ATK Promontory
Solid Rocket Motor Static Tests
Public Health Assessment

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Utah Department of Health

Environmental Epidemiology Program

The Environmental Epidemiology Program

UTAH DEPARTMENT OF HEALTH

Who We Are

- Part of the Utah Department of Health
- Co-operative partners with the federal Agency for Toxic Substances and Disease Registry (ATSDR)/Centers for Disease Control and Prevention (CDC)

What We Do

- Required to provide health-based assessments for all National Priorities List (NPL) superfund sites
- Assess communities for past, current, and potential hazardous exposures to environmental contaminants
- Work closely with local health departments, the Environmental Protection Agency (EPA), and the Utah Department of Environmental Quality (UDEQ)

The Environmental Epidemiology Program

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What We Provide

- Independent, objective health decisions based upon the best available science and data
- Health education to minimize exposure
- Recommendations to the EPA, UDEQ, and other regulatory and public health agencies for further actions

What We Do Not Provide

- Remediation or “site clean-up”
- Legal advice
- Enforcement of regulatory standards
- Medical attention or health care services

ATSDR Assessment Process

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Federal requirement, prior recommendation, or petition for action by public or EPA/UDEQ

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Determine “pathways” of exposure (air/water/soil/food chain); Conduct needs assessment

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Analyze sample data; Determine health risk; Report findings

Toxicological Assessment

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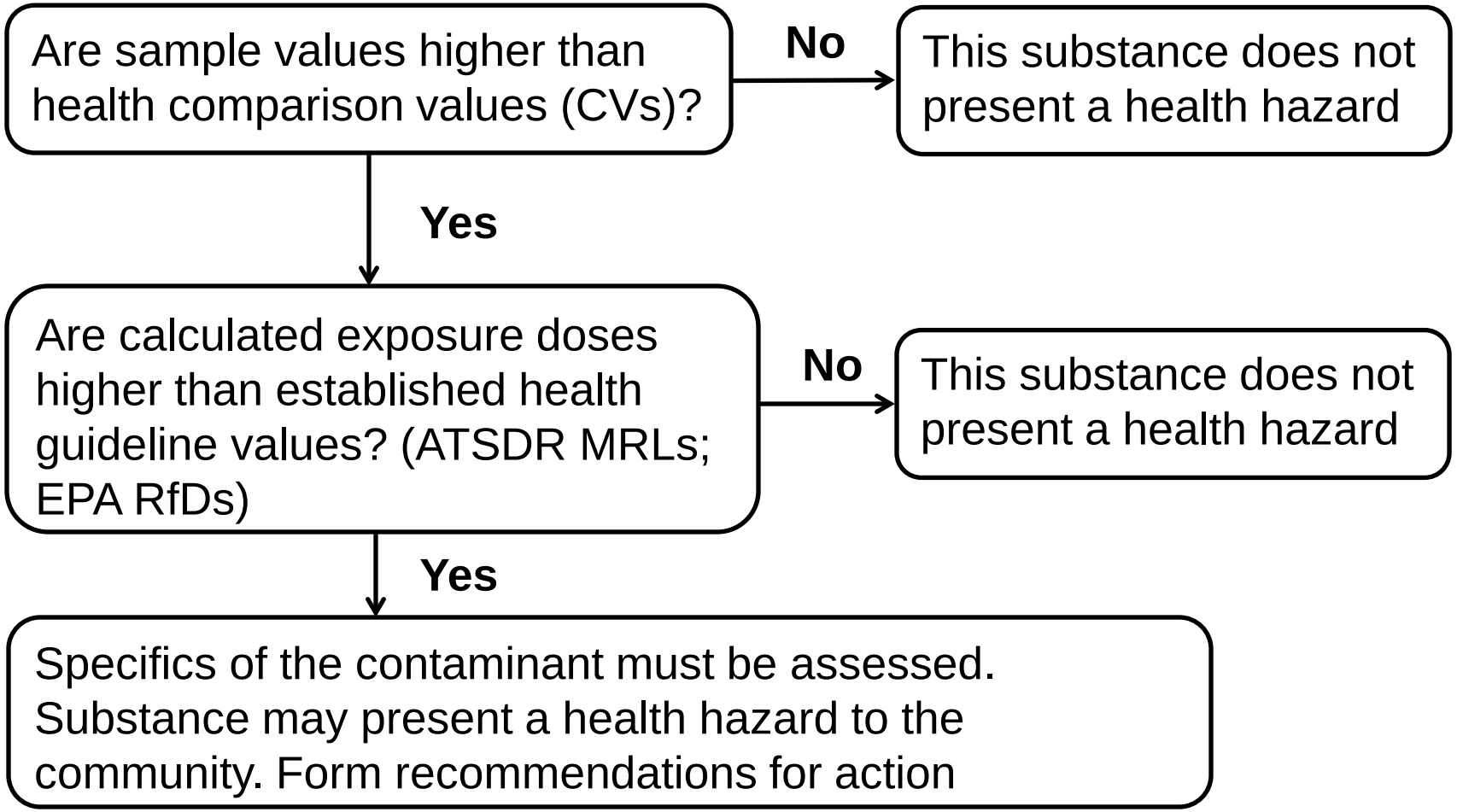

Toxicological Assessment

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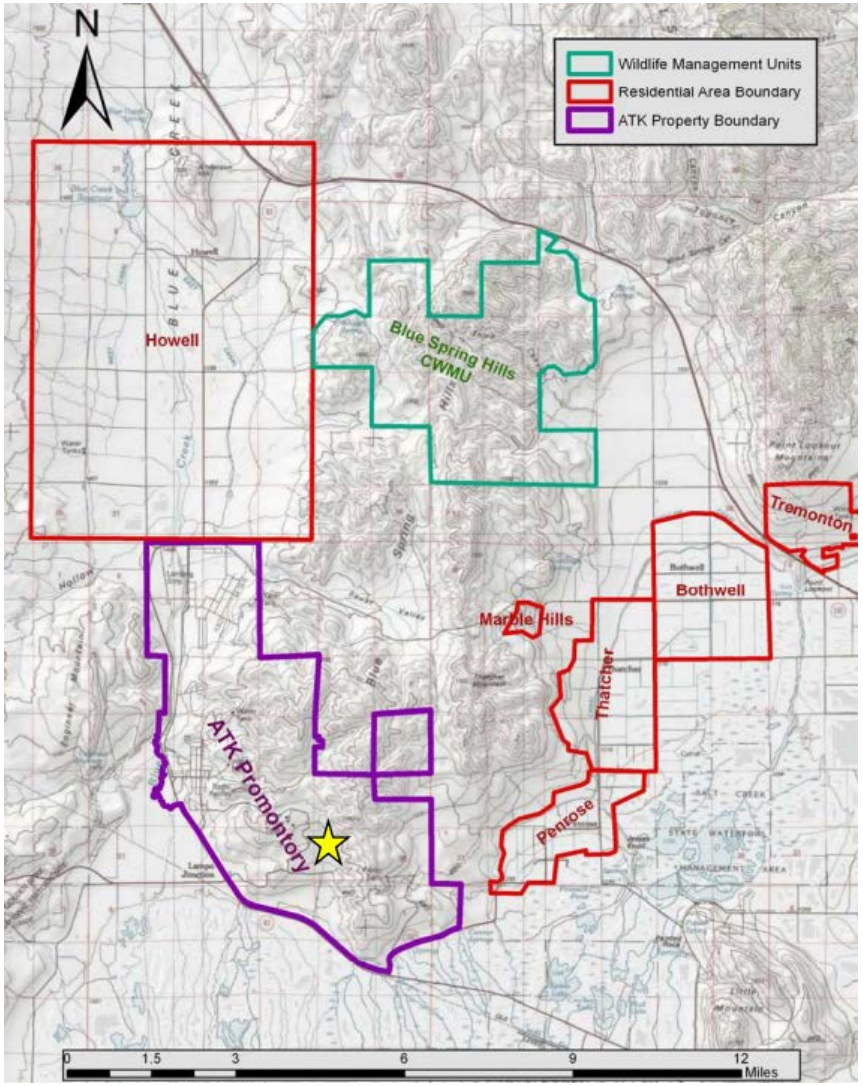
Exposure dose calculations include:

- Type of contaminant
- Amount of contaminant
- Type of exposure (ingestion, inhalation, dermal)
- Intake rates
- Duration of exposure (everyday, recreational, etc.)

Calculations made for adults <u>and</u> children

ATK Promontory Facility

- Built in the 1950s as a rocket manufacturing & testing facility
- ATK had a contract to design, develop, manufacture, test, and refurbish reusable solid rocket motors (SRMs) for the Space Shuttle and Ares programs
  - Static test: ignition and monitoring of a rocket while it is anchored to the ground
- First static test of an reusable SRM in 1977



Development Motors

- Derived from the Space Shuttle SRM
- Contains roughly 1.4 million pounds of propellant
  - 70% ammonium perchlorate
  - 16% powdered aluminum
  - 12% polymer
    - Polybutadiene & acrylonitrile
  - 2% epoxy curing agent
  - 0.4% iron oxide
- Three Development Motor (DM) tests:
  - DM-1: September 10, 2009
  - DM-2: August 30, 2010
  - DM-3: September 8, 2011

DM-2 on the T-97 test stand

DM Static Tests

- Each DM burns for about 2 minutes
- SECOR modeled exhaust constituents
  - 36% carbon dioxide
  - 26.5% aluminum oxide
  - 18.5% hydrogen chloride gas
  - 8.3% water
  - 7.7% nitrogen gas
  - 3.7% chlorine gas
  - 2.3% nitrogen oxides

DM-2 static test on August 30, 2010

DM Static Tests

- The exhaust gases from the DM tests were directed toward a natural rocky outcrop
  - Primarily limestone and sandstone
    - Trace amounts of heavy metals natural to the area
- Some of this material was scoured from the hillside and entered the plume
  - Some material likely reacted with the exhaust gases

DM-2 just prior to the static test

DM-2 Static Test Fire
August 30, 2010

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Plume during the test fire

Plume immediately post-test fire

Plume 3 minutes post-test fire

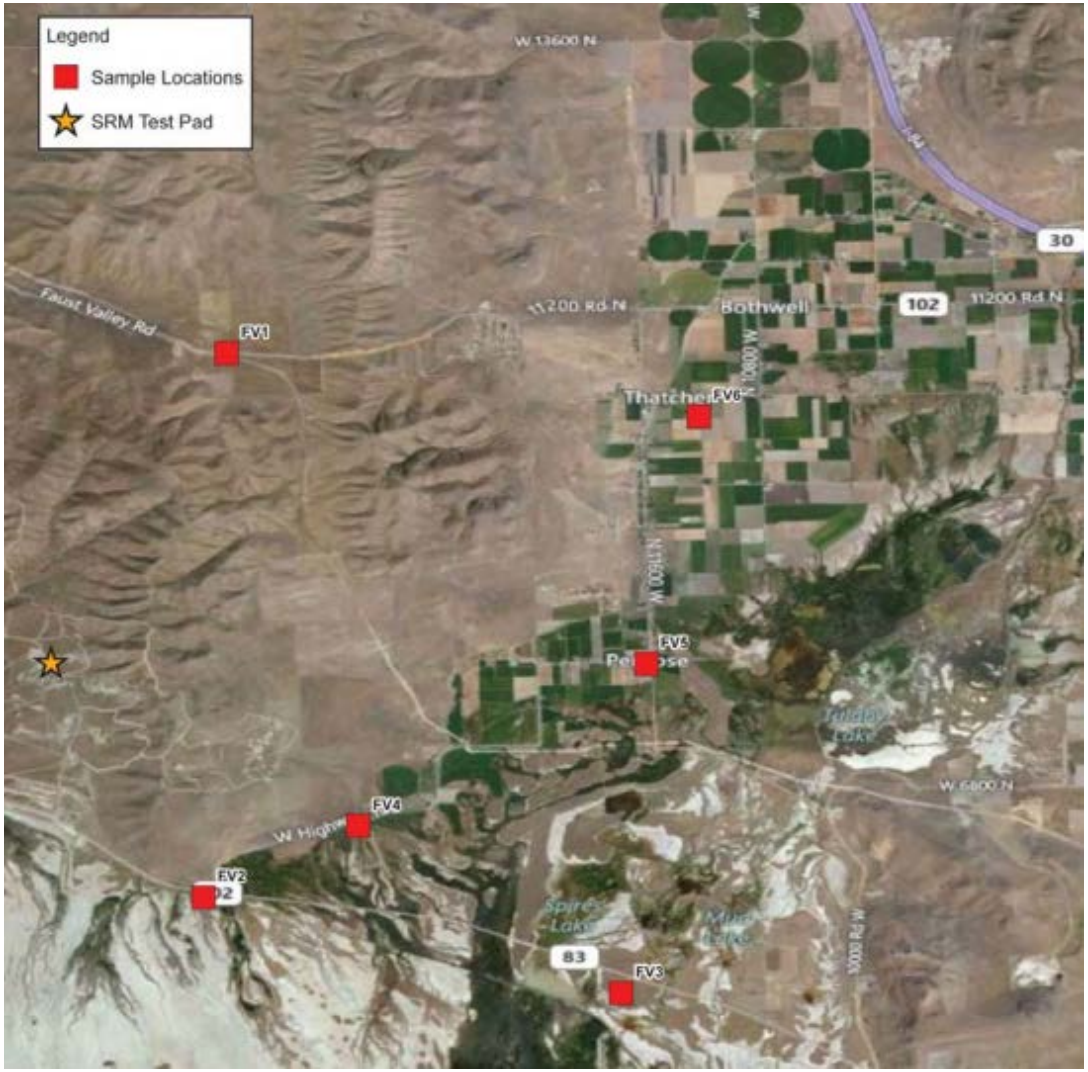
Exposure Pathways

Exposure pathways assessed in this PHA:

- Air: inhalation and contact with the exhaust plume
- Soil: incidental ingestion and contact with soil from the area communities
- Water: groundwater from private residential wells
  - Used for drinking water

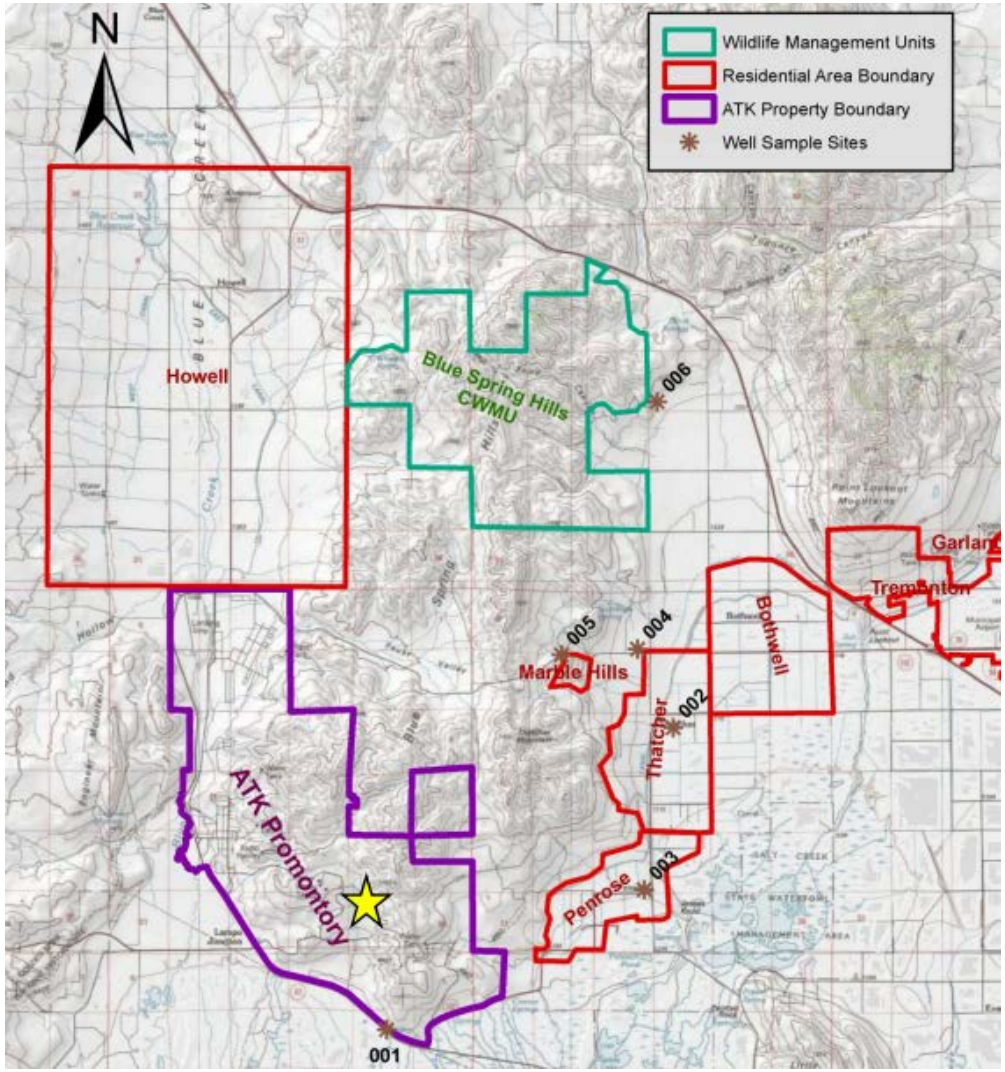
Air Exposure Pathway

- 6 air monitoring stations used during the DM-3 test
- Samples tested for:
  - Volatile organic compounds (VOCs)
  - Semivolatile organic compounds (SVOCs)
  - Metals
  - Inorganic anions
  - Perchlorate
- Plume traveled SSW and did not impact the air monitors



Soil Exposure Pathway

- UDEQ collected soil samples from 6 locations in the communities near ATK
- Analyzed for 25 metals, 7 anions, and perchlorate



Soil Sampling Results

Analyte	CV	Sample 001	Sample 002	Sample 003	Sample 004	Sample 005	Sample 006
Aluminum	50,000	7,060	17,300	8,830	14,200	7,550	13,000
Antimony	20.0	~ 2.2	~ 1.8	~ 2.0	~ 1.7	~ 1.7	~ 1.8
Arsenic	20.0	< 2.2	2.6	2.9	5.4	2.0	<1.8
Barium	10,000	142	167	116	139	88	141
Beryllium	100.0	< 1.1	< 0.9	< 1.0	< 0.8	<0.8	< 0.9
Boron	10,000	< 12	< 6.9	< 7.7	< 6.2	< 6.3	< 6.6
Cadmium	5.0	< 1.1	~ 1.4	< 1.0	< 0.8	< 0.8	~ 1.2
Calcium		40,300	9,580	47,600	5,370	4,750	8,160
Chloride		288	427	442	430	416	435
Chromium	50	10.4	21.6	11.9	17.4	11.9	17.2
Cobalt	500	2.7	7.7	3.4	6.4	3.5	5.6
Copper	500.0	23.9	27.6	16.3	23.0	14.7	28.3
Fluoride	3,100.0	< 5.0	12.2	6.4	6.6	< 5.0	14.6
Iron	55,000	6,770	18,000	8,020	13,100	6,880	12,460
Lead	400.0	21.3	14.6	10.4	13.6	24.0	25.6
Magnesium		11,000	9,670	15,000	6,050	2,790	5,790
Manganese	1,800	545	628	354	504	319	505

All results in mg/kg

CV Comparison value
~ Estimated value
< Undetected. Value reported is the detection limit

Analyte levels in all soil samples were below applicable comparison values

Soil Sampling Results

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Analyte	CV	Sample 001	Sample 002	Sample 003	Sample 004	Sample 005	Sample 006
Mercury	230	R 0.5	R 0.5	R 0.2	R 0.2	R 0.2	R 0.2
Molybdenum	300	1.6	< 0.9	< 1.0	< 0.8	< 0.8	< 0.9
Nickel	1,000	7.2	20.2	7.9	15.4	6.8	13.0
Nitrate	80,000	< 10	< 10	21.3	< 10	< 10	< 10
Nitrite	5,000	< 10	< 10	< 10	< 10	< 10	< 10
Perchlorate	40.0	< 40	< 40	< 40	< 40	< 40	< 40
Phosphate		494	572	671	554	201	525
Potassium		~ 3,760	~ 8,550	~ 4,780	~ 5,400	~ 2,930	~ 5,100
Selenium	300	< 2.2	< 1.8	3.0	< 1.7	< 1.7	< 1.8
Silver	300	< 2.2	< 1.8	< 2.0	< 1.7	< 1.7	< 1.8
Sodium		270	290	230	140	95	165
Sulfate		9,050	< 2,000	< 2,000	< 2,000	< 2,000	< 2,000
Sulfide		~ 10	35.4	~ 12.1	~ 50.7	< 10	~ 37.5
Thallium	4.0	< 2.2	< 1.8	< 2.0	< 1.7	< 1.7	< 1.8
Vanadium	200	10.0	24.2	12.6	20.1	11.9	18.7
Zinc	20,000	93.7	91.2	51.1	58.1	41.0	84.4

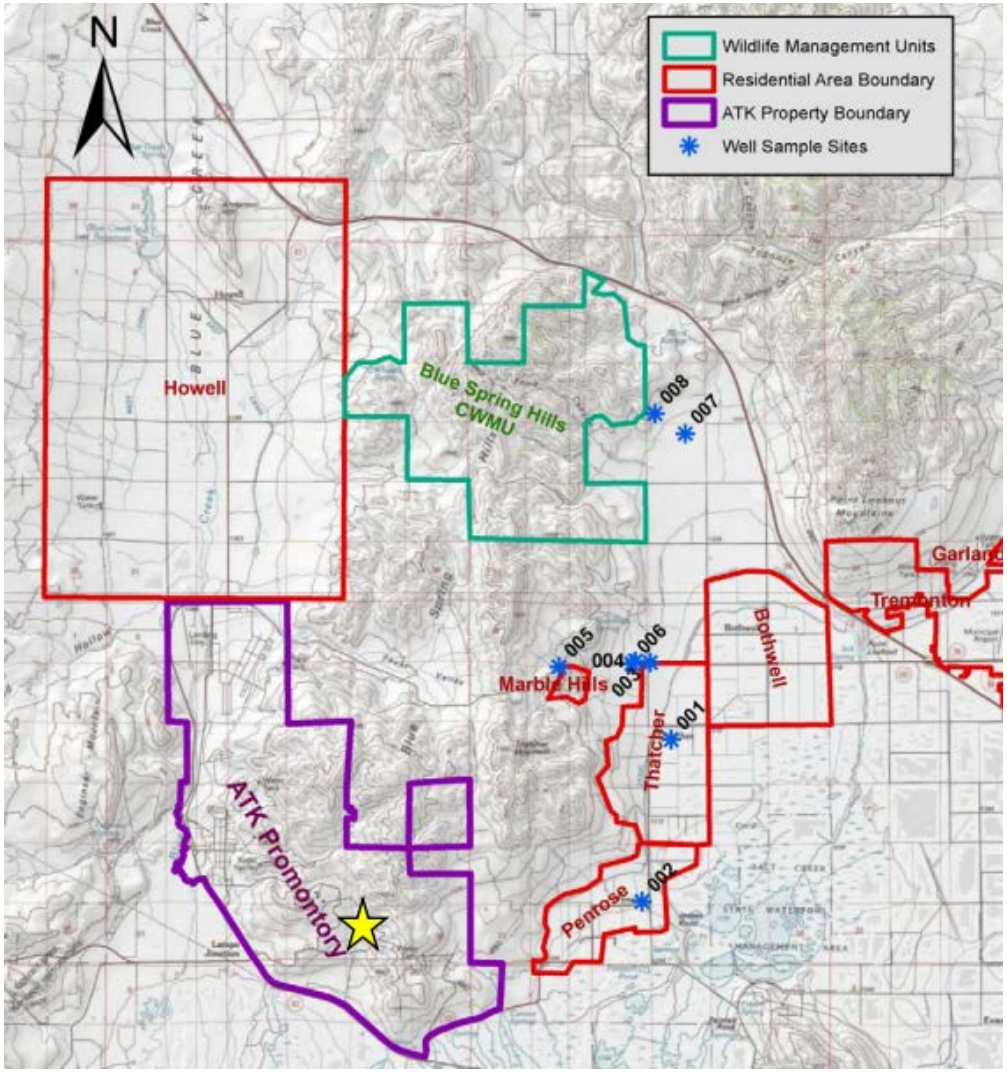
All results in mg/kg

CV Comparison value
~ Estimated value
< Undetected. Value reported is the detection limit
R Rejected value due to laboratory quality control concerns

Analyte levels in all soil samples were below applicable comparison values

Drinking Water Exposure Pathway

- UDEQ collected groundwater samples from 8 residential wells
  - Used as drinking water
- Analyzed for 25 metals, 7 anions, and perchlorate



Well Water Sampling Results

Analyte	CV / MCL	Sample 001	Sample 002	Sample 003	Sample 004	Sample 005	Sample 006	Sample 007	Sample 008
Aluminum	10,000 / -	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Antimony	4 / 6	< 6.0	< 60	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0	< 6.0
Arsenic	3 / 10	< 2.0	**~ 9.6**	< 2.0	< 2.0	< 2.0	**~ 3.4**	< 2.0	< 2.0
Barium	2,000 / 2,000	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Beryllium	20 / 4	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Boron	2,000 / -	~ 342	~ 286	~ 115	~ 142	~ 80.7	~ 152	69.3	69.4
Cadmium	1 / 5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Calcium		~ 116,000	~ 78,900	~ 76,800	~ 66,100	~ 44,700	~ 42,000	~ 87,000	~ 73,300
Chloride		147,000	325,000	417,000	257,000	68,900	190,000	286,000	242,000
Chromium	100 / 100	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
Cobalt	100 / -	< 60	< 60	< 60	< 60	< 60	< 60	< 60	< 60
Copper	100 / 1,300	~ 19.5	~ 21.4	~ 3.3	< 2.0	~ 3.2	< 2.0	9.5	5.7
Fluoride		244.0	458.0	378.0	561.0	315.0	543.0	228.0	237.0
Iron		~ 122	< 20	< 20	~ 213	< 20	~ 93.3	22	274
Lead	15 / 15	~ 1.7	~ 1.0	~ 0.7	~ 0.9	~ 1.3	~ 1.1	~ 1.2	~ 1.7
Magnesium		~ 66,900	~ 46,400	~ 42,500	~ 45,500	~ 17,400	~ 36,600	~ 41,900	~ 32,800
Manganese	300 / -	~ 11.1	~ 10.7	~ 12.9	< 10	< 10	< 10	< 10	< 10

All results in µg/L

CV Comparison value **~** Estimated value **<** Undetected. Value reported is the detection limit

Analyte levels, besides arsenic, in well water samples were below applicable CVs

- Arsenic was detected in two samples
  - Both were above the CV but below the EPA MCL
- The presence of arsenic is consistent with the natural hydrogeology of the area
  - USGS found 1 – 10 µg/L arsenic in the Cache Valley and Lower Bear River aquifers

Well Water Sampling Results

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Analyte	CV / MCL	Sample 001	Sample 002	Sample 003	Sample 004	Sample 005	Sample 006	Sample 007	Sample 008
Mercury	2 / 2	R 0.2	R 0.2	R 0.2	R 0.2	R 0.2	R 0.2	R 0.2	R 0.2
Molybdenum	50 / -	< 2.0	~ 4.4	< 2.0	~ 4.8	~ 4.7	< 2.0	< 2.0	< 2.0
Nickel	100 / -	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Nitrate	10,000 / 10,000	9,030	1,930	1,550	2,820	2,260	3,280	2,000	1,350
Nitrite	1,000 / 1,000	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Perchlorate	7 / -	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
Phosphate		52	50	< 20	< 20	< 20	< 20	< 20	< 20
Potassium		~ 7,750	~ 16,700	~ 6,650	~ 10,500	~ 2,650	~ 14,400	~ 4,470	~ 3,410
Selenium	50 / 50	~ 4.4	< 2.0	< 2.0	~ 2.8	< 2.0	< 2.0	< 2.0	~ 2.2
Silver	50 / -	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Sodium		~ 188,000	~ 289,000	~ 228,000	~ 129,000	~ 63,700	~ 117,000	~ 137,000	~ 123,000
Sulfate		466,000	166,000	71,000	89,600	31,900	52,700	58,900	39,200
Sulfide		< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Thallium	2 / 2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Vanadium	100 / -	< 60	< 60	< 60	< 60	< 60	< 60	< 60	< 60
Zinc	3,000 / -	~ 78.7	~35	~ 20.2	~ 839	~ 44.5	< 20	< 20	< 20

All results in µg/L

CV Comparison value
~ Estimated value
< Undetected. Value reported is the detection limit
R Rejected value due to laboratory quality control concerns

Analyte levels in all well water samples were below applicable comparison values

Health Effects of Arsenic Exposure

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- Arsenic is naturally occurring and widely distributed in the Earth's crust
- Large oral doses (>60,000 µg/L) can result in death
- Ingestion of 300 – 30,000 µg/L may cause:
  - Irritation of the stomach and intestines, resulting in nausea, vomiting, and diarrhea
  - Decreased production of blood cells, resulting in fatigue
  - Abnormal heart rhythm
  - Damage to blood vessels
  - Impaired nerve function, causing a "pins and needles" sensation
  - Skin changes: darkened patches and small "corns" or "warts" on the palms, soles, and torso
  - Inorganic arsenic has been classified as a carcinogen
    - Associated with skin, liver, lung, and bladder cancers

Arsenic Exposure Doses

Analyte	Chronic Oral MRL (mg/kg/day)	Well	Concentration (µg/L)	Exposure Dose (mg/kg/day) Child	Exposure Dose (mg/kg/day) Adult
Arsenic	0.0003	002	9.6	**0.00060**	0.00027
		006	3.4	0.00021	0.00010

Assumes ingestion of 1 liter/day for children and 2 liters/day for adults

- Further sampling of this region's aquifer is necessary to determine if a potential health hazard is present
- EPA target cancer risk range: 1E-04 to 1E-06
- Potential lifetime cancer risk from arsenic in well 002: 5.02E-04
  - 70 years total: 13 child years and 57 adult years
  - Assumes ingestion of 1 L (children) or 2 L (adults) of well water every day for 70 years

Arsenic Exposure Doses

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- The calculated exposure dose in children exceeded the chronic MRL. Is this a potential health hazard?
- **0.0140 mg/kg/day:** dose associated with cancers related to chronic oral exposure
- **0.0020 mg/kg/day:** threshold dose for skin changes
- **0.0008 mg/kg/day:** dosage at which no significant increase in adverse health effects resulted from long-term exposure (NOAEL)
- **0.0006 mg/kg/day:** the highest calculated dosage for area groundwater
  - Based on a single sample. More data is needed to properly assess

Fallout Debris Exposure Pathway

- Samples of the debris that fell from the plume were collected following the DM-3 static test
- Tested for 49 SVOCs
  - All SVOCs measured far below the applicable comparison values
  - 48 of 49 SVOCs also below the detection limit
- Perchlorate was not measured above the detection limit
  - The MDL is ~6,500 times lower than the CV

Fallout Debris Exposure Pathway

Analyte	CV	Sample
Aluminum	50,000	47,500
Antimony	20	0.706
Arsenic	20	6.84
Barium	10,000	85.7
Beryllium	100	0.44
Boron	10,000	44.7
Cadmium	5	< 0.14
Calcium	-	171,000
Chromium	-	26.2
Cobalt	500	2.97
Copper	500	8.08
Iron	55,000	8,350
Lead	400	5.73
Lithium	160	9.74

All results in mg/kg

CV Comparison value

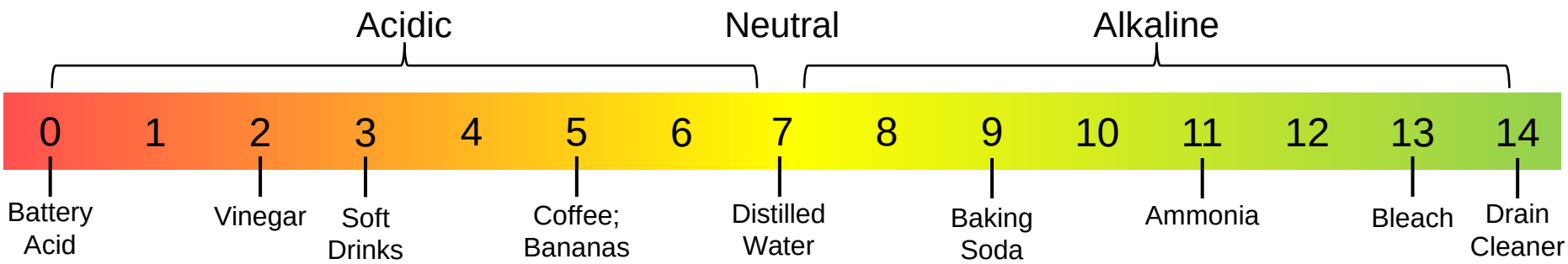
< Undetected. Value reported is the detection limit

Analyte	CV	Sample
Magnesium	-	6,110
Manganese	3,000	136
Molybdenum	300	0.743
Nickel	1,000	13.4
Phosphorus	10	**1,180**
Potassium	-	3,760
Selenium	300	2.39
Silver	300	< 0.29
Sodium	-	355
Strontium	30,000	348
Thallium	0.78	< 0.29
Tin	20,000	1.51
Titanium	-	392
Vanadium	500	24.2
Zinc	20,000	148

- Tested for 29 metals and minerals
- All analyte levels measured below the CVs except phosphorus
  - Soil and rocks near ATK are high in phosphorus, likely in the mineral apatite and phosphate forms
  - The only available CV for a phosphorus compound is for white phosphorus
    - Laboratory test method (SW-6010C) does not indicate the form of phosphorus
    - White phosphorus is highly reactive and not found in nature

Fallout Debris Exposure Pathway

- The pH of the fallout material was 9.77 – 11
  - Most likely contributors:
    - Calcium oxide: formed when calcium carbonate (e.g., limestone, antacids, chalk) is heated above 1,500ºF
    - Calcium hydroxide: formed from the reaction between calcium oxide & water
  - In sufficient quantities, both can cause skin irritation and corrosion of metals
  - Very short lived in the environment
    - Rapidly reforms calcium carbonate



Cancer Incidence Statistical Review

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- The EEP conducted this review among residents of Bothwell, Howell, Marble Hills, Penrose, and Thatcher
  - All 42 anatomical site-specific cancer categories were examined
  - Seven sequential 5-year time periods between 1973 and 2009
- Statistical review:
  - Historic trend and current status
    - Provides a measures of the relative risk of a study area
    - Provides an assessment of trends in rates over time
  - Is not an environmental risk assessment
    - Does not link disease risk to environmental risk
- <u>Statistically</u> significant incidence ratios may be due to mathematical artifacts and not be biologically relevant
  - Would expect 1 in 20 analyses to be significant due to random chance
- <u>Meaningfully</u> significant results:
  - Two or more sequential time periods with statistically elevated incidence ratios
  - ≥ 1 analytical period with rate ratios of 5 or greater

Cancer Incidence Statistical Review

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- None of the 42 site-specific cancer categories had meaningfully elevated incidence ratios
  - No cancer category had a significant trend of increasing incidence

- 3 cancer categories had elevated incidence ratios during a single time period
  - Among males
    - Lung & bronchial cancer, 1985 – 1989 (incidence ratio = 3.3)
    - Prostate cancer, 2000 – 2004 (incidence ratio = 2.1)
  - Among females
    - Non-Hodgkin lymphoma, 2005 – 2009 (incidence ratio = 4.3)

  - Cannot determine if these findings result from higher risk or statistical artifacts

  - Typical risk factors for these 3 cancer types are not associated with the non-occupational commercial or industrial environmental concerns in the area
    - Prostate cancer and non-Hodgkin lymphoma have been associated with agriculture-related environmental exposures (e.g., herbicides, pesticides, etc.)

Recommendations

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Appropriate and health protective recommendations:

- Public drinking water systems are recommended to work with the BRHD to confirm the presence of elevated arsenic levels in groundwater used for public potable water sources
- Private well owners are recommended to test their wells for arsenic
- To provide a more complete assessment, further air and soil sampling should be considered

UDOH/ATSDR Action Plan

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Public health actions that are ongoing or will be implemented:

- The EEP will remain available to address any public health questions or concerns regarding this public health assessment for residents, visitors, and the general public

- The EEP will provide continued support to UDEQ and EPA on interpreting any additional data collected with respect to ATK Promontory operations

Conclusions

- The EEP cannot conclude whether the DM-2 and DM-3 rocket motor tests could have harmed people's health
  - No useable air sampling data was collected during the DM-3 test
  - Soil and groundwater sampling did not identify public health concerns related to the SRM tests

- Elevated levels of arsenic were identified in two groundwater samples
  - Concentrations are consistent with the natural hydrogeology of the area
  - Fallout debris contained low amounts of arsenic (6.84 ppm)
  - Very unlikely that the SRM tests made a substantial contribution
  - Highest calculated exposure dose remained lower than the NOAEL

Conclusions

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- Fallout debris sampling suggested the presence of caustic calcium oxide and calcium hydroxide at the test site
  - May be the source of complaints regarding skin, eye, and throat irritation
  - Cannot determine if these materials travelled to the area communities
- No cancer types had meaningfully elevated incidence
  - Typical risk factors for the three cancer types with elevated incidence during a single time period are not associated with the commercial or industrial environmental concerns in the area
- EPA has determined that no further actions under the Superfund provisions are warranted at this site in regards to SRM testing

Public Comment Contact

This report is open for public comment until September 26, 2014

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