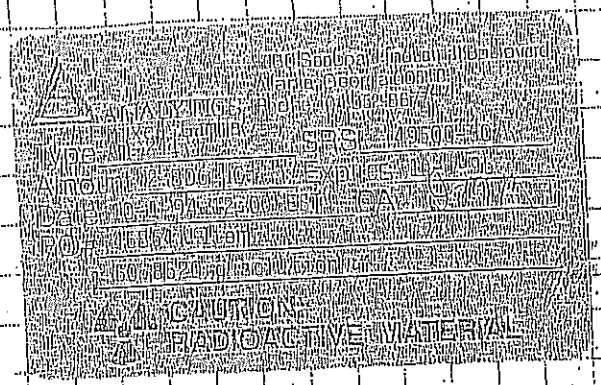
For the Director,

J.M. Robin Hutchinson, Acting Group Leader
Radioactivity Group
Physics Laboratory

(over)

000091

(ATI 178 thru L)
Analytics Std. 49500-307 was diluted 1:2 using
10 grams Deionized water and 5 grams of 49500-307 was added
to 200 ml Nalgene bottle #1 Volume-Tric with DI water
Bottle was capped and Teflon Tape was
then used to seal cap. Bottle was then shaken by hand
Activities (as of 10-1-96) are calculated below
The resulting 1 Liter of Standard is stored
in the Main Lab



ATI Working Standards 178-A through L
ATI Inventory Number 126
Analytics Standard ID: 49500-307
Prepared 01/08/95

Isotope	Energy	GPS	Abn.	Original Vol. (ml)	Aliquot ml	Final ml	Final pCi/ml	Final pCi Total	Final pCi/l	Final GPS	Final DPS
Am-241	59.5	1759	0.359	50	4	100	105.9	10594	105940	140.7	392.0
Cd-109	88	2622	0.0372	50	4	100	1524.0	152398	1523976	209.8	5638.7
Co-57	122	1472	0.8551	50	4	100	37.2	3722	37220	117.8	137.7
Ce-139	166	2037	0.8035	50	4	100	54.8	5481	54814	163.0	202.8
Hg-203	279	3978	0.773	50	4	100	111.3	11127	111269	318.2	411.7
Sn-113	392	2862	0.649	50	4	100	95.3	9535	95348	229.0	352.8
Cs-137	662	1735	0.8512	50	4	100	44.1	4407	44071	138.8	163.1
Y-88	898	7290	0.934	50	4	100	168.8	16876	168760	583.2	624.4
Co-60	1173	3347	1	50	4	100	72.4	7237	72368	267.8	267.8
Co-60	1332	3355	1	50	4	100	72.5	7254	72541	268.4	268.4
Y-88	1836	7630	0.9938	50	4	100	166.0	16600	166002	610.4	614.2

Continued on Page

Read and Understood By

Signed 1/8/95 Date — Signed 2/6/01 Date

Paragon Analytics

Gamma Spectrometer Calibration Log

Date: 2/8/06 Reviewed By/Date: MC 2/8/06

Det. No.	Out Of Service	Background		Source Check			Repeat Source Check			
		Started	OK	Started	OK	Failed Parameter(s)	OK	Failed Parameter(s)	Corrective Action Taken **	Removed from Service
1.	MC			✓	✓					
2.				JP	✓	1332 FWHM	JP			
3.	JP			✓	✓					
4.				JP	JP					
5.	MC			✓	✓					
6.				JP	JP					
7.				JP	JP					
8.				JP	JP					
9.	MC			✓	✓					
10.				JP	✓	662 FWHM 1332 Centroid	JP			
11.										
12.										

** Corrective Action:

303192 A

Form 754r11a.frm (6/13/2005)

000093

060402D07.SPC Analyzed by JP

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

****

ID: DAILY CHECK
Detector # 7 Detector Q.C. Analysis for 02/08/2006 07:06:16
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	123.484	*<FAIL>	Pass	N.A.
2	60 keV FWHM	8.935E-01	Pass	Pass	N.A.
3	60 keV Efficiency	7.153E-02	Pass	Pass	N.A.
4	662 keV Centroid	1325.046	Pass	Pass	N.A.
5	662 keV FWHM	1.366	Pass	Pass	N.A.
6	662 keV Efficiency	1.601E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2662.311	Pass	Pass	N.A.
8	1332 keV FWHM	1.923	Pass	Pass	N.A.
9	1332 keV Efficiency	7.480E-03	Pass	Pass	N.A.

*Paragon Analytics does not control on the n-sigma test. JP 2/8/06

060416D10.SPC Analyzed by JP

****

SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

****

ID: DAILY CHECK
Detector # 10 Detector Q.C. Analysis for 02/08/2006 07:06:43
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	121.334	Pass	Pass	N.A.
2	60 keV FWHM	1.055	Pass	Pass	N.A.
3	60 keV Efficiency	7.089E-02	Pass	Pass	N.A.
4	662 keV Centroid	1322.978	Pass	Pass	N.A.
5	662 keV FWHM	2.014	Pass	<FAIL>	N.A.
6	662 keV Efficiency	4.650E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2660.743	Pass	<FAIL>	N.A.
8	1332 keV FWHM	2.938	Pass	Pass	N.A.
9	1332 keV Efficiency	2.532E-02	Pass	Pass	N.A.

060418D10.SPC Analyzed by JP

****

SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

****

ID: DAILY CHECK
Detector # 10 Detector Q.C. Analysis for 02/08/2006 07:51:00
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	121.407	Pass	Pass	N.A.
2	60 keV FWHM	1.032	Pass	Pass	N.A.
3	60 keV Efficiency	6.948E-02	Pass	Pass	N.A.
4	662 keV Centroid	1323.198	Pass	Pass	N.A.
5	662 keV FWHM	2.086	<FAIL>	<FAIL>	N.A.
6	662 keV Efficiency	4.674E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2661.264	Pass	Pass	N.A.
8	1332 keV FWHM	2.964	Pass	Pass	N.A.
9	1332 keV Efficiency	2.523E-02	Pass	Pass	N.A.

060420D10.SPC Analyzed by JP

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

****

ID: DAILY CHECK
Detector # 10 Detector Q.C. Analysis for 02/08/2006 08:34:34
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	121.428	Pass	Pass	N.A.
2	60 keV FWHM	1.029	Pass	Pass	N.A.
3	60 keV Efficiency	6.855E-02	Pass	Pass	N.A.
4	662 keV Centroid	1323.235	Pass	Pass	N.A.
5	662 keV FWHM	1.988	Pass	Pass	N.A.
6	662 keV Efficiency	4.598E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2661.229	Pass	Pass	N.A.
8	1332 keV FWHM	2.886	Pass	Pass	N.A.
9	1332 keV Efficiency	2.452E-02	Pass	Pass	N.A.

Paragon Analytics

Gamma Spectrometer Calibration Log

Date: 2/9/06 Reviewed By/Date: JP 2/10/06

Det. No.	Out Of Service	Background		Source Check			Repeat Source Check			
		Started	OK	Started	OK	Failed Parameter(s)	OK	Failed Parameter(s)	Corrective Action Taken **	Removed from Service
1.				JP	JP					
2.				↓	/	1332 Eff	JP			
3.	MC			/	/					
4.				JP	JP					
5.				↓	JP					
6.				↓	JP					
7.				↓	/	662 FWHM	JP			
8.				↓	JP					
9.	MC			/	/					
10.				JP	/	662 1332 FWHM	JP			
11.										
12.										

** Corrective Action:

060419D07.SPC Analyzed by JP

****

SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

****

ID: DAILY CHECK
Detector # 7 Detector Q.C. Analysis for 02/09/2006 05:44:31
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	123.487	<FAIL>	Pass	N.A.
2	60 keV FWHM	8.859E-01	Pass	Pass	N.A.
3	60 keV Efficiency	7.232E-02	<FAIL>	Pass	N.A.
4	662 keV Centroid	1325.264	Pass	Pass	N.A.
5	662 keV FWHM	1.506	Pass	<FAIL>	N.A.
6	662 keV Efficiency	1.614E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2662.700	Pass	Pass	N.A.
8	1332 keV FWHM	2.030	Pass	Pass	N.A.
9	1332 keV Efficiency	8.156E-03	Pass	Pass	N.A.

060420D07.SPC Analyzed by JP

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

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ID: DAILY CHECK
Detector # 7 Detector Q.C. Analysis for 02/09/2006 06:08:17
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	123.491	<FAIL>	Pass	N.A.
2	60 keV FWHM	8.652E-01	Pass	Pass	N.A.
3	60 keV Efficiency	7.132E-02	Pass	Pass	N.A.
4	662 keV Centroid	1325.140	Pass	Pass	N.A.
5	662 keV FWHM	1.463	Pass	Pass	N.A.
6	662 keV Efficiency	1.651E-02	Pass	<FAIL>	N.A.
7	1332 keV Centroid	2662.651	Pass	Pass	N.A.
8	1332 keV FWHM	1.993	Pass	Pass	N.A.
9	1332 keV Efficiency	7.756E-03	Pass	Pass	N.A.

060421D07.SPC Analyzed by

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

****

ID: DAILY CHECK
Detector # 7 Detector Q.C. Analysis for 02/09/2006 06:29:50
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	123.502	* <FAIL>	Pass	N.A.
2	60 keV FWHM	8.730E-01	Pass	Pass	N.A.
3	60 keV Efficiency	7.242E-02	* <FAIL>	Pass	N.A.
4	662 keV Centroid	1325.105	Pass	Pass	N.A.
5	662 keV FWHM	1.433	Pass	Pass	N.A.
6	662 keV Efficiency	1.570E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2662.579	Pass	Pass	N.A.
8	1332 keV FWHM	2.067	Pass	Pass	N.A.
9	1332 keV Efficiency	7.967E-03	Pass	Pass	N.A.

*Paragon Analytics does not control on the n-sigma test. JP 2/9/06

060433D10.SPC Analyzed by JT

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

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ID: DAILY CHECK
Detector # 10 Detector Q.C. Analysis for 02/09/2006 05:44:59
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	121.372	Pass	Pass	N.A.
2	60 keV FWHM	1.031	Pass	Pass	N.A.
3	60 keV Efficiency	6.930E-02	Pass	Pass	N.A.
4	662 keV Centroid	1323.117	Pass	Pass	N.A.
5	662 keV FWHM	2.036	Pass	<FAIL>	N.A.
6	662 keV Efficiency	4.642E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2660.990	Pass	<FAIL>	N.A.
8	1332 keV FWHM	3.196	<FAIL>	<FAIL>	N.A.
9	1332 keV Efficiency	2.444E-02	Pass	Pass	N.A.

060434D10.SPC Analyzed by JD

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

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ID: DAILY CHECK
Detector # 10 Detector Q.C. Analysis for 02/09/2006 06:09:55
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	121.463	Pass	Pass	N.A.
2	60 keV FWHM	1.034	Pass	Pass	N.A.
3	60 keV Efficiency	6.822E-02	Pass	Pass	N.A.
4	662 keV Centroid	1324.099	Pass	Pass	N.A.
5	662 keV FWHM	2.045	Pass	<FAIL>	N.A.
6	662 keV Efficiency	4.749E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2662.924	Pass	Pass	N.A.
8	1332 keV FWHM	3.233	<FAIL>	<FAIL>	N.A.
9	1332 keV Efficiency	2.551E-02	Pass	Pass	N.A.

060437D10.SPC Analyzed by JP

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

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ID: DAILY CHECK
Detector # 10 Detector Q.C. Analysis for 02/09/2006 07:17:55
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	121.421	Pass	Pass	N.A.
2	60 keV FWHM	1.040	Pass	Pass	N.A.
3	60 keV Efficiency	6.903E-02	Pass	Pass	N.A.
4	662 keV Centroid	1323.493	Pass	Pass	N.A.
5	662 keV FWHM	1.986	Pass	Pass	N.A.
6	662 keV Efficiency	4.581E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2661.609	Pass	Pass	N.A.
8	1332 keV FWHM	2.965	Pass	Pass	N.A.
9	1332 keV Efficiency	2.521E-02	Pass	Pass	N.A.

Paragon Analytics

Gamma Spectrometer Calibration Log

Date: 2/10/06 Reviewed By/Date: JP 2/10/06

Det. No.	Out Of Service	Background		Source Check			Repeat Source Check			
		Started	OK	Started	OK	Failed Parameter(s)	OK	Failed Parameter(s)	Corrective Action Taken **	Removed from Service
1.				JP	JP					
2.				JP	JP					
3.				/	/					
4.				JP	/	1332 FWHM	JP			
5.				JP	JP					
6.				JP	JP					
7.				JP	JP					
8.				JP	/	662 Eff	JP			
9.				/	/					
10.				JP	/	662 1332 FWHM	JP			
11.										
12.										

** Corrective Action:

303198 A

Form 754r11a.frm (6/13/2005)

060434D07.SPC Analyzed by JD

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SEEKER D E T E C T O R Q. C. A N A L Y S I S Version 2.2.2

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ID: DAILY CHECK
Detector # 7 Detector Q.C. Analysis for 02/10/2006 06:44:19
Standards File #: 98 (Daily Performance Check 49500-307)

#	Parameter	Value	n Sigma Test	Bounds Test	T-Test
1	60 keV Centroid	123.391	*<FAIL>	Pass	N.A.
2	60 keV FWHM	8.840E-01	Pass	Pass	N.A.
3	60 keV Efficiency	7.255E-02	*<FAIL>	Pass	N.A.
4	662 keV Centroid	1324.741	Pass	Pass	N.A.
5	662 keV FWHM	1.426	Pass	Pass	N.A.
6	662 keV Efficiency	1.518E-02	Pass	Pass	N.A.
7	1332 keV Centroid	2661.846	Pass	Pass	N.A.
8	1332 keV FWHM	1.963	Pass	Pass	N.A.
9	1332 keV Efficiency	7.812E-03	Pass	Pass	N.A.

* Paragon Analytics does not control on the n-sigma test.
JD 2/10/06