Health Impact Assessment for Battlement Mesa, Garfield County Colorado

Prepared by:
Roxana Witter, MD, MSPH
Lisa McKenzie, PhD
Meredith Towle, BS
Kaylan Stinson, MSPH
Kenneth Scott, BA, MPH
Lee Newman, MD, MA
John Adgate, PhD, MSPH

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Contact: Roxana Witter, MD, MSPH
Colorado School of Public Health
University of Colorado Denver
13001 East 17th Place
Aurora, Colorado 80045
roxana.witter@ucdenver.edu

University of Colorado Denver, Colorado School of Public Health, Denver, Colorado

Disclaimer

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Executive Summary

This Health Impact Assessment (HIA) was conducted by members of the faculty and staff of the Department of Environmental and Occupational Health, Colorado School of Public Health (CSPH) at the request of the Garfield County Board of County Commissioners (BOCC), to help address community concerns regarding future land use decisions. The purpose of this HIA is to provide the BOCC with specific health information and recommendations relevant to Antero Resources Corporation (Antero) plans for natural gas development and production in the residential community of the Battlement Mesa Planned Urban Development (PUD), Garfield County, Colorado. To this end, CSPH worked in collaboration with Garfield County Public Health (GCPH) to conduct a qualitative and quantitative analysis of existing environmental, exposure, health, and safety data pertinent to the Battlement Mesa community. CSPH offers the BOCC specific recommendations for its consideration in Antero drilling permit decisions. In addition, the HIA provides baseline information for use in the design of a future prospective exposure and health monitoring project.

ES1 Introduction

Recent domestic energy production has brought industrial processes, and potentially exposures, into close proximity of residential urban, suburban and rural communities across the United States. Garfield County, Colorado is at the epicenter of natural gas development in the Piceance Basin and experienced rapid growth of the industry from 2003 – 2008, and a sudden downturn in 2009. Now, in 2010, permitting for the purpose of development and production is resuming and is expected to continue to increase.

Natural gas development and production is known to produce a variety of physical and chemical hazards that may cause negative health effects. In 2008, CSPH completed a white paper and literature review, outlining potential environmental hazards, vulnerable populations, and possible health outcomes in Garfield County. The 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado (referred to as the Saccomanno Study) documented baseline health status and negative health outcome trends potentially linked to natural gas development in Garfield County. Air monitoring in Garfield County has documented levels of some air toxics in ambient air that increase the risk of negative health effects for citizens. Furthermore, recent review of large scale "boom and bust" natural gas development in small and rural communities, such as those found in Garfield County, have the potential to affect community infrastructure. Taken together, this information suggests that natural gas permitting decisions within the residential community of Battlement Mesa has the potential to adversely affect health.

Battlement Mesa is community with a large number of retired citizens as well as young families. According to the 2000 United States Census estimates, the total population of the Battlement

Mesa/Parachute zip code was 5,041; the median age was 37.five years; 26.0 percent of the population were under 18 years of age, 7.2 percent under five years, and 19.8 percent were 65 years and older. In 2000, the County population was 43,791, rising 30% to 56,298 in 2009.

The Antero project is anticipated to include 200 natural gas wells on 9 pads, a centralized water storage facility with a covered/lined waste pit, and 8.4 miles of water and gas pipeline. Preliminary plans indicate that well pads and pipelines will be distributed throughout the PUD, raising the probability that health impacts could affect the entire community.

Community groups, including Battlement Mesa Service Association (BMSA, the homeowners association) and Battlement Mesa Concerned Citizens (BCC) and Grand Valley Citizens Alliance, expressed concerns about the proximity of natural gas development to homes, recreational areas and schools. At stakeholder meetings, citizens have expressed concerns regarding airborne volatile organic compounds (VOCs), diesel and other particulate matter (PM); hydraulic fracturing (also know as fracking) fluid, hydrocarbons, and VOCs in soil and water; increased risk of fires, explosions, and motor vehicle accidents; and changes in community "livability."

In November 2009, Battlement Mesa Concerned Citizens formally requested BOCC and GCPH address health concerns before Antero development activities begin. (Attachment 1) The BOCC expressed a desire for the HIA to be conducted by CSPH expeditiously, so that results could be available prior to permitting decisions. At that time, it was anticipated that Antero would be submitting their Major Land Use Impact Review (also known as MLUIR) and Comprehensive Drilling Plan in late spring 2010 and that these documents would be available as part of the basis for the HIA. At this time, however, Antero had not submitted either document. Therefore, we have used public meeting minutes, slides from power point presentations, the Surface Use Agreement with the surface owners the Battlement Mesa Company (BMC) and other information provided to us by Antero as sources for this report. Should Antero ultimately submit permit proposals that substantially differ from this information, our assessments may not necessarily reflect those differences.

The stakeholders for the Antero drilling plan include the residents and citizen groups of Battlement Mesa and nearby communities, Antero and other operators, GCPH, BOCC, the Battlement Mesa Consolidated Metropolitan District which provides drinking water and waste water services to Battlement Mesa, BMC, the Grand River Hospital District and other medical services providers, Colorado Department of Public Health and Environment (CDPHE), and Colorado Oil and Gas Conservation Commission (COGCC). There has been broad support for the HIA from all stakeholders, reflecting a common search for a means to address the concerns of potentially impacted residents in a systematic and impartial manner.

GCPH has been extremely instrumental in helping CSPH accomplish the HIA, by facilitating meetings with stakeholders and Antero; providing local contacts and context, environmental data, review and input on the scope, and analysis of the HIA; acting as the liaison between the

CSPH and the BOCC; providing web support for HIA related minutes, presentations, and this report; and providing information to local media. In addition, at the CSPH, the Mountain and Plains Educational and Research Center has provided outreach support. The Pew Health Impact Project provided funding for consultation with Habitat Health Impact Consulting, a Canadian firm with expertise in HIAs related to resource extraction.

ES2 The HIA Process

An HIA involves several defined steps: screening, scoping, assessment, recommendations and implementation, reporting and monitoring.

This HIA was screened and scoped using information from the white paper and literature review previously conducted by CSPH, concerns raised by the citizens (Table 3), the 2008 Saccomanno Report, as well as input from the BOCC, GCPH, CDPHE, COGCC and Antero obtained in meetings over the course of the last nine months. As a result, the HIA focuses on eight areas of health concern (stressors) associated with natural gas development and production: air emissions, water and soil contaminants, truck traffic, noise/light/vibration, health infrastructure, accidents and malfunctions, community wellness, and economics/employment.

Assessment of each stressor includes a review of its general impact on physical, mental and/or social health as described in relevant medical and social science literature; a compilation and analysis of existing environmental and health data describing current conditions in Battlement Mesa; the means by which Antero plans for drilling might alter the current conditions, and finally a characterization of the stressor's impact on health. Several physical health outcomes linked to potential exposures are considered, including respiratory, cardiovascular, cancer, psychiatric, and injury/motor vehicle-related impacts on vulnerable and general populations in the community. The Battlement Mesa Baseline Health Profile (Appendix C) provides supporting documentation of baseline physical and social health determinants. In addition, a Human Health Risk Assessment (Appendix D) provides a comprehensive review of available air quality and water contamination data and a systematic assessment of related health risk.

The HIA offers recommendations to the BOCC to help it address mitigate some of impacts of the Antero plan. It is important to recognize that it is not possible to mitigate all impacts. We have provided a relative rank for each stressor, to help emphasize where the most important impacts may occur.

Adoption of any recommendations of the HIA is at the discretion of the BOCC. We will assist in implementation, if requested by the BOCC, by continuing with stakeholder and professional presentations. We will continue to monitor how this HIA is used, in order to measure its value as a public health tool.

ES3 Battlement Mesa Baseline Health Profile

Several measures of health are best determined by using zip code to define a community. We use the zip codes 81635 and 81636, which are used by the residents of Battlement Mesa, Parachute and surrounding areas. Because these zip codes are shared, Parachute is included along with Battlement Mesa in the descriptions of physical health determinants and some social health determinants. Some of the social health determinant measurements were not available at a zip code level and so we provide descriptions of these at a county level. While the assessments of stressors focus on the impacts to those living within the Battlement Mesa PUD, others living nearby may experience some effects as well. The Battlement Mesa Baseline Health Profile is available in Appendix C.

ES3.1 Vulnerable Populations

Greater than 45% of the population may be considered to be more vulnerable to certain exposures, based on age. Additional factors, such as pre-existing disease, pregnancy and behaviors such as smoking history, alcohol use, nutrition, and genetic factors can also influence vulnerability to disease. Furthermore, occupational and residential exposures may also contribute to risk of disease. Although these factors can contribute considerably to vulnerability to disease, such information was not available to the HIA team and represents an important information gap that will need to be addressed in the future.

ES3.2 Physical Determinants of Health

To assess the baseline physical health of the Battlement Mesa/Parachute area, the CSPH team obtained and analyzed inpatient hospital diagnoses, cancer, birth, and death information from the CDPHE for the years 1998-2008. The analysis included health diagnoses, birth outcomes, and causes of death with a known association between disease and the exposures of concern, as well as those for which community members voiced concerns of elevated occurrence of disease. Major categories of disease and death included depression and those involving the nervous system, ear/nose/throat, vascular system and pulmonary system. Major categories of cancer included: Hodgkin lymphoma and non-Hodgkin lymphoma, multiple myeloma, leukemia, melanoma, breast cancer, prostate cancer, bladder cancer, colorectal cancer, and cancer of the adrenal gland. Birth outcomes included low birth weight and preterm delivery. Health for Battlement Mesa/Parachute residents was compared to the health of Colorado residents.

Overall, the citizens of Battlement Mesa appear to be generally healthier than other citizens of Colorado. They experienced fewer hospitalizations and fewer deaths. Battlement Mesa women experienced the same rates of cancer and of negative birth outcomes as other women in Colorado. In Battlement Mesa men, we observed a slightly higher than expected rate of prostate cancer, which we felt is an observation likely due to variability of small numbers or statistical chance (when multiple independent tests are compared, there is a statistical probability that 5 % of the tests will be abnormal by chance alone). No other differences were noted between men in Battlement Mesa when compared with other Colorado men.

ES3.3 Social Determinants of Health

To evaluate the baseline community health in Battlement Mesa/Parachute, the CSPH team obtained available information regarding sexually transmitted infections, crime, substance abuse, and education. Where information concerning Battlement Mesa was not available, we looked at Garfield County data.

Overall, the incidence of sexually transmitted infections in Garfield County rose during the years 2005- 2008, peaking between 2007 and 2008. Between the years 1992-2005, for adults, violent crime arrests doubled; property arrests fluctuated throughout the period, and increased slightly; and drug violations increased almost ten-fold. In the same time period, for juveniles, violent crime arrests increased; property arrests fluctuated but did not change significantly; and drug violations increased almost ten-fold. Substance abuse information extracted from the GCPH's 2006 assessment on community needs indicates depression, anxiety and stress along with tobacco smoking and alcohol abuse appear to be the top indicators of the burden of mental health and substance abuse, respectively, in Garfield County.

ES4 Assessment of Health Impacts

The HIA team developed a method for assessing and comparing potential health impacts for several areas of concern (stressors) by identifying and defining seven attributes relevant to the importance of potential health effects: direction of potential health effects (i.e., a positive or negative impact on health); the relationship of geography to health effects (i.e. proximity to natural gas development and production activities); the likelihood of health effects occurring as a result of Antero development plans; the presence of people considered especially vulnerable to the effects of the stressor; the estimated duration of exposure; the frequency of exposure when it does occur; and severity of the potential health effect.

To assist in characterizing the relative importance of health effects within this HIA, we assigned a numerical rank to each stressor. The lowest possible rank is 6 and the highest possible rank is 15 (six stressors are assigned values of 1 to 2 or 1 to 3). A negative (-) number indicates that the stressor is likely to produce negative health effects, a positive (+) number indicates that the stressor is likely to produce positive health effects. Some stressors may produce both negative and positive health effects and are therefore given a mixed (+/-) numerical rank. These rankings may be used to help describe the relative importance of each potential health effect within the context of this HIA only. It is important to note that these ranks do not represent a quantitative estimate of risk and have no relevance outside the context of this HIA.

These assessments take into account Antero's proposed control plans and mitigation strategies, to the extent that they are known (from public presentations, Surface Use Agreement, and other

information provided by Antero). Any significant deviation from the available information will not necessarily be reflected in this HIA.

ES4.1 Summary of Air Quality Assessment

The Air Quality Assessment relies upon the Human Health Risk Assessment (Appendix D) to determine the potential for air quality compromise. Plans for drilling throughout the community suggest that all areas within the PUD have the potential to be impacted by local emissions.

The Antero natural gas development plan is likely to change air quality and produce undesirable health impacts in residents living in close proximity throughout the community. Air quality is most likely to be acutely impacted during well pad construction and well completion stages and by truck traffic. Long term compromise of air quality is possible if fugitive emissions from production equipment are not controlled and the impacts to air quality are expected to occur constantly and/or reoccur. Children, older adults, and individuals with respiratory diseases may be more vulnerable to the air contaminants and could experience short-term and/or long-term disease. Health impacts may include respiratory disease, neurological problems, and there may be an increased risk of cancer. Medical attention would be necessary for some of these conditions. Some of these health consequences would not be reversible, and therefore should be considered moderate to high magnitude impacts. Using the numerical ranking scheme, air quality impacts on health are expected to produce a negative rank of -14.5 on a scale of ±6-15.

ES4.2 Summary of Water and Soil Quality Assessment

The primary drinking water source for Battlement Mesa is the Colorado River and the intake is upstream of areas potentially impacted by the Antero drilling plan. The primary drinking water source is therefore not likely to be impacted by Antero's Battlement Mesa natural gas development and production plans. The secondary water source is a series of ground water wells located "downhill" from some of the planned well sites. Since the hydrology of the area is not well understood, the likelihood that these wells could be compromised by drilling in the PUD is unclear, but their location suggests that they could be compromised by natural gas development and production activities.(See Appendix D for supporting documentation).

Impact on water quality in Battlement Mesa is not expected to occur frequently and it is unlikely that contamination of drinking water will occur as a result of Antero development plans. However, should water and soil contaminant exposures occur, these changes would produce undesirable health impacts. Areas in close proximity to the development areas would be most likely to show contamination of soil and shallow water. Impacts could be community-wide, should the need for compromised secondary water wells arise. Localized effects of wind erosion and surface run-off may impact children more than adults. Children, older adults, and individuals with pre-existing illnesses may be more vulnerable to water and soil contaminants. Reversal of water quality degradation could take years, and thus any impacts could be enduring. Should exposure occur, health impacts may include cancer, skin and eye irritation, neurological

problems. It is likely that medical attention would be needed for some of these resulting conditions and that some of these health consequences would not be reversible; therefore an impact would be considered moderate to high in magnitude. Using the numerical ranking scheme, compromise to water and soil quality would produce a negative rank of -11.5 on a scale of ±6-15.

ES4.3 Summary of Traffic Assessment

The traffic assessment relies on estimated average traffic counts provided to us by Antero. While such numbers are somewhat useful for the purpose of this HIA, the estimates may not reflect true numbers of vehicles on any given day. The Garfield County Geographic Information Systems Services is working on a map with the traffic routes Antero anticipates using for their natural gas development and production. This map also will contain information concerning school bus stops in Battlement Mesa, provided to the CSPH team by the Garfield County District 16 transportation office.

When considering safety risks to residents of Battlement Mesa, increased traffic is likely to create negative health impacts. Because the haul routes include the entire circle of the Battlement Mesa Parkway as well as other roads within and on the perimeter of the PUD, the impact of the traffic is likely to be community wide. Certain parts of the community will experience a greater impact for the entire duration of the Antero project (i.e., those homes next to CR300/Stone Quarry Road) while others will be impacted by very high volume traffic during the construction of some of the pads (i.e., along River Bluff Road). Because children often walk and ride bicycles and are not as safety conscious, children are considered more vulnerable than most adults to the impacts of traffic. The duration of exposure to increased traffic will likely be long, spanning the entire duration of the development the gas wells, at this time expected to be at least five years. The traffic will be frequent in some cases (River Bluff Road) where it is estimated that several hundred trucks passing a day for several months. Increased traffic is associated with increased risk of traffic accidents. Traffic accidents can cause minor to severe/fatal injuries and as such, there is wide range of potential health impacts. Using the numerical ranking scheme, impact due to traffic produces a negative rank of -13 on a scale of ±6-15.

ES4.4 Summary of Noise, Vibration, and Light Assessment

Anticipated noise, vibration and light exposures associated with the Antero development within the PUD may produce negative health effects. Of the three, noise is likely to have the most important impact on health. Increased noise is expected to be associated with construction and development phases and with truck traffic on haul routes. While all or most parts of the community may be near noise sources at different times, it is not likely that the entire community will be affected by noise during the development of an individual pad or by truck traffic. There are some residences that are close to haul routes and may experience elevated noise due to truck traffic for the entire development period (five years). Children may be more vulnerable to noise disturbance associated with truck traffic passing by the St. John Elementary School and the

Grand Valley Middle School during school hours. In addition, persons working at home may also be more vulnerable to noise disturbance. The elderly, particularly those with impaired hearing, may also be more vulnerable to noise pollution. Pad development will last several months, while nearby truck traffic may last several years for some residents, and thus, duration of exposure is expected to be medium to long, depending on location. On the other hand, major elevations in noise levels are not expected to occur during normal production phases in the 20 years subsequent to well development. Should well maintenance (workover) be conducted, noise levels are expected to increase during the reworking phase, which can last several days per well. When noise occurs, it is expected to be constant (e.g. diesel generators) and/or frequently reoccurring (e.g. truck traffic), depending upon the source. It is unlikely that noise exposure will cause noise-induced hearing loss or other noise-related health effects. In general, health impacts are likely to result from annoyance due to noise above background and may cause sleep disturbance, displeasure, fatigue, etc. It is not likely that medical attention will be necessary for most people, although some may seek medical assistance. Therefore the impacts are rated as low- medium magnitude. It is possible that in some individuals, noise levels will produce significant annoyance and may produce larger health effects. Using the numerical ranking scheme, impacts to safety due to noise, vibration, and light increases produces a negative rank of -10.5 on a scale of +/-6-15.

ES4.5 Summary of Community Wellness Assessment

Community wellness is difficult to define and more difficult to measure. We describe crime rates, mental health, substance abuse and suicide, occurrence of sexually transmitted infection and enrollment in K-12 education as measures of community wellness. Other factors, such as recreational opportunities and social cohesion do not lend themselves to measurement, but were considered in the assessment. Antero estimates an average of 120-150 persons to be working in Battlement Mesa. This estimate was used to evaluate the impacts on these aspects of community wellness.

Effects on community wellness are expected to be mixed. Positive effects might include less stress over finances, if increased demand for local business benefits the local economy, and increased access to social resources, services and infrastructure that expand to support a growing and changing population. For example, increased school enrollment can lead to more educational opportunity (Jacquet, 2009). Negative effects may include increased substance abuse, crime, sexually transmitted infection, demands on the education system beyond current capacity, interference with recreational activity and decreased social cohesion. Community impacts would be expected to be community wide, affecting the entire geographic extent of the Battlement Mesa PUD. It is possible that the elderly or youth of the community are more vulnerable to impacts on community well-being. Elderly may be more vulnerable to crimes of theft or burglary, and are the likely group most affected by changes in social service availability and accessibility. Children would be most affected by changes in school enrollment and class size. They may also be affected by changes in outdoor areas used for play, which may overlap with areas prone to more industrial activity or along haul routes. We expect the community impacts

to continue for the duration of the development phase of Antero's project (five years). However, because the Antero project is relatively small, it is expected that exposure to factors that impact community wellness will actually be infrequent and unlikely. If impacts do occur, they are anticipated to have low to medium impacts on citizens in the community. The overall magnitude of negative health effects are expected to be low to medium and may be related to distress over changes to the community, to increased availability of illegal substances, and more widespread sexually transmitted infection. The overall magnitude of positive health effects are expected to be low and related to decreased financial stress for some residents and possible increased resources for schools. Given adequate coverage and support offered by social infrastructure, we expect the residents of Battlement Mesa will be able to successfully adjust to the impact on community well-being. Using the numerical ranking scheme, impacts to community wellness produce a mixed rank of ± 11.5 on a scale of ±6-15.

ES4.6 Summary of Economic and Employment Assessment

The economic and employment assessment is based upon Antero's estimate of an average of 120-150 workers, (both direct Antero employees and subcontracted workers) for a 2 rig operation over the five year development period. It is important to note that these numbers represent an estimate of the average number of workers and may not reflect employment on any given day.

The economic and employment changes related to Antero gas development in Battlement Mesa may produce mixed health effects. Positive effects would be related to higher wages for some residents, while negative effects would be related to higher inflation and no wage increase for others. Economic impacts would be experienced community wide and those on fixed incomes would be more vulnerable to the negative effects of inflation. The impacts of increased economic activity are likely to last the duration of the five year development period. The frequency health impact (stress, sleep disturbance) as a result of the economic activity is likely to be infrequent to constant, depending upon the individual circumstances. It is, however, unlikely that there will be large positive or negative economic impacts from the Antero development, given the relatively small economic scale of project and the probability that such impacts will be absorbed into Garfield County as a whole. Health impacts due to changing economic conditions are expected to be of low magnitude. Using the numerical ranking scheme, impacts on the economy and employment produce a mixed rank of ± 10.5 on a scale of ± 6-15.

ES4.7 Summary of Health Infrastructure Assessment

The assessment of changes to health infrastructure impacts on health is also based upon Antero's estimate of an average of 120-150 workers, on a two rig operation over the five year development period.

Changes to local health infrastructure associated with an increase in workforce and population in Battlement Mesa and the associated potential increase in health care utilization could have mixed

health impacts on Battlement Mesa community. Positive impacts could occur if the workers are insured and therefore support the existing healthcare system when it is used. On the other hand, if workers are uninsured, their use of medical services could strain the health system. However, like the economic impacts, health care system impacts are anticipated to be small given that Antero estimates an average workforce of 120-150 workers. Health care utilization is likely to be spread into Garfield County, depending upon where the workers live. Impacts of uninsured workers are likely to be noted by providers, but it is unclear that this would reach a level that would negatively impact either clinical or public health services. The potential for increased utilization of the health care services to strain existing services is small unless a large number of workers are uninsured and they all utilize the same services. It is not expected that the extent of such a strain would lead to decreased availability and quality of clinical services. Likewise, insured workers will support local health services but the extent of such support may not be sufficient to lead to increased availability and quality of services. Local tax revenues from the Antero project will contribute to the overall county fund, but are not likely to be large enough to directly impact public health services in Battlement Mesa. Should health services be impacted in Battlement Mesa, the impacts would affect the entire community, and those that utilize health care services most frequently such as the elderly, young children and disabled may be more vulnerable to negative impacts such as decreased availability. Likewise, those groups would benefit from expanded health care services. Should health service impacts occur, they are likely to be noted in the first few years of Antero's project as the health infrastructure adjusts to new needs. Impacts to the health care infrastructure are not anticipated to last the entire duration of the project. The frequency of both positive and negative on impacts the health care system and therefore on the community are likely to be sporadic, given that the relatively small number of workers and families associated with the project. It is possible that large financial strain to local providers, particularly emergency care providers, could occur should expensive emergent care become necessary for an uninsured worker, but this is anticipated to be an infrequent event. Potential impact to vulnerable groups, the community at large and the multiple years of potential exposure create a relatively high ranking, however, it is unlikely that Battlement Mesa citizens will experience positive or negative health impacts as a result of changes to the health care infrastructure related to the project. Any impacts to health as a result of changes to the health care infrastructure are expected to be low. Using the numerical ranking scheme, impacts on the economy and employment produce a mixed rank of ± 10 on a scale of ±6-15.

ES4.8 Summary of Accidents and Malfunctions Assessment

The assessment of accidents and malfunctions relies on a review of past accidents and malfunctions in Garfield County, Colorado from the COGCC incident database and individual cases in other areas. The very nature of accidents and malfunctions makes it difficult to predict whether or how an incident may impact health. Review of several years of COGCC data however, indicates that reportable incidents occur in approximately 6% of wells permitted, state wide, in Garfield County and for Antero's previous operations, as well. Therefore, it is possible to predict that with 200 wells being drilled in Battlement Mesa, there may be approximately 12 incidents that could be considered an accident or malfunction.

When considering the possible health impacts due to an accident or malfunction, the impacts are likely to be negative. Depending upon the size and nature of the incident, health and safety impacts may be felt by those only in close proximity, or throughout the PUD. Again, depending upon the nature of the incident, certain populations may be more vulnerable to health impacts. For instance, elderly or frail and those living in the assisted living facility, may have difficulty evacuating an area quickly. Children in school may also be slower to evacuate. Those with underlying medical conditions such as pulmonary or cardiovascular disease may have negative health effects related to fires or air emissions at levels that are may not have significant impact to others. Accidents and malfunctions are likely to be short in duration and infrequent. Given the 6% rate of incidents in the industry and within Antero's other operations in Garfield County, incidents are likely to occur and it is possible that health impacts will occur. The health impacts will be low to high in magnitude, potentially ranging from minor irritation to more severe exacerbation of underlying health conditions to severe injury or death. Using the numerical ranking scheme, impacts to health due to accidents and malfunctions produce a negative rank of -10 on a scale of ±6-15.

ES5 Recommendations

At the end of each assessment we have provided several recommendations aimed at decreasing negative public health impacts, improving positive ones, and filling information gags. The summary recommendations that could be acted upon in the near future are listed below, and more long term summary recommendations are listed in the following section.

- **Promote Pollution Prevention:** Require Antero to use best available technology and rapidly adapt new technology, to reduce emissions of air, water and soil pollutants as well as noise reduction and control. Establish a system for short-term odor monitoring and reduction during gas well completion.

- **Protect Public Safety:** Review pipeline system for routes that avoid proximity to homes, schools or other areas used by residents. Require best available technology to avoid accidents and malfunctions and regular inspection of facilities and pipelines. Review emergency response plans and periodically test emergency response system.

- **Address Boomtown Effects**: Develop plans to address temporary and permanent population influx that may affect demand and capacity of social services, schools and other key community facilities and programs. Identify gaps in access to public health or social services and implement monitoring of community health needs.

ES6 Next Steps and Conclusions

This HIA used the compiled baseline health characteristics of Battlement Mesa, current ambient environmental conditions in Garfield County and Antero's proposed gas development and production plans to evaluate probable and possible health impacts of Antero's project to the residents of Battlement Mesa. Through this process we have attempted to address the concerns of the citizens outlined in the BCC petition.

At the end of each assessment we have provided recommendations aimed at decreasing potential negative health impacts, based upon existing information. However, we also identified numerous gaps in information that limited this evaluation and may limit future evaluations of health in Battlement Mesa. Recommendations intended to address some of these gaps are provided in the HIA. Some of these issues will be addressed in an environmental health monitoring study (EHMS) currently being developed by CSPH investigators. These "next steps" recommendations can be summarized as follows:

- **Establish Baselines:** Improve monitoring of environmental exposures and health effects. Past environmental monitoring (i.e., air, traffic) and public health tracking (e.g., substance abuse, mental health) are insufficient to establish current health impacts among Battlement Mesa/Garfield County residents during gas development and production.

- **Enhance Environmental Monitoring**: Establish monitoring and data systems to conduct ongoing measurement of environmental exposures. Such exposures include 1) pollution of air, water and soil impacts; 2) physical hazards such as traffic, noise, vibration and light, and 3) psychosocial and community changes. Where feasible, tie environmental monitoring to risk-based environmental standards.

- **Improve Health Effects Tracking Systems:** Develop a robust health tracking system for Battlement Mesa/Garfield County so that providers report health conditions potentially related to natural gas development and production to the county health department.

- **Ensure Transparency:** Make exposure and health monitoring data from all public and industry interventions and monitoring available to the Battlement Mesa/Garfield County residents public in a timely manner.

- **Enhance Current Regulations:** Utilize findings of the HIA and future studies to complement ongoing state and local efforts to protect public health.

Because natural gas development and production will continue to grow in Garfield County, other parts of the region and state, as well as other parts of the country, the results of this HIA and the

future EHMS will likely have application beyond the study area and will contribute to filling many knowledge gaps about natural gas development and production and health.

In addition, because the domestic natural gas resource is part of the national policy to increase domestic energy production and reduce greenhouse gas emissions, a high level discussion of the health implications of this policy needs to take place. While municipal, county and state governments have begun to respond to citizen concerns, a national discussion of the benefits and risks associated with this policy is due. As outlined in this HIA, in addition to potential local economic benefits of energy development, there are potential local negative impacts to the physical and social health of the community. It will be important to understand public health implications in the context of national priorities for domestic energy production.

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Annotated Acronym Definitions

Antero: Antero Resources Corporation

BCC: Battlement Concerned Citizens: Grassroots citizen group formed in response to the Antero gas project.

bgs: below ground surface

BMC: Battlement Mesa Company: Owner of mineral and surface rights in Battlement Mesa.

BMSA: Battlement Mesa Service Association: Home owners association for Battlement Mesa residential communities.

BOCC: Garfield County Board of County Commissioners: Requested county environmental health to develop proposals to respond to citizens health concerns. Have indicated that HIA and health study proposals will satisfy this request.

BTEX: Benzene, Toluene, Ethyl-benzene, Xylene

CDPHE: Colorado Department of Public Health and Environment: Has consultative responsibility to the state permitting agency for comment health and environmental concerns, but has no regulatory responsibilities.

COGCC: Colorado Oil and Gas Conservation Commission: Colorado regulatory and permitting agency. Maintains databases for water quality, spills, and well locations Databases include federal and tribal lease owners as well as state lease owners. Provides permitting for state lease owners only.

CR: County Road

CSPH: Colorado School of Public Health: Faculty within the school, in the Division of Occupational and Environmental Health are primary investigators.

dB: decibel

EHMS: Environmental and Health Monitoring Study

EnCana: EnCana Oil and Gas (USA) Incorporated

EPA: United States Environmental Protection Agency

GCPH: Garfield County Public Health Department: county health agency with environmental health program. Environmental health program directed to respond to citizen concerns and has strong ties to all stakeholder groups. Environmental health program considered a regional leader in health and gas E&P.

HIA: Health Impact Assessment

µg/L: micrograms per liter

µg/m^3: micrograms per cubic meter

PM: Particulate Matter

$PM_{2.5}$: Particulate Matter of 2.5 microns or less

PM_{10}: Particulate Matter of 10 microns or less

PAH: polycyclic aromatic hydrocarbon

ppb: parts per billion

PUD: Planned Urban Development

RV: Recreational Vehicle

Saccomanno Study 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado

SGM: Schmueser/Gorden/Meyer Inc.

SIR: Standardized Incidence Ratio

tpy: tons per year

VdB: vibration decibels

VOC: Volatile Organic Compound

vt/d: vehicle trips per day

USGS: United States Geological Survey

Part One: Health Impact Assessment

Preface

HIA is used to evaluate objectively the potential health effects of a project or policy before it is built or implemented. HIA can provide recommendations to increase positive health outcomes and minimize adverse health outcomes. The HIA framework is used to bring potential public health impacts and considerations to the decision-making process for plans, projects, and policies that fall outside of traditional public health arenas, such as transportation and land use. - Centers for Disease Control [1]

The health of an individual human being is determined by a complex interaction of social, economic, genetic, and environmental factors which he or she experiences throughout life. Income, access to clean drinking water, unpolluted air, social support from friends and family, healthy food, access to education, and a whole host of other factors combine to have a profound effect on the health of an individual.

Similarly, when social, economic, and environmental conditions are common to a group of people, those conditions can influence the health of the population as a whole. Public policies have the potential to impact population health. While there are public programs and policies designed to influence population health (e.g. food safety regulations), population health is not accounted for in all or even most of the policies that can impact health. To improve the accessibility and utility of existing scientific knowledge as it applies to program and policy development, public health researchers have developed the Health Impact Assessment (HIA) approach. While HIAs vary in their goals and methods, the general approach is consistent across HIAs: A group of public health experts works with community stakeholders to identify the potential health risks and potential benefits to public health of a proposed policy, program, or project. The HIA team then collects information to assess how likely public health will be impacted. Based on the potential impacts and the estimated likelihood of those impacts, the HIA team offers recommendations to maximize public health gains and minimize negative effects of the program, project or policy at hand.

While the goal of an HIA is to anticipate and provide recommendations that advance public health, it cannot be expected to prevent all negative health impacts of a given decision. A HIA is an approach to incorporating public health into decision-making processes. As opposed to costly retrofitting and remediation, HIAs are proactive and preventive public health tools that have the potential to save health care costs in the long-term. HIAs are open processes that necessarily include stakeholder participation, review, and input as an essential part of the methods. Through this open dialogue, the HIA seeks to generate realistic and broadly supported recommendations to protect public health.

A HIA differs from a scientific epidemiological study in that an epidemiological study typically evaluates the effects of exposures on populations after the exposures have occurred, whereas, a

HIA is conducted before a project or policy is started, with the ultimate goal of identifying potential exposures and determining if there are needs to mitigate their impact on health. Both kinds of investigations provide valuable information to those concerned with understanding and protecting public health.

Regarding Ozone and Human Health

The impact of ground level ozone and ozone precursors are not included in this HIA. The Antero project itself will contribute ozone precursors (volatile organic compounds (VOCs) and nitrogen oxides), however, it is the sum of the ozone precursors produced in the county that contributes to ozone levels county wide. Ozone can cause important negative health effects and should be the considered when discussing public health in Garfield County. However, the impact of Antero's contribution to ozone on the health of Battlement Mesa citizens is not discussed in this assessment.

Regarding Climate Change and Human Health

This Health Impact Assessment does not account for the potential health effects of climate change. There is reason to believe that fossil fuel combustion has changed the global climate[2]. There is also reason to believe that climate change will impact human health[2]. However, it is in the opinion of the HIA authors that while this specific natural gas development contributes to climate change, is not likely to influence the global climate enough to have a measurable impact on the health of Battlement Mesa residents.

1 Introduction

This report summarizes the Battlement Mesa HIA commissioned by the Garfield County Board of County Commissioners (BOCC) with the Colorado School of Public Health (CSPH). The introductory section provides context for the HIA, a site description, and Antero Resources Corporation's (Antero) plans for Battlement Mesa.

1.1 The Battlement Mesa Community

The Battlement Mesa Planned Urban Development (PUD) is a 3,200-acre unincorporated jurisdiction divided into several neighborhoods, the names of which are:

- The Reserve
- Battlement Creek Village
- Willow Creek Village
- Willow Ridge Apartments
- Willow Park Apartments
- Eagles Point
- Valley View Village
- Fairway Villas
- Stone Ridge Village
- Monument Creek Village
- Canyon View Village
- Mesa Ridge
- Mesa Vista
- Tamarisk Village
- Tamarisk Meadows
- Saddleback Village

The community sits on a 500 foot mesa approximately to the south of Colorado River and mesas continue to rise above the community for another 500-1000 feet. There has been natural gas development and production going on for the last several years outside the PUD.

A 2005 academic study describes Battlement Mesa's transformation from a company town to a retirement community. Depending on the neighborhood, homes range from $85,000 to $450,000 in price and from 1,500 square feet to 4,400 square feet in size. While the community is often thought of as a "retirement community" (4), in fact there are also many families with children that live in Battlement Mesa. [3]

1.1.1 Parachute

Because the town of Parachute shares a zip code with Battlement Mesa, the HIA includes Parachute in several sections, including the health outcomes baseline analysis. Parachute is a small town adjacent to Battlement Mesa. Parachute sits at the base of the Parachute Creek valley, between the Battlement Mesa PUD to the south and a large natural gas field to the north, at an elevation of 5,000 feet. Both Interstate-70 and the Colorado River run through the town. Parachute has a population of approximately 1,300 people and there are small family ranches outside the town limits. There is significant industrial activity in Parachute Creek valley and on the surrounding mesas, including natural gas development and production, a gas processing plant and a bicarbonate of soda plant.

1.1.2 Demography[4]

According to the 2000 United States Census estimates, there total population of the Battlement Mesa/Parachute zip code was 5,041; 49.3 percent of the Battlement Mesa/Parachute population was female and 50.7 percent male. The median age was 37.5 years. 26.0 percent of the population were under 18 years of age, 7.2 percent under five years, and 19.8 percent were 65 years and older. For people reporting race in Battlement Mesa/Parachute, 93.4 percent identified as White, 0.5 percent as Black or African American; 9.7 percent of the population identified as Hispanic or Latino (of any race). In Colorado in 2000, 9.7 percent of the population was 65 years and over compared to 19.8 percent of the population in the Battlement Mesa/Parachute zip code.

Demographics
Population Battlement Mesa/Parachute, 2000 Total population: 5, 041 Males: 2,487 (49.3) Females: 2,554 (50.70) Mean age 37.5 Garfield County 2000 Total population: 43,791 2009 Total population estimate: 56,298 % change 2000-2009: 28.6%

Demographics
Vulnerable populations Battlement Mesa/Parachute Under 18: 1,311 (26.0) Over 65: 998 (19.8) Total <18, >65: 2309 (45.8)

Although the Battlement Mesa PUD is often described as a "retirement community", it is difficult to precisely define a "retirement community". Several objective measures reflect the characteristics of Battlement Mesa's population. In 2000, the percentage of Battlement Mesa residents, excluding Parachute, aged 65 years and older was approximately twice the national average (24.5 % vs. 12.4%, respectively). Furthermore, whereas 63.9% of the United States population (aged 16 years and older) was participating in the labor force, only 48.9% of Battlement Mesa residents were either working or looking for work in 2000.

While the lower labor force participation rate of Battlement Mesa residents and the higher proportion of people aged 65 years and over are likely indicators of a high retiree population in the PUD, almost half of the PUD residents aged 16 years and over were either working or looking for work. More than a quarter of the family households in Battlement Mesa had children under the age of 18 years (27.2%). So, while the Battlement Mesa PUD is home to higher proportions of people aged 65 years and over than the United States as a whole, the community is not homogeneously "retired."

1.1.3 Economy

Currently, the Battlement Mesa community is entirely residential. The only businesses in the PUD support the local residents. While several natural gas operators drill extensively the area surrounding the PUD, there are currently only two natural gas wells in the PUD itself. The businesses within the PUD include:

- A grocery store
- Two gas stations
- Several medical facilities
- A public golf course
- Banks
- A café
- A recreation center (paid for by homeowner association dues)
- A local newspaper

In addition to the local businesses, the PUD is home to two churches (with five others in Parachute), a 40-unit assisted living facility in the Battlement Mesa PUD serving seniors of low to moderate income,[3] and three schools – Underwood Elementary School (grades 1-3), St. John Elementary School (grades 4-5) and Grand Valley Middle School (grades 6-8). Battlement Mesa students attend the Early Childhood Center for pre-kindergarten and kindergarten and Grand Valley High School in Parachute for grades 9-12. These schools are all in Garfield County District 16.

1.2 Antero's Plan to Drill Within the Battlement Mesa PUD

The combination of technological advances (e.g. hydraulic fracturing), Federal and State economic incentives to develop natural gas resources and population growth in previously uninhabited (or sparsely inhabited) areas have contributed to a relatively new phenomenon. Whereas oil and gas development has historically taken place in locations that are geographically distant from human habitation (other than, perhaps, the housing for oil and gas workers themselves), it is increasingly common for drilling activities to occur in rural, suburban and urban areas close to where people otherwise unaffiliated with the industry live, work and play[5]. Throughout the country and in Garfield County, the residents in close proximity to drilling activities are raising concerns about the potential impacts drilling may have on air quality, water quality, public safety and public health[6]. The human health impact natural gas development and production has not been thoroughly studied.

In the Spring of 2009, Antero announced plans to purchase surface rights and mineral rights from the Battlement Mesa Community (BMC), as well as its intent to develop natural gas within the Battlement Mesa PUD[7]. The contract that establishes the PUD requires the Garfield County BOCC to review and any proposed land-use changes within the Battlement Mesa PUD through a *Major Land Use Impact Review* (also know as the MLUIR) process. The Garfield County BOCC has the authority to require modifications to the plans outlined in a given Major Land Use Impact Review application. Because its plans pertain to the Battlement Mesa PUD, Antero will submit a Major Land Use Impact Review to the BOCC before initiating their drilling activities. In addition to county review, Antero will also submit plans through a state permitting process, conducted by the Colorado Oil and Gas Conservation Commission (COGCC). Under a 2008 rule[8], natural gas operators may submit Comprehensive Drilling Plans to COGCC[9]. If Antero submits a Comprehensive Drilling Plan to COGCC, COGCC will review the development project as a whole, which streamlines permitting for individual wells within Antero's project. The Comprehensive Drilling Plan has not been submitted as of the date of this HIA report. Antero has, however, entered into a legally-binding Surface Use Agreement with the BMC. This Surface Use Agreement outlines characteristics of its natural gas drilling plans for the Battlement Mesa PUD. While not as detailed as a Major Land Use Impact Review or Comprehensive Drilling Plan, the Surface Use Agreement between Antero and the BMC provides some information regarding Antero's plans for the Battlement Mesa project. Furthermore, Antero held several community meetings during 2009 and 2010 where plans for Antero's project were

described and the power point presentations from these meetings are available online[10-11]. These sources of information plus information provided to the CSPH team are used to as a basis for this HIA. Appendix A includes a summary of the natural gas drilling process. Appendix B includes a review of energy development in the Piceance basin and the Surface Use Agreement between Antero and BMC.

1.3 Community Concerns

After Antero announced its intentions to drill within the Battlement Mesa PUD, community members living in Battlement Mesa expressed concern regarding potential environmental, health, and safety impacts. Citizen concerns have included but are not limited to:

- The proximity of drilling and gas production to homes, recreational areas and schools
- "Vulnerable" populations with diminished immune capacity
- Exposure to airborne volatile organic compounds (VOCs), diesel emissions, particulate matter (PM) and other air contaminants
- Exposure to fluids used in the fracking process, hydrocarbons and VOCs through soil or water exposure routes
- Potential increased risk of fires, explosions and/or motor vehicle crashes
- Changes in community "livability"

A grassroots advocacy organization, the Battlement Mesa Concerned Citizens (BCC) formed under a parent organization, the Grand Valley Citizens Alliance. In November 2009, the BCC submitted a citizen petition to the Garfield County BOCC requesting that BOCC require Antero to address health concerns before drilling for natural gas within the Battlement Mesa PUD (Attachment 1).

While the human health impacts of natural gas development and production have not been specifically studied using state-of-the-art public health epidemiologic research methods, there has been substantial research related to exposures of potential concern in the natural gas industry. For instance, drilling for natural gas has the potential to increase occupational and community exposures to VOCs such as benzene, toluene, ethyl-benzene and xylene (BTEX). Heavy metals released in drilling activities, particulate matter (PM) generated by transportation activities and diesel fuel combustion, and ozone precursors (ozone formation) are also known to be associated with natural gas development. Some constituents of fracking chemicals may pose health risks to workers or community members.

Sufficient exposures to these chemical compounds are associated with serious negative health outcomes such as lung disease in children and adults (i.e., asthma, chronic bronchitis, obstructive disease), cardiovascular disease, poor birth outcomes (premature birth, low birth weight), various cancers, and other long and short-term health issues [12-16]. Environmental contaminants to which

people may be exposed include air emissions, ground and surface water pollution and soil contamination. In addition, physical hazards can include increased truck traffic and domestic explosions associated with gas seepage into domestic water supplies. Social hazards can include a variety of community disruptions associated with boom-and-bust cycles, itinerant workforces and industrialization of residential areas[17].

1.4 Initial Responses to Community Concerns

In response to community concerns, Antero has held several informational community meetings[11] and has responded to community concerns by modifying its some the drilling plans, for example the removal of drilling pad C (replaced by the Parks and Rec pad). The Surface Use Agreement between Antero and BMC includes some measures which are intended to reduce the impact on the community's health and quality of life.

Even before it commissioned the HIA, Garfield County had undertaken many steps in response to community concerns regarding natural gas development and production in the county. Garfield County Public Health Department (GCPH), the county health department, initiated and managed the Saccommano Report and currently manages on-going ambient air monitoring stations at several locations in Garfield County. The Garfield County Oil and Gas Department initiated and managed an intensive study water quality and hydrology of the Mamm Creek Gas Field. GCPH also has participated in numerous Colorado Department of Public Health and Environment (CDPHE), COGCC, and United States Environmental Protection Agency (EPA) air and water studies documenting:

- Air toxics (e.g. benzene) in ambient air, at levels higher than levels measured in a neighboring county with no gas development [18]
- Evidence of ground-level ozone formation, which once exceeded the EPA 8 hour standard of 75 parts per billion (ppb) in 2008 [19]
- Ground water containing thermogenic methane in natural gas development and production areas [20-22]
- Trends in health impacts consistent with potential exposures (via a county-wide health assessment) [23]
- Citizen concerns over oil and gas impacts to health (via county-wide surveys)[24]

More recently, the BOCC instructed GCPH to address the BCC's concerns raised in its citizen petition. GCPH approached the CSPH with a request to collaborate on a HIA. Subsequently, the BOCC agreed to contract with the CSPH to conduct this HIA. Through funding from the Pew Health Impact Project, a Canadian HIA consultation firm with experience in resource development projects, Habitat Health Impact Consulting has provided technical assistance to the CSPH for this HIA.

2 HIA Methods

Methods for the HIA were based upon guidelines provided by the Pew Health Impact Project[25], as well as those found in the Merseyside Guidelines for HIA[26]. There are seven steps for this HIA, including scoping, screening, assessment, recommendations, implementation, reporting, and evaluation.

2.1 Screening

This HIA is was performed in response to a citizen petition to the Garfield County BOCC requesting a health an environment study be conducted to evaluate potential health impacts of Antero's natural gas project in Battlement Mesa. Garfield County has several years of experience with natural gas development and production and with community concerns over air and water degradation and the potential health impact. The county has responded by initiating ongoing ambient air monitoring and had previously commissioned the 2008 Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, Colorado (referred to as the Saccomanno Study) [23]. Based upon the results of the air monitoring and the recommendations of the Saccomanno Study, GCPH determined that an HIA could be used to provide decision makers (the BOCC) with valuable information that could allow them to respond to citizen concerns and help them in making informed decisions.

2.2 Scoping

The Scope of the HIA was defined in part by the requests outlined in the BCC petition (Attachment 1). The CSPH team determined that assembly and analysis of baseline health, environmental, and social data were possible within the framework of a HIA. In order to further elucidate specific stakeholder concerns, the CSPH team conducted a series of stakeholder meetings with citizens, the industry state regulatory agency, the state health department, and Antero representatives (Tables 1 and 2). As a result of this stakeholder process, a Scope of Work was written that was informed by citizen concerns in order to provide a framework for the HIA. This work ultimately led to a focus on eight areas of health concern (stressors) specific to natural gas development and production: air emissions, water and soil contaminants, truck traffic, noise/light/vibration, health infrastructure, accidents and malfunctions, community wellness, and economics/employment.

2.3 Assessment

The assessment of the stressors began with a demographic characterization of the population of Battlement Mesa and a baseline health characterization of the community by compiling information from a variety of sources. A Battlement Mesa Baseline Health Profile is included in

Appendix C. This information was used to describe the general population, as well as identify potentially high risk sub-populations. A health literature review, previously conducted by members of the CSPH team, was used to identify potential health risks and vulnerable subpopulations associated with natural gas development and production [27-28]. A human health risk assessment was conducted using longitudinal air and water quality data (Appendix D). All this information was used to develop assessments of air quality, water and soil quality, traffic, noise, community wellness, economics/employment, health infrastructure, and accidents/malfunctions.

Each assessment of the stressors includes a review of its general impact on physical, mental and/or social health as described in relevant medical and social science literature; a compilation and analysis of existing environmental and health data describing current conditions in Battlement Mesa; the means by which Antero's plans for drilling could alter the stressor; and finally a characterization of the stressor's impact on health. Several physical health outcomes linked to potential exposures are considered, including respiratory, cardiovascular, cancer, psychiatric, and injury/motor vehicle-related impacts on vulnerable and general populations in the community. The Battlement Mesa Baseline Health Profile (Appendix C) provides supporting documentation of baseline physical and social health determinants. In addition, the Human Health Risk Assessment (Appendix D) provides a comprehensive review of available air quality and water and soil contamination data and a systematic assessment of related health risk.

Of note, as of the date of this report, Antero had not submitted a Major Land Use Impact Review to Garfield County nor had they submitted a Comprehensive Drilling Plan to the COGCC. As such, based on consultation with GCPH, this HIA has been conducted based upon information provided by Antero to the public in community meetings and provided to the CSPH, by request, from Antero. If the ultimate Major Land Use Impact Review/Comprehensive Drilling Plan presented by Antero differs from the information available to the CSPH team, then it is possible that there will be other risks/benefits not identified in this report.

2.4 Recommendations

At the end of each assessment we have summarized what is known and not known about the impact of the Antero plans on the stressor. We then have provided several recommendations aimed at decreasing negative impacts or improving positive ones. In general, recommendations focus on continued monitoring of air and water sheds and strict enforcement of existing regulations; use of best available current technology and rapid adoption of new technologies to decrease emissions; traffic and noise mitigation; economic benefits used locally to mitigate negative local effects; and planning for the impacts of increased population, as well as for the loss of economic activity when development ends in five years should help decrease social impacts.

2.5 Reporting

This document represents the Draft HIA and Recommendations. This Draft HIA will be delivered to the Garfield County BOCC, and will be presented at a BOCC meeting. The GCPH will post this report on their Battlement Mesa HIA website for public review. There will be a 30-day public comment period, after which stakeholder review and input will be considered in the preparation of the final HIA. There will be a presentation to the community after the report is finalized. External review was provided by Habitat Health Impact Consulting and Dr. Teresa Coons, co-author of the Saccomanno Study. CDPHE provided review of the sections describing Physical Health Determinants and the Human Health Risk Assessment.

2.6 Implementation

Implementation of any recommendations in this report is the responsibility of the BOCC. The CSPH team will assist the BOCC with dissemination and education of the community regarding the findings of the report as needed by conducting community meetings.

2.7 Evaluation

In order to determine the value of this HIA and HIA process to the Garfield County BOCC and stakeholder groups, the CSPH will monitor Antero's project permitting process at both the county and state level. Our evaluation of HIA effectiveness will be, in part, determined by whether potential health impacts and mitigation strategies were considered when the permitting process occurs. In addition, CSPH will seek specific comments from GCPH and Garfield County BOCC on their assessment of the HIA and HIA process. Furthermore, the CSPH will present the HIA and descriptions of the HIA process at several scientific, professional, and community meetings in 2010-2011. Finally, an evaluation report will be delivered to the BOCC by December 31, 2010.

3 Summary of Battlement Mesa Baseline Health Profile

The health of a community can be estimated by measuring a variety of outcomes, including physical health outcomes, social outcomes, rates of injuries, educational climate, and others. There are many factors that can influence health status, such as age, genetic background, personal habits, employment, and environmental exposures or other hazards. The BCC requested that baseline health of the Battlement Mesa community be assessed prior to drilling within the PUD.

In order to determine the baseline health of citizens and the Battlement Mesa/Parachute community, both physical and social health were considered. Where available, information specific to the Battlement Mesa/ Parachute was obtained. Because of the shared zip codes (81635 and 81636), it was not possible to distinguish between the two areas. In some instances, zip code level information was not available in which case county level data are presented. The physical health of Battlement Mesa citizens, based on zip codes, is described by standardized incidence ratios (also known as an SIR). The standardized incidence ratio is a fraction: the proportion of people with a particular health condition divided by the expected proportion of people who have that same health condition. The state of Colorado was used as the reference (expected) population for these comparisons. The health of the community is described by available zip code level statistics for sexually transmitted infection; county level statistics for crime, substance abuse and motor vehicle crashes; and School District 16 educational information. The full and more detailed Battlement Mesa Baseline Health Profile is available in Appendix C.

3.1 Vulnerable populations

It is important to note that within a population there are individuals and groups of individuals which are at increased risk or which are more vulnerable to disease and to injury. Increased vulnerability is dependent upon a number of factors that can be categorized as demographic factors, genetic factors, and acquired factors. Age is an important factor in determining health risk. According to the 2000 United States Census data for the 81635 zip code, greater than 45% of the population may be considered to be more vulnerable to certain exposures, based on age (26 % under the age of 18 and 19.8 % over the age of 65). Acquired factors such as pre-existing disease, pregnancy, and behaviors such as smoking history, alcohol use, and nutrition, as well as genetic factors, can also influence vulnerability to illness and injury. Furthermore, occupational and residential exposures may also contribute to risk of illness and injury. Although these factors can contribute significantly to vulnerability, such information is not available to the HIA team. Future characterization of the prevalence of the factors that influence health would greatly enhance our understanding of this community, especially if that information can be collected prospectively.

3.2 Physical determinants of health

To assess the baseline physical health of the Battlement Mesa/Parachute area, the CSPH team obtained and analyzed inpatient hospital diagnoses, cancer, and death information from the CDPHE for the years 1998-2008. Inpatient hospital diagnosis data were derived from the Colorado Hospital Association Discharge Dataset. Birth data were calculated by the CSPH team using Colorado Birth Registry Data for the years 1998 - 2008. Aggregated counts and the standardized incidence ratio of select diagnoses, birth outcomes, and cancer types are presented in Appendix C. The CSPH team chose to analyze health diagnoses, birth outcomes, and causes of death that are understood to be associated with exposures related to natural gas processes, as well as those for which community members voiced concerns of elevated occurrence of disease. Major categories of disease and death include depression and those involving the nervous system, ear/nose/throat, vascular system and pulmonary system. Major categories of cancer include cancers with known association with exposures of concern, cancers for which there has been community concern, and the five most common cancers in Colorado. These cancers included: Hodgkin and non-Hodgkin lymphoma, multiple myeloma, leukemia (all types), melanoma, breast cancer, prostate cancer, bladder cancer, colorectal cancer, and cancer of the adrenal gland. It is important to keep in mind that just because an exposure to a contaminant is associated with a cancer, it does not mean an individual exposed to the contaminant will get that cancer. The amount of exposure and length of exposure to a contaminant also are important factors in determining the risk of cancer and other diseases. Birth outcomes analyzed included low birth weight and preterm delivery.

Within the hospital data analysis, we looked at several discharge diagnoses and determined that people living in the Battlement Mesa/Parachute zip codes had fewer or equal rates of these

diagnoses as their counterparts in Colorado. Battlement Mesa/parachute men and women had fewer than expected diagnoses involving the nervous system, ear/nose/throat and the vascular system and the pulmonary system. Within the cancer data, men in Battlement Mesa/Parachute had a slightly higher than expected prostate cancer rate. This finding is felt to be likely due to slight variation in a small number of cancers. Another possibility is that this slight elevation could simply be due to the fact that when comparing multiple independent health outcomes, there is the likelihood that 5 % of the tests will be abnormal by chance alone. Women had no higher than expected cancer incidence. There were no lower than expected cancer incidences in men or women. Fewer Battlement Mesa men and women died when compared with other Colorado residents. There were fewer deaths associated with nervous system diseases, and major cardiovascular diseases. There were no more negative birth outcomes than expected for the Battlement Mesa/Parachute zip codes.

Physical determinants of health
Hospitalization diagnoses Higher than expected: None Lower than expected: Females: Nervous system, ENT, Vascular, Pulmonary Males: Depression, Vascular, Pulmonary
Cancer Higher than expected: Prostate (felt to be a statistical variation) Lower than expected: None
Mortality Higher than expected: None Lower than expected: Females: Total deaths, Cardiovascular Males: Total deaths
Birth outcomes Higher than expected: None Lower than expected: None

3.3 Social determinants of health

To assess the baseline community health in Battlement Mesa/Parachute the CSPH team obtained available information regarding sexually transmitted infections, crime, substance abuse, motor vehicle crashes, and education from a variety of sources, as summarized in Appendix C.

Information regarding sexually transmitted infections for the years 2005-09 was obtained from the Disease Control and Environmental Epidemiology Division, CDPHE. During this time period, the incidence of chlamydia and gonorrhea in Garfield County rose, peaking between 2007 and 2008. Other sexually transmitted infections (syphilis and HIV) had three or fewer cases each year in Garfield County, and no cases in Battlement Mesa/Parachute.

Information regarding crime was obtained from the Colorado Bureau of Investigation as reported Parachute Police Department for the years 2000-2009, data for the year 2001 was not available. Due to its close proximity and similar community composition, data were analyzed as a surrogate for criminal activity in Battlement Mesa. For the years obtained, total arrests peaked in 2008, with a total of 339 arrests. All categories of arrests: violent offenses, nonviolent offenses, prostitution/sex offenses, substance use offenses, and the category of other offenses fluctuated throughout the period, with an increase in all categories of arrest during the years of 2005-2008.

Significant efforts were made to obtain data on mental health, substance abuse, and suicide specific to residents of Battlement Mesa. We were unable to obtain primary data, however, substance abuse information is publicly available for Garfield County from the Community Health Initiative website. Substance abuse data were extracted from the Garfield GCPH Department's 2006 assessment on community needs. From these data, depression, anxiety, and stress along with tobacco smoking and alcohol abuse appear to be the top indicators of the burden of mental health and substance abuse, respectively. It is important to note that the survey respondents were self-selected through survey distribution at libraries, city halls, community centers, health clinics, and mailings to some randomly selected homes.

Data on school enrollment were collected from the Colorado Department of Education. In 2009, at which time there were 1,229 students enrolled in Colorado School District 16, there was an increase of nearly 400 students (19.0%) since 2005 and 35.7% since 2000. While total enrollment increased significantly, proportional enrollment by grade remained relatively stable. Since 2000, there was a shift in the racial and ethnic profile of students enrolled in the district schools. The percentage of Hispanic children doubled from approximately 15% in 2000 to 30% in 2009 and the percentage of Caucasian, non-Hispanic children decreased from 82% to 65%. Proportions of African American, American Indian, and Asian children are small and remained stable. Student teacher ratios remained stable through the initial period of the oil and gas boom in 2003, with the highest student-teacher ratio seen in the early education setting. Student teacher ratios are not available beyond 2004.

Social determinants of health
Sexually transmitted infections (number of cases, baseline →peak) Battlement Mesa/Parachute Chlamydia: Females: 4→12 Males: 2→7 Garfield County Females: 39→93 Males: 13→27
Crime Violent Crime: 10→18 Nonviolent Crime : 34→40 Prostitution/sex offenses: 0→1 Substance use offenses: 69→46 Other offenses: 63→76
Hospitalization for Alcohol/Drug Abuse and Suicidal Behavior Garfield County 2003-05: 275 persons
Education, Garfield County District 16 Enrollment 2000: 906 2005: 1033 2009: 1,229 (35.7% increase)

3.4 Limitations

Limitations for the data described in the Battlement Mesa Baseline Health Profile section of this document can be found in the Appendix C.

4 Assessment of Health Impacts

Eight potential stressors to health were identified and assessed: air quality; water and soil quality; traffic and transportation; noise, vibration and lighting; community wellness; employment and economy; health system infrastructure; and accidents and malfunctions. These assessments take into account Antero's proposed control plans and mitigation strategies, to the extent that they are known (from public presentations, Surface Use Agreement, and other information provided by Antero). Any significant deviation from the available information will not necessarily be reflected in this assessment. Each stressor was then characterized based on seven attributes relevant to public health: direction of health effects; geographic extent; likelihood; vulnerable populations; duration of exposure; frequency of exposure; and magnitude/severity of health effects. For each attribute, consistent definitions were created and numerical values were assigned to each level of the attributes, as shown in the tables below. The characterization consists of describing and ranking each potential health impact in terms of each attribute. To compare the relative importance of the potential stressors to one another, these numeric rankings were summed for each health impact to create a relative rank. Both the numerical value assigned to each attribute level and the summed rank are qualitative with the sole purpose of helping to describe the relative importance of each potential health impact to the other potential health impacts identified in this HIA. As such, any individual ranking is only meaningful when used in context with another ranking within this HIA. The numeric levels and summed ranks do not represent a quantitative estimate of risk, nor should they be used to compare health impacts identified in this HIA to other HIAs, risk assessments, or health standards.

Direction of Potential Health Effects

Positive	Changes that may improve health in the community	+
Negative	Changes that may detract from health in the community	-

Geographic Extent of Health Effects

Localized	Effects mainly occur in close proximity to drilling or other related activities	1
Community-wide	Effects occur across most or all of the Battlement Mesa PUD	2

Presence of Vulnerable Populations within Battlement Mesa

Yes	Disproportionately affects subpopulations that are more vulnerable to health impacts (e.g. children, the elderly or people with pre-existing health conditions)	2
No	Affects all subpopulations evenly	1

Duration of Exposure

Short	Lasts less than one month	1
Medium	Lasts at least one month but less than one year	2
Long	Lasts one year or more	3

Frequency of Exposure

Infrequent	Occurs sporadically or rarely	1
Frequent	Occurs constantly, recurrently and/or numerously	2

Likelihood of Health Effects

Unlikely	There is little evidence that health effects will occur as a result of this the Antero drilling in the PUD	1
Possible	Evidence suggests that health effects may occur, but are not common in similar situations	2
Likely	Evidence suggests that health effects commonly occur in projects of this type	3

Magnitude/Severity of Health Effects

Low	Causes health effects that can be quickly and easily managed or do not require treatment	1
Medium	Causes health effects that necessitate treatment or medical management and are reversible	2
High	Causes health effects that are chronic, irreversible or fatal	3

EXAMPLE:

The following characterization of a hypothetical health impact from Antero's plan illustrates how attribute levels are assigned and then summed to provide a relative ranking for the potential health.

Impact	**Direction of health effects**	**Geographical Extent of exposure**	**Vulnerable populations**	**Duration of exposure**	**Frequency of exposure**	**Likelihood of health effects as a result of Project**	**Magnitude of health effects**	**Rank**
Hypothetical	Negative:-	Localized: 1	No: 1	Short: 1	Infrequent: 1	Unlikely: 1	Low: 1	-6

The hypothetical health impact may produce **negative health effects** only in areas in close proximity to the development areas and is **localized.** No particular pollution is more vulnerable to the health effect. The duration of the hypothetical impact is expected to be less than a month, **short,** and only occur once, **infrequent**. It is **unlikely** to occur and any health effects could be

easily managed at home and would be **low**. The hypothetical health impact is has a ranking of -6 out of 15.

The following sections provide an assessment, characterization, and recommendations for each potential health impact.

4.1 Assessment of Air Quality on Health in Battlement Mesa

> "What happens if the air is so bad that I have to close all my windows and shut off my swamp cooler?"
> *June 15 stakeholder meeting*

Exposure to airborne contaminants from natural gas development and production is a major concern to Battlement Mesa residents. There is the potential for release of hundreds of airborne contaminants during most if not all natural gas development and production. The potential for release of contaminants to air increases with well installation errors, blow outs, or well fires. Sources of contaminants during these operations include the natural gas resource itself, chemicals used in well development operations, such as fracking, wastes from well development activities such as produced water, and diesel exhaust from trucks and generators.

4.1.1 Air Quality and Health

Natural gas development and production and the diesel engines used to support them have the potential to release hundreds of hydrocarbons, carbonyls, and other contaminants into the air. People can be exposed to these contaminants as they breathe ambient air in and outside of their homes. Some of these contaminants, such as benzene, diesel exhaust, and $PM_{2.5}$, are human carcinogens. Others, such as carbonyls, alkanes, ground-level ozone, and 1,2,4-trimethylbenzene, can act as irritants of the eyes, skin, and respiratory tract or cause neurological effects[29-30]. In addition, hydrocarbons, carbonyls, and nitrogen oxides serve as precursors for ground level ozone formation. The health effects of many other of the potential contaminants are not known. Descriptions of health effects of the air contaminants of potential concern are presented in Section 4 of the Human Health Risk Assessment (Appendix D). The Human Health Risk Assessment reviews ambient air data collected in Garfield County between 2002 and 2009.

In addition to the effects that each of these substances can produce by itself, there is also the possibility of complex health reactions occurring as a result of the interaction of multiple substances. There is some indication that complex mixtures can act additively or synergistically to increase effects on human health. For example, studies on air pollution indicate that continuous exposure of healthy human adults to sulfur dioxide or nitrogen dioxide increases ozone absorption, suggesting that co-exposure to other gaseous pollutants in the ambient air may enhance ozone absorption. Studies that evaluated response to allergens in asthmatics (allergic and dust-mite sensitive) suggest that ozone enhances response to allergen challenge. Other

studies have reported increased response (lung tissue injury, inflammatory and phagocytosis) to the mixture of PM and ozone compared to either PM or ozone alone[30-31].

4.1.2 Current Air Quality Conditions

There are several sources of air emissions that currently affect air quality in Battlement Mesa. The main sources are vehicle emissions and natural gas development and production, as described below.

Battlement Mesa residences are located one mile from Interstate-70, which likely has some impacts on the current ambient air quality. The Garfield County emissions inventory indicates that highway vehicles were a primary contributor to carbon monoxide, sulfur dioxide, and nitrogen dioxide emissions in 2007[32]. The current traffic in the Battlement Mesa PUD, described in Antero's traffic analysis, also has impact on the current ambient air quality.

With the exception of two natural gas wells, Battlement Mesa does not currently house any industrial activity. While there are many gas wells located to the north, east, and south of the PUD boundaries, the impact on the ambient air quality within the PUD is estimated to be similar to other rural locations in Western Garfield County without significant natural gas development and production. There currently is no baseline air quality data specific to Battlement Mesa, although the GCPH plans to begin collecting air quality data (carbonyls, SNOMCs, and meteorology) in Battlement Mesa beginning in the Fall of 2010. Therefore, this can be verified when the results from the ambient air sampling in Battlement Mesa are available.

The air quality measurements and risks determined for the Silt-Daley and Silt-Cox monitoring sites in the Human Health Risk Assessment performed with the 2005-2007 ambient air study data and background samples collected in the 2008 Garfield County Air Toxics study were employed to estimate baseline air quality and risk within the Battlement Mesa PUD[33-34]. The Silt-Daley and Silt-Cox monitoring sites are described as rural sites without natural gas development and production.

The average PM_{10} levels at Silt-Daley (9.2 $\mu g/m^3$) and Silt-Cox (13.6 $\mu g/m^3$) were well below the 150 $\mu g/m^3$ National Ambient Air Quality Standard. Chemical speciation of the PM_{10} samples indicated that the main source of carbon in the samples is most likely from a combination of oil and gas production and building heating[18]. The 24-hour average $PM_{2.5}$ levels measured in background samples the Garfield County Air Toxics Study Summer 2008 ranged from 4.9 to 10. 3 $\mu g/m^3$, and were well below the 35 $\mu g/m^3$ National Ambient Air Quality Standard [34].

Baseline cancer risk estimates ranged from 6.2 excess cancers per 1 million individuals at Silt-Daley to 21 excess cancers per 1 million individuals at Silt-Cox, after adjusting for a 30-year exposure duration and 350 day/year exposure frequency. The difference in cancer risk between the two sites is because different contaminants are driving the risk. The cancer risk at Silt-Daley

is driven by benzene, which was not detected at Silt-Cox. The cancer risk at Silt-Cox is driven by 1,4-dichlorobenzene, which was not detected at Silt-Daly. At both sites the non-cancer hazard was less the one, below which health effects are not expected to occur.

It is important to note that 2005-2007 and 2008 studies were limited to determining only 128 possible air contaminants. Several other potential air contaminants, such as, ozone, and PAHs, were not measured[33] and therefore not included in the Human Health Risk Assessment or other Human Health Risk Assessment conducted by CDPHE in the past.

EnCana Oil and Gas (USA) Incorporated (EnCana) began conducting ozone measurements in 2007 at their mountain station in Garfield County. The mountain station is located at 8407 feet above sea level in a remote area with very little natural gas development and production. Ozone levels averaged over 8 hours ranged from 17 ppb to 74 ppb. While Encana's ozone data are from a rural area within Western Garfield County, it may not be a good estimate of ambient ozone levels in the Battlement Mesa PUD. This is because of the 3200 foot elevation difference between the two areas (the elevation of the PUD is approximately 5200 feet above sea level). Ground level ozone concentrations vary by elevation, with higher concentrations at higher elevations.

4.1.3 Antero Drilling Plans in Battlement Mesa and Air Quality

Garfield County's 2007 emission inventory indicates that the oil and gas industry (point and non-point sources combined) is the highest contributor to nitrogen dioxide, benzene, and sulfur dioxide emissions within Garfield County. For example, the oil and gas industry contributes five times more benzene to the inventory than any other emission source listed. The oil and gas industry also is a significant contributor to VOC, PM_{10}, and carbon monoxide emissions[32]. Therefore, it is expected that Antero's project will impact air quality in the PUD.

The VOC emissions from natural gas development and production have the potential to degrade the air quality within the PUD, if they are not adequately controlled. There is the potential for the production tank on each well pad to emit 37 tons per year (tpy) VOCs (including methane), based on Antero's estimate of 0.36 tpy benzene and the composition of the condensate at the Watson Ranch Well located on the south east border of the PUD (Antero Battlement Mesa Natural Gas Development Plan Meeting #7, October 7, 2009, Information provided by Antero). Antero has specified that they will use combustors to control VOC emissions from production tanks[7] to achieve a 95% VOC control efficiency in compliance with COGCC rule 805b[9]. Applying a 95% control efficiency to the potential VOCs emissions results in 18.6 tpy VOC emissions from the production tanks on all 10 proposed well pads combined. Production tanks are only one of a number of potential sources of VOCs emissions from natural gas production activities. Some sources, such as flow back operations, are likely to cause a higher emission rate of VOCs, while others may have VOC emissions similar to the production tanks. It is important to note that while combustors may decrease VOC emissions, they have the potential to increase carbon monoxide, carbon dioxide, and nitrogen oxides emissions.

COGCC Rule 324A requires operators to take precautions to prevent significant negative impacts to air; COGCC Rule 317 requires that any gas escaping during drilling must be directed a safe distance from the well and burned (flared); and COGCC Rule 805b requires that gas facilities and equipment shall be operated in such a manner that odors and dust do not constitute a nuisance or hazard to public welfare. However, natural gas development and production may have some impact on localized air quality at residences near the well pad, as evidenced by odor complaints to COGCC and the Garfield County Oil and Gas Department from Battlement Mesa residents in July 2010 (COGCC complaint reports)[9]. The odor complaints occurred during flow back operations at Antero's Watson Ranch Pad located on the southeast border of the PUD, within approximately ½ a mile from several residences, and resulted in COGCC issuing a notice of alleged violation (also known as NOAV) to Antero on 7/14/2010. In the 2005 to 2007 Garfield County Ambient Air study, air samples collected when residents noticed odors (thought to be from natural gas development and production), contained levels of benzene, ethylbenzene, toluene, and xylenes that were greater than EPA regional screening levels for residential ambient air[18]. EPA Regional Screening Levels are health-based levels above which health effects may occur.

Diesel exhaust from heavy trucks and generators has the potential to impact air quality within the PUD. The transportation and traffic assessment discusses the number of expected truck trips that were used to estimate the annual emissions from Antero's projected heavy truck activity as summarized in the following table.

Estimated Annual Emissions from Trucks

Contaminant	five year Well Development (Phases 1 through 3)	20 - 30 Years of Well Production and Operations
PM (tons/year)[1]	0.26 to 0.75	0.05 to 0.12
Nitrogen dioxide (tons/year)[2]	0.35 to 0.45	0.068
Carbonyls (tons/year)[3]	0.063 to 0.082	0.012
Alkanes (tons/year)[4]	0.05 to 0.064	0.0097
PAHs (tons/year)[5]	0.14 to 0.18	0.027

[1]assuming a PM emission rate of 0.64 to 1.4 grams per mile [35], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[2]assuming a nitrogen dioxide emission rate of 0.84 grams per mile[36], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[3]assuming a carbonyl emission rate of 0.15 grams per mile[36], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[4]assuming an alkane emission rate of 0.121 grams per mile[37], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip
[5]assuming a PAH emission rate of 0.0.338 grams per mile[37], a fuel efficiency of 5.5 miles per gallon of diesel, and 10 miles within the PUD per trip

The estimated emissions are based on the period of time during which trucks are moving and do not include emissions created during idling and emissions from diesel powered generators. Each of the proposed truck routes is near at least one Battlement Mesa housing area[38].

With the following control measures in place, project dust from construction activities, well pads, and access roads is not expected to significantly impact Battlement Mesa air quality. COGCC rule 805b requires operators to employ practices for control of fugitive dust caused by their operations. Antero has specified the following dust control measures: (1) soiltac and/or liquid dust suppressants will be used; (2) all access roads and well pads will be graveled; (3) truck traffic will not exceed 20 miles per hour (mph); and (4) all contractors will be notified they must obey traffic laws and that they will be disciplined, up to removal from Antero's project, if they fail to comply[7].

Fugitive emissions from pipes, valves, pneumatic devices, and wellheads have the potential to impact Battlement Mesa air quality and can do so over the life of the well, estimated to be at least 20 years. In addition, VOCs may be vented during maintenance ("pigging") of pipes, occurring intermittently over 20 years. COGCC rules require that no bleed valves be used on pneumatic devices, where technically feasible. Appendix B discusses specific requirements for pipelines within the PUD, as agreed in the Surface Use Agreement. No centralized compressor stations will be located in the PUD[7].

Appendix D contains a Human Health Risk Assessment that was performed by the CSPH team to estimate the potential impacts to the public health from Antero's proposed project. The Human Health Risk Assessment was conducted using five years of data from the Bell-Melton Ranch monitoring station, the 2008 Air Toxics study, and the 2005-2007 air study. Three exposure scenarios were evaluated: (1) chronic exposure of all residents within the Battlement Mesa PUD; (2) chronic exposure of residents within the PUD living adjacent to a well pad; and (3) acute exposure of child residents living within the PUD living adjacent to a well pad. The Human Health Risk Assessment concludes that there is a potential for natural gas development and production within the Battlement Mesa PUD to adversely impact public health. The highest risk is projected for residents living adjacent to well pads through acute exposure to air contaminants emitted during well completion activities. Following is a summary of the conclusions of the Human Health Risk Assessment:

- These non-cancer hazards and cancer risks may be significantly underestimated because there is currently little or no information for many contaminants associated with natural gas operations. They may be even higher if information were available for polycyclic aromatic hydrocarbons (PAHs), chemicals in fracking fluids, ozone, $PM_{2.5,}$ PM_{10}, and contaminants without toxicity values. In addition, little information is available for soil and water.
- For Battlement Mesa residents living adjacent to a well pad, the estimated Hazard Index of 40 for acute non-cancer hazard and the estimated Hazard Index of 2 for the chronic

non-cancer both are greater than one, above which health effects may occur. Both of these hazard estimates are driven by trimethylbenzenes and benzene in ambient air.

- For chronic exposure of Battlement Mesa residents living adjacent to a well pad, the estimated lifetime excess cancer risk of 83 cancers per one million people, while within EPA's acceptable range of one to 100 cancers per one million people, exceeds EPA's goal of less than one cancer per million people and is near the high end of the acceptable range. This translates to a population attributable risk of less than one cancer for a population of 5,041. The contribution of benzene, methylene chloride, and ethylbenzene also exceed the contribution of these contaminants to the baseline cancer risks measured at the Silt-Daley and Silt-Cox monitoring stations.
- For chronic exposure of Battlement Mesa residents not living adjacent to well pads, the estimated Hazard Index of 0.6 for non-cancer hazards is less than one, below which health effects are not expected to occur.
- For Battlement Mesa residents not living adjacent to well pads, the estimated lifetime excess cancer risk of 71 cancers per one million people, while within EPA's acceptable range of one to 100 cancers per one million people, exceeds EPA's goal of less than one cancer per million people and is near the high end of the acceptable range. This translates to a population attributable risk of less than one cancer for a population of 5,041.

4.1.4 Characterization of the Air Quality on Health

The impact of air quality due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Air Quality	Negative(-)	Community wide	Yes	Long	Frequent	Likely	Moderate to High	-14.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated air contaminant exposures associated with the Antero development within the Battlement Mesa PUD, air quality will likely produce **undesirable health effects** in the areas both in near development areas and **community wide.** Much of the community will be near sources of air contamination and ambient air quality will affect the entire community. Children, older adults, and individuals with respiratory diseases may be more vulnerable to the air contaminants and are considered **vulnerable populations**. Air quality degradation may last for the duration of Antero's project, from well pad preparation through well abandonment, and therefore could be long in duration. The impacts to air quality are expected to be **frequent** and occur constantly and/or reoccur. It is **likely** that contaminant concentrations in residential ambient air may be high enough to cause short-term and long-term disease. Health effects may

include respiratory disease, neurological problems, and cancer. It is likely that medical attention will be necessary for some of these effects and that some of these effects will not be reversible. Therefore the impacts are rated as **moderate to high** magnitude. Using the numerical ranking scheme, air quality impacts are expected to produce a negative rank of -14.5 on a scale of ±6-15.

4.1.5 Findings and Recommendations from Air Quality Assessment

What we know: Air pollution is a hazard to the public health. GCPH and CDPHE ambient air studies, air toxics studies, and the broader scientific literature demonstrate that natural gas development and production contribute diminish air quality. These studies also show that the largest volume of emissions to air occur during well development. The Human Health Risk Assessment in this HIA, previous CDPHE risk assessments, and Saccomanno Study all conclude that there is likely to be an increased risk of cancer and other chronic and acute health effects from residential exposure to air emissions that can result from natural gas development and production. There have been several odor complaints associated with the Watson-Ranch well pad at the perimeter of the PUD filed with the COGCC. These odor complaints resulted in COGCC issuing a Notice of Alleged Violation.

What we do not know: The ambient air quality within the Battlement Mesa PUD is not known. The levels of air emissions during all stages of natural gas development and production are not known. Many types of possible emissions, such as PAHs and fracking chemicals, as well as the contribution of PM and ozone have not been assessed. It is not known if the set backs of wells from occupied buildings are adequate to protect public health.

Recommendations to Reduce Impacts to Public Health from Air Pollution

Based on these findings, the following are some of the suggested ways to reduce the potential impact of air emissions.

1. Require submission of a quality assurance project plan (also known as a QAPP) to GCPH for review and approval for all monitoring specified in these recommendations to assure monitoring information will be adequate for informing public health decisions.
2. Require Antero monitoring results conducted in response to CDPHE consultation (dated 4/12/2010) be made available to the public in a timely manner to provide accessible information and transparency.
3. Require corrective action when odor events occur, including notification of the GCPH and residents to reduce impacts.
4. Require adherence to COGCC 805b green completion practices, with no variances, and EPA natural gas STAR program to reduce VOC emissions to the lowest level technically possible.
5. Require use of electrically powered generators in place of diesel powered generators for well drilling and fracking operations to reduce VOC, PAH, and PM emissions.
6. Require a valid emissions permit from the CDPHE for each well pad, per COGCC rule 805b to establish inspection and monitoring requirements.

7. To reduce VOC emission, require pilot lights on production tank combustors remain lit through use of appropriate technology, such as spark igniters.
8. Require adherence to dust control measures and traffic measures specified in the Surface Use Agreement.
9. Require that Antero establish and implement a plan that ensures all trucks used for its plan within the PUD meet emission standards specified in the Clean Fuel Vehicles (heavy trucks) for the Clean Fuel Fleet Program (CFR Part 88.105-94) to reduce VOC, PAH, and PM emissions.
10. Require truck loads of dirt, sand, aggregate materials, drilling cuttings, and similar materials be covered to reduce dust and PM emissions.
11. Require pits at the water storage facility to be covered to reduce VOC emissions.
12. Require air monitoring of water storage facility for VOC/BTEX and report results to GCPH.

The recommendations to address information gaps are in Section 5.

4.2 Assessment of Water and Soil Quality on Health in Battlement Mesa

> "What will be the effect of chemicals on the water supply?"
> *June 15 stakeholder meeting*

The impact of natural gas development and production on water and soil quality and the water supply is a major concern to Battlement Mesa residents. Surface run-off, and infiltration from drilling cuttings and produced water stored in pits on well pads or off-site locations; well installation errors; and uncontrolled well development (kick backs, blow outs, and well fires) could result in emissions of contaminants to groundwater, subsurface soil, surface soil and surface water. Spills of fracking fluids, drilling muds, condensate, and diesel could result in contamination of surface soil. Run-off and infiltration then could result in subsequent contamination of surface waters and of groundwater and subsurface soil, respectively. Exhaust from diesel engines (through dry deposition of particulates) and wind erosion from drill cuttings could contaminate surface soils (through deposition of particulates). If the groundwater or subsurface soil is contaminated, VOCs could infiltrate and accumulate in the air of buildings. Sources of contaminants include the natural gas resource itself, chemicals used in well production activities, wastes from well production activities, and exhaust from machinery used in well production and maintenance.

4.2.1 Water and Soil Quality Impacts on Health

Natural gas development and production and the diesel engines used to support them have the potential to release hundreds of metals, salts, hydrocarbons, carbonyls, and other contaminants to groundwater, surface water, and soil. People can be exposed to these contaminants through ingestion of water, incidental ingestion of soil, dermal absorption from water, inhalation of soil particulates, inhalation of VOCs released from water during activities such as showering, and

inhalation of VOCs in building air. Some of these contaminants, such as benzene[39] and several of the PAHs, are human carcinogens. Others, such as the carbonyls, alkanes, and 1,2,4-trimethylbenzene, can act as irritants of the eyes and skin or cause neurologic effects[29]. Specific health effects of several potential contaminants are described in the Air Quality Assessment and in the Human Health Risk Assessment (Appendix D).

Significant contamination of water supplies with salts, such as those containing chloride, can make the water unsuitable for human consumption and stress water treatment facilities. The water requirements for natural gas development and production are large, with the potential to tax local water supplies, particularly in the event of a drought.

4.2.2 Current Conditions of Water and Soil Quality

The primary source of drinking and domestic water in Battlement Mesa is the Colorado River. The Battlement Mesa Water Treatment Plant draws water from two intakes located in the middle of the river for treatment. The available baseline groundwater and surface water data specific to Battlement is Mesa is limited to the annual testing of the surface water intake and back-up groundwater wells at the Battlement Mesa Water treatment facility. These results indicate that there is no VOC, herbicide, pesticide or carbamate contamination of either drinking water supply. In addition, a domestic well at the Historic Battlement Mesa Schoolhouse was sampled on May 17, 2010 in response to an anonymous request from a landowner in the vicinity of Antero's Watson Ranch Well. The COGCC concluded the laboratory analysis did not indicate any impacts to this domestic water well from natural gas production operation[40].

A baseline water quality study for the Piceance Basin was performed in 2006 [22]. Seventy groundwater samples were collected from water supply wells located north of the Colorado River and south of the upland "Hogback" between the communities of Rifle and Parachute. The inorganic results are not applicable to Battlement Mesa, because the water chemistry between these two areas could be quite different. However, the BTEX and methyl-tert-butyl-ether (also known as MTBE) results could be somewhat representative of Battlement Mesa, because they are not naturally occurring. No measureable concentrations of BTEX, methyl-tert-butyl ether, or methane were detected in any of the samples.

There is no baseline data for surface soil or subsurface soil within the PUD and current conditions are not known.

The Colorado Department of Labor & Employment's Oil and Public Safety Division has permitted ten underground storage tanks within the PUD, summarized in the following table.

Permit Holder	**Fuel**	**Tank Capacity (gallons)**
Battlement Mesa Service	Gasoline	1,000

Permit Holder	Fuel	Tank Capacity (gallons)
Battlement Mesa Service	Diesel	1,000
Battlement Mesa Golf Course	Gasoline	2,000
Battlement Mesa Golf Course	Diesel	1,000
Kum and Go, Stone Quarry Road	Gasoline	20,000
Kum and Go, Stone Quarry Road	Gasoline	12,000
Kum and Go, Stone Quarry Road	Diesel	12,000
Kum and Go, Tamarisk Trail	Gasoline	10,000
Kum and Go, Tamarisk Trail	Gasoline	10,000
Kum and Go, Tamarisk Trail	Gasoline	8,000

These underground storage tanks have the potential to leak and contaminant subsurface soil and groundwater with fuel contaminants, including benzene. The permit holder is required to perform weekly leak tests on the underground storage tanks and the Oil and Gas Public Safety Division performs an annual inspection of the underground storage tank. Review of the Oil and Gas Public Safety Division files on August 18, 2010 indicated no leaks or contamination of soil or groundwater associated with these underground storage tanks.

There also are natural gas productions operations occurring on the border of the PUD that could potentially impact the water and soil quality within the PUD, as well as the water supply. Other potential sources of contamination to groundwater and soil are the golf course and landscaping operations (e.g. application of fertilizers, herbicides and pesticides).

In the event that the Battlement Mesa Water Treatment Plant was shut down, drinking and domestic water for Battlement Mesa residents would be supplied from four groundwater wells along the south bank of the Colorado River. These wells are not supplied with water from the Colorado River and it is believed that the source of water in these wells is from an up-gradient aquifer. There could be a hydrologic connection between these wells and the aquifer on Battlement Mesa, allowing for a conduit of natural gas extraction activity contaminants to the secondary drinking water source, although this has not been verified.

4.2.3 Antero Drilling Plans in Battlement Mesa and Water and Soil Quality

The Mamm Creek field, located approximately 20 miles to the east of Battlement Mesa in Garfield County, has experienced extensive natural gas development and production, with over 1100 gas wells installed between 2000 and 2007. The two phase hydrogeologic study conducted between 2006 and 2007 on the Mamm Creek field [21-22] provides data that is useful in estimating potential impacts from natural gas development and production on water quality in Battlement Mesa. An increasing temporal trend of methane and chloride groundwater concentrations coincident with the increasing number of gas wells installed was observed in the hydrogeologic

study[21-22, 41]. The isotopic methane data indicate a thermogenic origin of methane, which may be attributed to the Williams Fork gas. The increasing chloride concentrations are attributed to Williams Fork production water.

In the Mamm Creek field hydrogeologic study, chloride concentrations did not exceed regulatory limits and there is no regulatory limit for methane. Benzene was only detected in groundwater and surface water samples collected in proximity to the West Divide Creek seep and the Amos well. Many of the benzene concentrations in these samples exceeded the 5 µg/L regulatory limit and the 0.41 µg/L EPA Regional Screening Level for tap water. At the West Divide Creek seep, a faulty cement job on the casing of the Schwartz well resulted in the migration of natural gas and BTEX over 2,000 feet southeast of the well and seepage into Divide Creek. At the Amos well, Williams Fork gas from poorly installed wells are believed to be responsible for the contamination.

Pavillion Wyoming, a community of approximately 166 residents located in Fremont County, also has experienced intensive natural gas development and production, with 211 active gas wells, 30 plugged and abandoned wells, 20 "shut-in" wells, and 37 production pits in an 8 square mile area. In response to complaints from Pavillion residents of odors and off-tastes in domestic water, EPA conducted sampling of both domestic and monitoring wells in the area between 2009 and 2010. The sampling results indicate that domestic wells are contaminated with low levels of petroleum hydrocarbons and thermogenic methane and that the shallow groundwater is heavily contaminated with petroleum hydrocarbons and BTEX. Natural gas development and production are the most likely source of the petroleum hydrocarbons and BTEX. Several inorganic compounds, such as sodium, sulfate, and nitrate, also were detected which could have sources other than natural gas development and production. The hydrologic connection between the drinking water aquifer and shallow groundwater is not well characterized. In their health consultation based on EPA's results, ATSDR found the quality of the drinking water in several of the domestic wells was not acceptable and concluded that exposure to some of the contaminants could result in health effects[42-43]. While the groundwater contamination that occurred in Pavillion is not directly comparable to Battlement Mesa because of differences in the natural gas resource and state regulations, it does indicate that natural gas development and production can adversely impact groundwater quality.

Review of water quality data in the USGS and COGCC databases indicate that groundwater and surface water contamination from natural gas development and production at levels with the potential to impact water quality and exceed regulatory levels results from incidents such as loss of well control during development, well installation errors, and spills from produced water pits, as described in the Accidents and -Malfunctions Assessment. Available routine monitoring data in these databases indicate routine natural gas development and production (i.e. without incidents) may not be a significant source of water contamination, however, routine monitoring is limited and may not be representative of all instances of gas development and production. It is noted, that samples are most often collected in response to a complaint or incident or as part of a remedial action. There is very little data for routine monitoring of impacts to water quality at gas

wells or exploration and production (also known as E&P) waste pits, with the exception of required monitoring in the 3-mile perimeter of Project Rulison. This small about of data limits the ability to make a true estimate of exposures from groundwater and surface water.

The Mamm Creek field hydrogeologic study results and USGS and COGCC databases indicate that routine natural gas development and production could impact water quality in Battlement Mesa, but not to an extent that causes exceedence of regulatory standards and triggers regulatory action. It is possible that increasing chloride concentrations could eventually affect the potable groundwater. Incidents resulting from well installation errors, uncontrolled well development, and spills could significantly affect the potable groundwater and water quality, as well as soil quality, in Battlement Mesa.

While there is no permanent surface water body in the PUD, there are intermittent drainages and creeks that could discharge to the Colorado River. Monument Creek, one of the major drainages off of Battlement Mesa discharges to the river downstream of domestic water intakes. It still is possible that surface run-off could introduce contaminants from upstream well pads into the river. However, the Colorado River has a high volume of water and it is most likely that any contamination would be diluted to non-harmful concentrations. The annual surface water quality results have not indicated any detectable levels of contamination from natural gas development and production at the intakes. In addition, natural gas operators must inform the Battlement Mesa Water Treatment Plant of upstream spills or incidents affecting the river (COGCC rule 317B) [9]. In the event of such a spill or incident, the intakes to the treatment plant can be shut down. The treatment plant routinely stores a week's supply of water allowing time for remediation of spills. The Battlement Mesa Metropolitan District is subject to the protections of COGCC Rule 317B, which regulates natural gas operations in surface water supply areas.

Antero is proposing to employ pitless drilling systems on the well pads within the PUD and to distribute and store production water at a centralized water storage facility, within the PUD. COGCC rule 904 requires liners for pits at centralized water storage facilities and has a provision[9], at the discretion of the director, for the installation of leak detection systems in sensitive areas such as the PUD. COGCC rule 908 requires that centralized water storage facilities be permitted[9]; the geologic and hydrogeologic characterization of site; control of public access; fire lanes; surface water diversion systems, waste characterization profiles; an operating plan; baseline groundwater sampling and analysis; groundwater and surface water monitoring (at the discretion of the COGCC director); and groundwater and soil sampling when a pit is closed and the site remediated. Adherence to these rules, including the discretionary leak detection and monitoring, will significantly reduce the potential for impacts to water and soil quality from produced water and other exploration and production waste stored in the centralized pit. However, leaking pipelines and spills from chemical and production water hauling trucks could still create the potential to impact surface water quality. COGCC rules do not specifically address water pipeline leaks.

Any spills that occur on the pads could potentially impact water and soil quality by surface run-off and infiltration during precipitation events. This potential is evidenced in a sample of snow melt collected from a project Rulison well pad contained levels of benzene greater than regulatory limits[44]. COGCC rule 603 specifies that in high density areas, such as the PUD, berms (or other secondary containment devices) capable of containing 150 percent of the fluid in the largest tank within the berm be constructed around produced water and condensate tanks[9]. However, this rule does not provide for containment of spills that may occur outside the berm perimeter, such as during transfer of chemicals and materials to and from trucks and at well heads.

Wind erosion and surface run-off from drill cuttings stored on Antero's pads could impact surface water and surface soil quality. The COGCC rules do not specifically address drill cutting stored on well pads[9].

At time of preparation of this HIA, it was not known if Antero is planning for deep injection of exploration and production wastewater within the PUD. COGCC rule requires written permission from the COGCC director prior to construction of an injection well. The HIA would need to be updated to include potential impacts to public health, if injections wells are proposed.

The Battlement Mesa Metropolitan District has a capacity of 6 million gallons of water per day. Currently, 3-3 ½ million gallons per day are used, allowing for the accommodation of Antero's water needs during well development operations. If water capacity were to significantly decrease, the needs of Battlement Mesa would take precedence to Antero's needs.

It is unlikely that Antero's proposed project will have a significant impact on the primary domestic water supply for Battlement Mesa. The potential for a significant impact to the secondary water supply may exist. If the potable groundwater is impaired, Battlement Mesa may not have a back up source of domestic water. In addition, there is the potential for the Antero's project to impact the water quality of intermittent streams, creeks, and puddles, as well as soil quality. Finally, it is possible that shallow aquifer contamination could cause VOC off gassing into Battlement Mesa homes, but since the hydrology of the area is not well understood, the likelihood of such an occurrence is not clear.

4.2.4 Characterization of the impact on Water and Soil Quality

The impact of water and soil quality due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Water and Soil Quality	Negative(-)	Community wide	Yes	Long	Infrequent	Unlikely	Moderate to High	-11.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated water and soil contaminant exposures associated with the Antero development within the Battlement Mesa PUD, water and soil quality may produce **negative health impacts** in the areas in close proximity to the development areas and community wide. If the domestic water supply were to be contaminated, the health effects would be **community wide**. Effects of wind erosion and surface run-off could be more localized, and could impact children more than adults. Children, older adults, and individuals with pre-existing disease may be more vulnerable to water and soil contaminants and are considered a **vulnerable population**. The duration of water quality degradation could be **long** and may last through the life of the Antero's project, from well pad preparation through well abandonment. The impacts to water quality are expected to be **infrequent**. It is, however, **unlikely** that contaminant concentrations in water and soil will be high enough to cause short-term and long-term disease because the current supply of domestic water is the Colorado River and the COGCC has extensive rules to protect this resource. If exposure were to occur, health impacts may include skin and eye irritation, neurological problems, and cancer. It is likely that medical attention would be necessary for some of these impacts and that some of these impacts will not be reversible. Therefore the health impacts, if exposure were to occur, are rated as **moderate to high** magnitude. . Using the numerical ranking scheme, water and soil quality impacts are expected to produce a negative rank of -11.5 on a scale of ±6-15.

4.2.5 Findings and Recommendations from Water and Soil Quality Assessment

What we know: Water pollution is hazardous to the public health. Garfield County Oil and Gas studies, EPA studies, and other studies demonstrate that natural gas development and production can release contaminants to domestic water supplies and compromise water quality. Individual circumstances can influence the potential contamination of water. In Garfield County, accidents and malfunctions have been the most common cause of water contamination from natural gas development and production. If a domestic water resource is contaminated, remediation is time and cost intensive and may not restore the water resource to a quality for domestic use.

What we do not know: The hydrogeology in Battlement Mesa has not been characterized and the relationship between groundwater, domestic water supplies, and the Colorado River in not well understood. The quality of groundwater in the Battlement Mesa PUD is not known and the extent of routine natural gas development and production on water quality is not known.

Recommendations to Reduce Impacts to Public Health from Water and Soil Pollution

Based on these findings, the following are some of the suggested ways to reduce the potential impact of water and soil pollution.

1. Require COGCC rules 317B, 603, 904, and 908, including those at the discretion of the director, be applied with no variances or exemptions, to prevent pollution of water and soil.
2. Require Antero to develop and implement plans to ensure removal of mud from vehicles leaving the well pads and access roads to prevent tracking of mud onto Battlement Mesa and Garfield County roads.
3. Require full disclosure of all chemicals, with their volumes, concentrations, and Material Safety Data Sheets (also known as MSDS), used in natural gas development process to GCPH and Battlement Mesa Residents.
4. Require continuation of all baseline and continuing monitoring requirements for groundwater, surface water, and soil and leak detection to prevent pollution of potential domestic water supplies.
5. Require the berming of the down gradient well pad perimeters, as well as surface water diversion ditches for each well pad to prevent pollution of water and soil.
6. Require monthly inspection of water and gas pipeline for leaks to prevent water and soil pollution.
7. Require immediate notification of GCPH (in addition to COGCC) in the event of a spill of five barrels to protect public health.
8. Require that drill cuttings be covered during storage on well pads to prevent wind transport and soil pollution.
9. Place an inlet protection system, similar to the system in place for Rifle and planned for Parachute, on the two intakes for the Battlement Mesa water treatment plant that would shut off the intakes if contaminants are detected to protect public health.

The recommendations to address information gaps are in Section 5.

4.3 Assessment of Transportation and Traffic on Health in Battlement Mesa

> Will there be motor vehicle accidents and related injury and death?
> *February 3, 2010 stakeholder meeting*

Increases in transportation and traffic can impact health and safety of a community by increasing the risk of motor vehicle accidents, release of hazardous pollutants, creation of road dust, and impediment of walking and biking routes. Development of natural gas wells can cause significant increases in a variety of traffic, especially large truck traffic. Workers driving at high speeds may place residents at risk for severe injury or death. Residents living in Battlement Mesa have expressed concerns that traffic associated with the Antero gas project will impact the health

and safety of those living in the community. This assessment will address traffic impacts to the safety of Battlement Mesa citizens. Air quality, noise, and quality of life impacts due to increased traffic are addressed in other sections.

4.3.1 Traffic and Safety

Vehicular traffic is a known hazard to safety. Increases in traffic are associated with increased risk of motor vehicle injury and death, due to vehicle-vehicle, vehicle-pedestrian, and vehicle-bicycle accidents. Motor vehicle accidents can be associated with speeding, poor traffic management at intersections, and heavy vehicle movement. Numbers of injuries/fatalities are directly related to vehicle volume and severity of injury is directly related to vehicle speed[45-46].

4.3.2 Current Traffic Conditions

Currently, large truck traffic within the PUD is mainly from delivery trucks supplying the local businesses, including gas stations and convenience and grocery stores. There are established county approved haul routes along the perimeter of the PUD, while most roads within the perimeter are limited to small vehicles. There are two entries into Battlement Mesa. The main entrance is just south of Exit 75 off of Interstate-70. A traffic analysis conducted by Schmueser/Gordon/Meyer, Inc. (SGM) for Antero in September 2009 [38] found that this entrance had the highest traffic count in Battlement Mesa with 8,662 vehicle trips per day (vt/d). The second entry into Battlement Mesa is from Exit 75 via US 6 west to County Road (CR) 300 (CR 300/Stone Quarry Road) on the southwest side of Battlement Mesa. Traffic counts at the US 6/CR 300 intersection were 2,300 vt/d, but were only 648 vt/d on CR 300 where it enters the PUD west of the recreational vehicle (RV) park. Other counts indicate that on West Battlement Mesa Parkway there were 5,340 vt/d and on CR 307 (River Bluff Road) there were 371 vt/d. Since there is no current industrial activity and very few retail stores, it is assumed that the large majority of these vehicle trips were passenger cars and light trucks, although this is not specifically stated in the traffic report. The report also projects an increase of 2.3% vehicle trips annually unrelated to the Antero drilling plan, based on average annual growth of Garfield County.

Motor vehicle accidents in Garfield County are handled by the county sheriff's office, local municipal law enforcement and the Colorado State Patrol. When looking at accidents handled by the state patrol, Garfield County had the 9th highest number of motor vehicle accidents in the state in 2008, with 1,091 accidents total (14 fatal crashes, 116 that resulted in injury and 961 that resulted in property damage)[47]. Data from the county sheriff's office and data specific to Battlement Mesa are not currently available.

Top 10 Colorado Counties **2008 Fatal, Injury, and Property Damage Crashes by County** **as Covered by the Colorado State Petrol (not all Colorado Crashes)**
http://csp.state.co.us/TS_CrashStat.html

County	Fatal	Injury	Property Damage	Grand Total
Jefferson	19	395	2,530	2,944
El Paso	20	278	1,953	2,251
Adams	13	233	1,773	2,019
Mesa	7	211	1,188	1,406
Larimer	14	275	1,080	1,369
Weld	28	258	1,065	1,351
Eagle	6	132	1,073	1,211
Douglas	10	145	1,032	1,187
Garfield	14	116	961	1,091
Boulder	14	182	860	1,056
Grand Total	**290**	**3,895**	**23,028**	**27,213**

Children attending school in Battlement Mesa arrive and leave via passenger car, school bus, walking, or bicycle. Underwood Elementary (grades 1-3), St. John Elementary (grades 4-5) and Grand Valley Middle School (grades 6-8) are in Battlement Mesa. The Early Childhood Center (PreK-Kindergarten) and Grand Valley High School are in Parachute. Some students are not offered bus service if they live within a "Walk" zone. Specifically, students attending Underwood Elementary and living in Saddleback Village, Tamarisk Village, Tamarack Meadows are not offered bus service; children attending St. John Elementary and living in Willow Ridge, Willow Park, Valley View, Monument Creek Village, Canyon View, and Stone Ridge are not offered bus service; and children attending Grand Valley Middle School and living in Mesa Ridge, Eagle's Point, Willow Ridge, Willow Park, and Valley View are not offered bus service. (Battlement Mesa early childhood students and high school students are all offered bus service and ride together.) School hours in Battlement Mesa schools are 8:40 am -3:40 pm at Underwood (early release at 2:10pm); 8:25am- 3:25pm at St. John (early release at 1:55pm); and 7:50am-7:15pm at Grand Valley Middle School (1:45pm early release). A map detailing Antero's planned haul routes and school bus stops will be included in the final report.

4.3.3 Antero Drilling Plans in Battlement Mesa and Traffic

Traffic associated with natural gas development is related to earth moving construction of well pads; movement of materials and waste to and from the well site; installation of pipelines; long term production; maintenance operations; final reclamation of the site after production is completed; and travel of workers to/from work. The most traffic intensive phases involve pad construction, drilling and well completion and pipeline construction.

Antero has described a three phase development plan for the Battlement Mesa project as described in the public meetings powerpoints. Phase 1 will develop the Stierberger Pad, Pad E,

Pad G, and the water storage facility (Pad F) on the south side of the PUD. Phase 2 will develop the Parks and Rec Pad, Pad A, Pad B, and Pad D on the north side of the PUD. The Parks and Rec pad replaces the Pad C originally planned. Phase 3 will develop the L and M pads on the northeast side of the PUD. Each phase will involve access road, pad and pipeline construction needed to develop the wells and tie them to the water movement system and the gas gathering lines at the eastern edge of the PUD.

The traffic analysis conducted by SGM used estimates from previous Antero development sites in the Mamm Creek area to project average and maximum trips per day, for the Battlement Mesa project. Trips per day range from 2 (production phase) to 280 or more (intensive construction phase). Drilling completion, light construction, and pipeline installation range from on average 16-31 vt/d and a maximum of 30-46 vt/d. The duration of the pad construction ranges from 10-30 days and the other phase durations *per well* are drilling (18 days); completion (30 days); pipe installation (60 days/ mile); duration of each phase per pad was not calculated but efficiencies associated with drilling multiple wells sequentially on a pad will reduce the time of each phase on a pad. Production is projected to last 20 years. Reclamation after production is expected to have 7-10 vt/d for 11 days per pad.

Although initial presentations to the public describe well development phases to last 3-4 years, more recent estimates in the traffic analysis indicate that well development is expected to occur for at least five years, maybe longer, depending on economic and regulatory conditions. Well development phases will overlap on different well pads so that while pad construction is occurring on one pad, drilling is accomplished on another and completion may be occurring on another pad. Therefore, traffic will be overlapping as well, with trucks associated with construction, drilling, pipeline and completion using the haul routes simultaneously. Trips per day for each of these phases are added to estimate the number of trips per day expected during the first five years when well development is occurring. The number of trips per day is estimated to be 90-120 vt/d when light construction is occurring. When more intense well pad construction is occurring (during the Phase 2 well pad construction) traffic is projected to be 340 vt/d for approximately 120 days. Some activities will occur 24 hours a day and the vehicle trips will be spread throughout the day and night. Antero has stated they will limit truck hauling to hours outside of school zone hours. The majority of these trips are expected to be heavy trucks.

Antero plans to use county haul routes for traffic. During all phases entrance and exit from Battlement Mesa will be via the US 6/ CR 300 route (Stone Quarry Road), on the southwest side of the PUD. Phase 1 also will utilize CR 303, CR 308 and CR 302. Phase 2 will utilize CR 303, CR 308, East Battlement Mesa Parkway, South Battlement Mesa Parkway, and CR 307 (River Bluff Road). Phase 3 will utilize CR 303, CR 308, East Battlement Mesa Parkway, North Battlement Mesa Parkway, and West Battlement Mesa Parkway. The county restricts hauling on CR302, CR 307, South Battlement Mesa Parkway, and West Battlement Mesa Parkway. It is assumed that Antero will be required to obtain special permits to use these roads.

School buses for all the schools use and cross Antero haul routes. Although all children in the PUD may be impacted by crossing the haul routes while going to and from school, middle school age children may be the most impacted since the middle school is near two haul routes and children this age are more likely than younger children to be walking or bicycling on their own. According to the traffic analysis plan, Antero has decided to avoid any heavy truck hauling during school zone hours. Children going to/from school outside of school zone hours will be crossing haul routes while truck traffic is occurring.

Antero has planned mitigations to decrease impacts of traffic on the Battlement Mesa Community. Of significance, Antero has committed to building a water management system comprised of water distribution pipes going from the well pads to the water storage site on the south side of the PUD. This water management system is intended to decrease movement of water by trucks and it is estimated that there will be fewer trips during the development phases because of this system.

In addition to heavy truck traffic, there will be workers coming into Battlement Mesa and traveling within Battlement Mesa in passenger cars and light trucks. It is estimated that there will be an average of 120-150 workers in Battlement Mesa during the five year development period. Antero intends to house some workers in Battlement Mesa to decrease worker movement into and out of the PUD. Workers exceeding speed limits can put other vehicles and pedestrians at risk for injury and fatality. . Antero management emphasizes safe driving but a formal safe driving program does not exist.

It is expected that the increase in heavy truck volume from negligible to tens or hundreds per day within the PUD may compromise road integrity and needs for increased road maintenance is anticipated. County funds will be needed to maintain haul routes as well as installation of road and pedestrian safety mitigations if needed. Utilization of county funds for roads and road safety may divert funds from other county programs, including health programs, there by potentially impacting public health infrastructure.

4.3.4 Characterization of Traffic Impacts on Safety

The following table summarizes the characterization of impacts from traffic.

Impact	Direction of health effects	Geographic extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Ranked
Traffic and Transportation	Negative (-)	Community-wide	Yes	Long	Frequent	Possible	Low to high	-13.0*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering public health to residents of Battlement Mesa, the increased traffic within the PUD is likely to create **negative** health effects due to increased safety risks. Because the haul routes include the entire circle of the Battlement Mesa Parkway as well as other roads within and on the perimeter of the PUD, the impact of the traffic is likely to be **community-wide**. There will be certain parts of the community that will be greater impacts for the duration of Antero's project (those homes next to CR300/Stone Quarry Road) while others will be impacted by very high volume traffic during the construction of the Phase 3 pads (those along River Bluff Road). Because children often walk and ride bicycles and are not as safety conscious, they are more **vulnerable** than most adults to the impacts of traffic within the PUD. Antero has committed to limit heavy truck traffic during school zone hours which will decrease risk to children traveling to and from school at those times. Children staying after school for sports and other activities may be at risk for traffic incidents related to truck traffic outside of those hours. Furthermore, truck traffic is likely to continue on weekends and holidays and children may be crossing haul routes at those times. The duration of exposure to increased traffic will be **long**, spanning the entire duration of the development of all three phases, at least five years. The traffic will be frequent, in some cases (River Bluff Road), several hundred trucks will be passing a day for several months. Along Stone Quarry road, there will be 45 to 113 trucks passing a day for approximately five years. Increased traffic is known to be associated with increased risk of traffic accidents and it is **possible** that there will be traffic related accident as a result of the Antero project. The magnitude will depend upon how well the traffic is controlled, how well mitigation efforts are adhered to, and to unrelated or perhaps chance factors. Traffic can cause minor to severe/fatal injuries and as such, the magnitude of the impacts will be **low to high**. Using the numerical ranking scheme, traffic impacts are expected to produce a negative rank of -13.0 on a scale of ±6-15.

4.3.5 Findings and Recommendations from Traffic and Transportation Assessment

What we know: An increase in traffic is associated with an increase in risk for motor vehicle accidents that can involve cars, pedestrians, and bicycles. The risk of severe injuries in motor vehicle accidents increases as the speed of traffic increases. Increased traffic also increases air pollution and noise levels.

What we do not know: We do not know if Battlement Mesa has dangerous traffic spots or the normal pedestrian/bicycle patterns.

Recommendations to Reduce Impacts to Public Health from Traffic and Transportation

Based on these findings, the following are some of the suggested ways to reduce the potential impact of traffic and transportation.

1. Require Antero to build water treatment facility and associated pipelines in advance of well development, to immediately remove water hauling traffic from PUD.
2. Require Antero to communicate and coordinate with local school district to develop plan for transportation and safety needs of all children going to and from school by car, bus, bicycle and walking during and outside of school zone hours to prevent injury to school children.
3. Reduce truck speed limits to 20 mph in areas where there is existing pedestrian traffic that is not buffered from haul routes to prevent accidents and to reduce the severity of injury should an accident occur.
4. Consider speed control measures on worker ingress and egress routes (ie decreased speed limits, signage, real time speed measurement signs, photo speed ticket vans, speed bumps or other measures) to prevent workers from speeding.
5. Mark pedestrian/bike high use routes and establish safe crossing zones where they intersect Battlement Mesa Parkway or other haul routes to alert drivers of potential pedestrians and bicyclers.
6. Install safety measures (ie, signaled cross walks, elevated side walks, green space buffers) for pedestrians/bikes where established waking/biking routes overlap/run along haul routes to prevent accidents.
7. Request that the Garfield County Sheriff's Department or other qualified entity to review Antero's Traffic Impact Analysis and request feedback on possible safety mitigations and traffic hot spots to ensure the plan has is protective of public health.
8. Require safe driver training for workers and implement penalty system for unsafe drivers, to encourage safe driving.
9. Require Antero to have a system to identify and remove unsafe drivers to prevent accidents and injuries.
10. Provide Sheriff's Auxiliary Unit with authority to log speeding and unsafe driving incidents and complaints within the PUD, which can be provided to Antero, subcontractors and the Sheriff's department so that problems can be resolved, to identify unsafe conditions.

The recommendations to address information gaps are in Section 5.

4.4 Assessment of Noise, Vibration, and Light Pollution on Health in Battlement Mesa

> "I am concerned that noise and vibration will affect my sleep. Will these be addressed?"
> *June 15 stakeholder meeting*

Increased noise, vibration, and light are common concerns for citizens near construction and industrial sites. At natural gas sites noise and vibration can occur in the construction phase, drilling and completion phases, and due to truck traffic. Light pollution can occur due to 24 hour lighting during development and production operations. Because of these sources, noise,

vibration, and light concerns have been expressed by Battlement Mesa residents at stakeholder meetings.

COGCC Rule 802[48], based upon the State of Colorado Noise Ordinance[49], states that pad construction operations are considered industrial sites and site noise may not exceed 80 decibels (dB) in the day and 75 dB at night. Residential noise must not exceed 55 dB in the day and 50 dB at night. COGCC Rule 803[50] states "site lighting shall be directed downward and internally so as to avoid glare on public roads and building units within seven (700) hundred feet." COGCC does not have a rule limiting ground vibration, but according to the US Department of Transportation ground vibration is generally not felt below 65 VdB and annoyance can be experienced at 70 VdB[51].

According to EPA research, construction equipment can produce noise ranging from 80-89 dB at a distance of 50 feet and 60-69 dB at 500 feet[52]. Heavy construction equipment can cause vibration of 85 VdB 50 feet from the source[51].

Because there is a potential for noise, light and vibration to exceed COGCC rules and background levels, a review of potential noise, vibration and light impacts is warranted.

4.4.1 Noise, Vibration, Light pollution and Health

Both acute loud noise and chronic lower level noise have been associated with a variety of negative health effects. Hearing loss and impairment are known to occur as a result of exposure to acute, high decibel noise (greater than 85 dB). The odds of hearing loss increase as the decibel level increases. A dose relationship between noise level and hearing loss exists[53].

Studies looking at the relationship between noise and cardiovascular disease, hypertension, psychological symptoms, and respiratory impairment are numerous. Reviews and meta-analysis of these studies conclude that noise has the potential to impact these health outcomes[54-57]. Cardiovascular risk factors have been shown to be impacted by noise levels in the range of 51-70 dB in persons with several years of exposure[58].

Noise annoyance can lead to stress related impacts on health such as feelings of displeasure, interference with thoughts, feelings, and activities and disturbed sleep and can have impacts on mood, performance, fatigue, and cognition[59]. Noise levels that produce these impacts can vary: annoyance can occur at 55dB; school performance can be impacted at 70 dB; and sleep can be impacted by as little as 35-60 dB. Ground vibration and low frequency noise may cause health impacts similar to those associated with noise annoyance.

Establishment of causal relationships between noise/ vibration and health impacts is complicated by the fact that noise annoyance in particular can vary with pitch, frequency, and duration. In addition, individual adaptation to noise can vary and complicates subjective reporting as well as expected outcomes.

Preliminary research suggests that light at night may affect health by disrupting normal circadian rhythms[60-61]. The International Agency for Research on Cancer has listed shift work a Class 2A (probable) carcinogen based on epidemiologic links to breast cancer. Mechanisms for the health effects of light at night are actively being studied and include altered melatonin and other hormone release[62].

4.4.2 Current Noise, Vibration, and Light Conditions

Residences in Battlement Mesa are located one mile or more from Interstate-70 and are not likely to have noise impacts from this source. As such, background noise is likely to be comparable to other non-industrial, rural/semi-rural communities. In 2002, La Plata County, Colorado conducted noise sampling in rural, residential, traffic corridors and light industrial areas[63]. Twenty-four hour residential subdivision noise ranged from 37-53 dB, with an average of 42-45 dB. Traffic corridors ranged from 55-65 dB, with an average of 57 on a state highway and 45 on a collector road. Battlement Mesa neighborhoods are likely to have noise levels similar to those measured in La Plata County. Likewise, night time light is likely to be similar to other residential areas, consisting of municipal street and outdoor home lighting. Baseline lighting measures for Battlement Mesa do not exist.

Some residences in Battlement Mesa, however, may already be proximate to natural gas production sites located outside the PUD and maybe experiencing or have experienced noise and light trespass elevated above background in relation to this development. There not currently any significant sources of vibration within the PUD.

4.4.3 Antero Drilling Plans in Battlement Mesa and Noise/Vibration/Light

Sources of noise will include: large truck traffic; road and well pad construction machinery; diesel engines used during drilling; fracking and completion stages; and drill rig brakes. Antero has stated that they will use electric engines for some drilling operations within the PUD but that diesel engines will be used for all completion activities. Antero indicates that well pads are expected to be at least 500 feet from residences and much well pad noise will be abated by distance. However, without ancillary noise abatement, it is likely that the Antero project will produce noise above background, and possibly above COGCC levels, during the construction and well development phases and during well maintenance (workovers). The topography of the land may play an important role in increasing or decreasing noise emanating from the well pad. Noise is expected to range from intermittent (traffic and drill rig brakes) to continuous (diesel engine use during drilling and fracking) for several weeks to months. Drilling and associated noise will also round the clock. Although specific distances from truck haul routes to schools is not available, rough estimates indicate that schools are roughly 1,000 feet or more from truck routes and may not experience significant noise impacts. Residents living less than 500 feet from truck routes, such as along CR 300 (Saddleback Village) or West Battlement Mesa Parkway (Willow Creek Village), are close enough to experience noise that could be between 65

and 85 dB when trucks are passing, at times 9- 12 times per hour or more. These areas could experience some associated intermittent vibration as well.

Because drilling operations occur round the clock, the well pad is lighted and may contribute to light at night at nearby residences. Elevated light levels would be expected to last throughout the drilling period for each pad. In addition, Antero may choose to light well pads for security reasons.

In community meetings, Antero has described possible noise and light abatement strategies. According to meetings documents and the Surface Use Agreement, Antero is not planning centralized compression (a significant noise source). Well head compression if utilized will be housed with noise suppression equipment. Other noise abatement strategies may include use of hay bale walls around the pad, noise blankets for diesel engines, and electric grid power for drilling. Antero documents also indicated possible use of drill rig placement strategies and sodium vapor lights to decrease light trespass. At this time, it is unclear which of these mitigations will be included in the Major Land Use Impact Review and Comprehensive Drilling Plan permit application. However, because Battlement Mesa currently enjoys very low ambient noise and light levels, the Antero project will likely produce noise and light above ambient levels during construction and well development/workover stages and along haul routes, and may at times exceed COGCC rules.

4.4.4 Characterization of Noise, Vibration and Light Impacts

The impact of noise due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable Populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Noise, Vibration, Light	Negative (-)	Local	No	Long	Frequent	Possible	Low-Medium	-10.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated noise, vibration, and light exposures associated with the Antero development within the Battlement Mesa PUD, noise, vibration and light may produce **negative** health effects. Of the three, noise is likely to be the significant health driver. Distance and light mitigations should decrease light at night to the point where there are not significant health impacts. Vibration may occur as a result of truck traffic but health effects are more likely to be due to noise annoyance in these situations. While all or most parts of the community may be proximate to noise sources at different times, it is not likely that the entire community will be

affected by noise during the development of an individual pad or by truck traffic. There are some residents close to haul routes that may experience elevated noise due to truck traffic for five years or more. Noise impacts will therefore be **local** to areas in close proximity to the development areas and areas close to truck traffic routes. There are **no vulnerable populations** in Battlement Mesa, although truck traffic passing by the St. John Elementary School and the Grand Valley Middle School may be disruptive during school hours. The elevated noise is expected to be associated with construction and development phases and with truck traffic on haul routes. The pad development phases will last several months, while nearby truck traffic may last several years for some residents, and so, duration of exposure is expected to be **long** depending on location. Significant noise levels are not expected during normal production phases in the years subsequent to well development. Should reworking of wells be conducted, noise levels are expected to increase, again for several months, during the reworking phase. When noise occurs is expected to occur **frequently** as it will be constant and/or frequently reoccurring. It is unlikely that residential noise will be loud enough to cause noise induced hearing loss or long enough in duration to impact cardiovascular disease. In general, health impacts are likely to result from annoyance due to noise above background and may cause sleep disturbance, displeasure, fatigue, etc. It is not likely that medical attention will be necessary for most people, although some may seek medical assistance. Therefore the health effects are rated as **low-medium magnitude**. It is possible that in some individuals, noise levels will produce significant annoyance and may produce larger health effects. Using the numerical ranking scheme, noise/vibration/light impacts are expected to produce a negative rank of -10.5 on a scale of ±6-15.

4.4.5 Findings and Recommendations from Noise, Vibration, and Light Assessment

What we know: Noise can have negative effects on public health that can vary at the individual level. Background noise levels in Battlement Mesa are low.

What we do not know: The potential noise levels at COGCC and Antero's proposed set backs and along truck haul routes are not known.

Recommendations to Reduce Impacts to Public Health from Noise, Vibration, and Light

Based on these findings, the following are some of the suggested ways to reduce the potential impact of noise, vibration, and light pollution.

1. Reduce speed limits for trucks within the PUD to 20 miles per hour to reduce noise and vibration levels.
2. Require best available noise reduction technology for heavy equipment, including trucks and truck brakes, to reduce noise levels.
3. Require Antero to alert residents of anticipated noise, including time, duration, decibel levels, and machinery to be used to protect public health.

4. Require Antero, in cooperation with Battlement Mesa residents and GCPH, to develop and implement a plan that includes a variety of noise control strategies to address the Battlement Mesa resident's noise concerns to protect public health and to prevent long-term nuisance noise levels.
5. Provide residents the option of requiring Antero to install permanent/semi-permanent noise mitigation structures (sound walls) along haul routes CR300 and other routes where trucks are anticipated to be passing throughout the development period to reduce noise levels.
6. Consider installation of traffic noise barriers near the St. John Elementary School and Grand Valley Middle School to reduce noise levels at schools.

The recommendations to address information gaps are in Section 5.

4.5 Assessment of Impacts on Community Wellness

> Will the development have impacts on education? What will be the mental health impacts? Will there be more or less services in the community?
> *February 3, 2010 stakeholder meeting*

Residents of Battlement Mesa are concerned that the Antero project may affect the well-being of their social and community environment. Current epidemiologic literature cites a myriad of challenges in understanding the specific effects of the community and social environment on individual physical and psychological health. Largely, this is due to the difficulty in analyzing the separate and complex processes through which community and individual factors work together to influence health[64-65]. As such, it is difficult to identify and measure community factors which may influence health and well-being independent of individual level risk factors. Never the less, it is widely accepted that societal factors contribute to the health status of individuals through either the promotion or hindering of healthy choices and behaviors, and it is the collective health of individuals which contribute to the broader sense of community well-being among residents[66-67].

While there is no single determinant or definition of a healthy community, the CSPH team assessed current community wellness conditions through societal-based factors which were expressed as concerns by Battlement Mesa citizens. School enrollment, crime rates, prevalence of substance abuse, prevalence of sexually transmitted infection, and social service availability were assessed as surrogate measures of community health. Other measures of quality of life, such as the availability of and participation in recreational activities and the depth and breadth of active social networks, may also speak to the health status of a community, but these are more difficult to codify with data.

4.5.1 Current Community Wellness Conditions

Primary data on several baseline community health characteristics were collected and are cited and described in detail in Appendix C, including data on school enrollment, criminal activity, mental health and substance abuse, and sexually transmitted infections. The years 2005-2008 appear to be a period of increase for several of the measures observed. During this time, school enrollment in Garfield County's District 16 increased by 37.4%. There was a substantive change in the racial/ethnic distribution of students enrolled during this time, demonstrated by the decrease in the proportion of Caucasian/non-Hispanic students accompanied by a rise in the percentage of Hispanic children. Criminal activity was elevated during 2005-08, with a calculated average of over 300 arrests per year during that time. Chlamydia and gonorrhea counts in Garfield County steadily increased during the 2005-2008 time period. However, counts for Battlement Mesa varied, with a larger number of cases occurring in 2007 and 2008. For the purposes of community health monitoring, is important to review these data prospectively to evaluate future changes and trends.

Longitudinal data on mental health, substance abuse and suicide were not available for similar analysis. Results from a 2006 public health survey conducted by the Garfield GCPH found that upwards of 17% of residents were burdened by at least one of these conditions. Further, in many cases, when respondents reported experiencing mental health problems (defined as experiencing depression or stress), they also reported difficulties coping with substance abuse issues and engaging in physical activity[68]. A 2006 study of hospital discharge data for Garfield County regional hospitals found that 275 persons had been hospitalized for alcohol/substance abuse or suicidal behavior during the period 2003-05. Of those 275, 47 (17.1%) had an alcohol/drug abuse diagnosis and 228 (82.9%) had a diagnosis of suicidal behavior [69].

To meet area community health needs, Garfield County operates a comprehensive Public Health Department (the GCPH) with locations in Rifle and Glenwood Springs[70]. Battlement Mesa residents are eligible for all services provided by the GCPH. Some services relevant to the community health measures discussed include:

- General health education and screenings
- Communicable disease surveillance
- STD/HIV screening
- Crisis support hotlines for domestic violence, suicide and mental health
- Tobacco prevention
- Emergency service and assistance
- Adult education programs
- Human services, including employment, food and housing assistance programs
- Services of a designated environmental health department, including the C.A.R.E.S. project for responding to community concern about environmental health issues

4.5.2 Antero Drilling Plans in Battlement Mesa and Community Wellness

While numerous case studies and assessments have been done around boomtown and industrial effects on psychosocial and community health, very little peer-reviewed research has looked at the relationship between natural gas development and production exposure and social-based health effects, and the existing literature appears to be mixed. While there are several studies providing evidence that exposure to natural gas development and production can have negative psycho-social health implications, there are also studies that find positive effects[71 72-75]. Additionally, there are a few studies that find no association at all between natural gas development and production and social and psychological health[17, 76]. Based on the current state of this literature, it is difficult to estimate social and community health effects related to natural gas development and production.

There is some literature available which discusses the relationship of "boomtown" economies and community health. According to information provided by Antero, the workforce for Antero's project is likely to average 120-150 workers. The impact of the Antero workforce may produce some "boomtown" effects, but the magnitude of these effects will depend a great deal upon the makeup of the workforce (number of single men, number of families, living in or out of Battlement Mesa, etc.). Some commonly recognized social impacts of boomtown economies, many of which can be attributed to rapid increases in population and changes in the economic base, are: stresses on local government support and planning agencies; shortages of permanent housing units; and changing employment and business trends, both positive and negative[77]. The social problems of mental health, criminal activity, divorce, suicide and alcoholism are said to occur at disproportionate rates in boomtown economies compared to non-impacted communities[77]. Boomtown literature also describes disruptions in social cohesion due to population influx and the likely opposition that arises between the "new comers" (both temporary and permanent new residents) and the "old timers"[77]. However, both groups are vulnerable to combination of positive and negative community impacts.

Due to limited availability of readily accessible data measures, only the following topics were assessed to address uncertainty and community concern for community impacts of Antero's project.

***Education*:** Inherent with changes in population come changes to school enrollment; increased population generally leads to an increase in the class size, which may dictate an increase in the ratio of students-to-teachers. Larger class sizes also put a strain on the physical aspects of educational facilities with increased wear-and-tear on furniture, books and equipment and need for more physical space. Influx of a semi-permanent or long-term work force coupled with a booming local economy could increase local school enrollments beyond capacity and expected annual growth rates. Increase school enrollment may also have positive effects in that the schools may qualify for increased funds to improve educational services and options.

***Crime*:** Several research studies have correlated increased crime rates with communities involved in natural gas development and production, including crimes such as domestic violence,

rape, prostitution, assault, child abuse, and homicide[72-75]. Because jobs in natural gas development and production usually attract a transient workforce, residents in affected communities often attribute increasing crime rates to the industry workers. On the other hand, there has also been some literature reporting lower crime rates after the commencement of natural gas development and production [71] and some research arguing that there is no association at all between natural gas development and production and social and psychological health outcomes[17, 76]. Due to the uncertainty and potential for high impact on community residents, it is important to examine and monitor the available crime data for Battlement Mesa.

***Substance Abuse*:** Several studies have reported an increased burden of substance abuse behaviors in communities involved in natural gas development and production, with primary emphasis being that substance abuse is prevalent among workers in the oil natural gas development and production [71, 75, 78]. In some cases, increased illegal substance activity has been associated with seasonal increases in natural gas development and production [79]. At the local level, a 2006 survey of EnCana subcontractors working in Colorado, conducted by White River Counseling, reported that 66.3% of subcontractors were concerned about methamphetamine use among their employees, and 68.9% were concerned about heavy drinking. Concern was rated primarily with respect to productivity and workplace safety, however questions about community impact were also assessed. Notably, the respondents who reported higher levels of concern about the potential impact of employee substance abuse affecting the local community also had stronger feelings about being proactive to prevent alcohol and drug abuse[80]. While not a conclusive study, this indicates that workers may be receptive to substance abuse prevention and intervention efforts presented as part of a community health initiative. For these reasons, it is important to monitor whether drug and alcohol use among community residents shifts with the introduction of gas drilling.

***Mental Health and Suicide*:** Treatment for mental health conditions and suicidal tendencies is conducted predominantly in the outpatient setting. As such, hospital discharge data for these and related conditions generally do not reflect the true burden of these issues in any given community. Additionally, due to their highly sensitive nature, outpatient data for these issues at the local community level is not publicly available. Studies of the community impacts of boomtown industries do not offer clear evidence for direct impacts to mental health, other than to suggest that changes in other measures may add or subtract from the levels stress, worry, and satisfaction experienced by individuals in the community[77, 79].

***Sexually Transmitted Infection*:** In any population, sexually transmitted infections are an important public health prevention priority. Undetected and untreated infection with certain sexually transmitted infections can cause long term health problems. As described by the National Institute of Allergy and Infectious Diseases, some of the health complications that arise from sexually transmitted infections include pelvic inflammatory disease, infertility, tubal or ectopic pregnancy, cervical cancer, and perinatal or congenital infections in infants born to infected mothers[81]. In addition, syphilis and HIV/AIDS cause substantial health problems in all those infected. In addition to long-term health effects of acquired sexually transmitted

infection's, there are the daily consequences of pain, discomfort, and often embarrassment. Loss of worker productivity is also a concern with sexually transmitted infection, due to time required away from work to access testing, and received results and treatment, a process which may involve two days off work depending on travel distance to the nearest confidential testing/treatment center[82-83].

Increases in the community burden of sexually transmitted infection have been identified as a health effect of extraction industries in many low- and middle-income countries [82-83]. The same association has not been causally established by research conducted in relation to North American energy-extraction; however, it stands to reason that this is an area which should be monitored. Key factors perceived to increase the spread of sexually transmitted infection with the influx of extraction-industries include the transient nature of the in-migrant worker population who are away from social controls of their home community, the long and difficult work days possibly fostering desire for drug and alcohol binges during time off, and high salaries and disposable income in a young work-force[82-83]. These contributing factors are concerning given the difficulties often experienced in providing sexually transmitted infection prevention and treatment for an itinerant natural gas development and production workforce. In addition to the inherent stigmas often associated with sexually transmitted infection testing/treatment, workers cite lack of access to sexually transmitted infection services due to geographic isolation from sexually transmitted infection services, lack of available walk-in testing and sexually transmitted infection clinic hours overlapping with their own working hours[82-83].

***Lifestyle/Recreation*:** Many residents of Battlement Mesa seek the enjoyment of outdoor recreational activities, and thus expressed concern over potential impediments to participating in activities such as hiking, biking, fishing, hunting, and golfing. Negative effects to community engagement in these activities would likely be due to changes in the surrounding wilderness and public lands that may be caused by natural gas development and production. We were unable to assess whether public access to recreational activities would be altered by this project, and the extent of potential environmental effects are not known at this time. In addition to outdoor recreation, Battlement Mesa offers residents a 53,000 square-foot indoor recreation facility. An increase in local population may raise membership at the activity center, however this is not expected to supersede capacity as the facility was designed and built as part of the planned community of Battlement Mesa[11].

***Social Capital/Social Cohesion*:** Perhaps the biggest contributor to the social cohesion of Battlement Mesa is its status as a "planned community", where business, schools, and facilities and access for recreation are cohesively integrated with residential living[11]. Well-planned combinations of built and natural environments promote social interaction and pride in community living, which are in turn determinants of mental health and well-being[66]. Strong social support and community networks have generally positive effects on physical and mental health of individuals[84]. As such, effects on the social cohesion of Battlement Mesa residents may be determined and intertwined with physical effects to the community itself, such as damaged or neglected roads, neighboring homes and businesses, public lands and parks. There is limited

data available to directly assess the functioning level of social capital and cohesion in any community, yet surrogate measures can be monitored. These include many of the issues already discussed, as well as monitoring access and use of public health and social services. As population of an area changes or grows, it is expected that the infrastructure of services rendered to that community may need to adapt to meet increasing or changing demands

4.5.3 Characterization of Community Wellness Impacts

As described above, community wellness is characterized by a compilation of factors such as school enrollment, rates of sexually transmitted infection, incidence of criminal activity, burden of substance abuse, and other immeasurable factors such as quality of life, social cohesion, and social capital. For the purposes of this project, the impact due to the Antero project in Battlement Mesa on the community wellness of local residents was calculated as a single factor as follows:

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Community Wellness	Mixed (±)	Community Wide	Yes	Long	Infrequent	Possible	Low to Medium	±11.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

Community health effects are expected to be **mixed**, both positive and negative. Positive effects might include less stress over finances if increased demand for local business trickles down through the local economy, and increased access to social resources, services and infrastructure expanded to support a growing and changing population[77]. Negative effects that may be experienced include stresses associated with perceived or real increased threat of crime, heavier industrial traffic and visible impacts to natural environment and recreation areas. Community impacts would be expected to be **community-wide,** affecting the entire geographic extent of the Battlement Mesa PUD equivalently. It is possible that the elderly or youth of the community are more **vulnerable** to impacts of community well-being. Elderly may be more vulnerable to crimes of theft or burglary, and are the likely group most affected by changes in social service availability and accessibility. Children would be most affected by changes in school enrollment and class size. They may also be affected by changes in outdoor areas used for play, which may overlap with areas prone to more industrial activity or along roadsides used more frequently for hauling drilling materials. We expect the community impacts to continue for the duration of Antero's project (five years), and therefore be **long**. Because the Antero project is relatively small, it is expected that exposure to altered community wellness will actually be **infrequent**. The overall magnitude of health effects is **low to medium**. This assessment is made based on

the nature of community impacts, which do not often present through acute mechanisms. Given adequate coverage and support offered by social infrastructure, we expect the residents of Battlement Mesa will be able to successfully tolerate and adjust to community well-being impacts. Using the numerical ranking scheme, community wellness impacts are expected to produce a negative rank of -11.5 on a scale of ±6-15.

4.5.4 Findings and Recommendations Related to Community Wellness

What we know: A variety of physical and social factors impact the health of a community. The little information available on these physical and social factors for Battlement Mesa show the community is in good health, as compared to the population of Colorado.

What we do not know: We do not know the actual population count, demographics, physical and social health specific to the Battlement Mesa PUD because information has not been collected at this level. In addition, several physical and social health measurements are not routinely monitored.

Recommendations to Reduce Impacts to Community Wellness

Based on these findings, the following are some of the suggested ways to reduce the potential impact to Community Wellness.

1. Establish a mechanism to facilitate on-going community engagement between Antero, GCPH officials and residents of Battlement Mesa for early identification of impacts to community wellness.
2. Review sexually transmitted infection clinic access, outreach and education, with particular attention to in-migrant workforce to reduce spread of sexually transmitted infections within the community.
3. Identify employers that have implemented drug and alcohol free work-place programs and encourage other employers to do so to reduce drug and alcohol abuse. Provide education to employers regarding benefits of such programs.

The recommendations to address information gaps are in Section 5.

4.6 Assessment of Economic and Employment Impacts on Health in Battlement Mesa

> ***Will a boom and bust cycle occur? We are now in a bust and the food banks drying up.***
> *February 3, 2010 stakeholder meeting*

Economic conditions of a region can have significant impact on the health of the population. Employment status can impact individual health and well being and economic uncertainty can impact health by increasing stress. Economic development of poor and rural areas is often credited with bringing resources that support health; however "boom town" growth related to natural gas development in Garfield County and other parts of the West have had mixed economic impacts. Residents of Battlement Mesa have expressed concerns that sudden economic growth within their community may negatively impact the community by causing housing and goods inflation, and impacting services. Others in the community are concerned that gas industry development will decrease the appeal of the community and cause a decrease in home values. A review of economic and employment impacts of the Antero gas project in Battlement Mesa is warranted.

4.6.1 Economy, employment, and health

Income and employment influence many central determinants of health and wellbeing, including quality of housing, education, diet, lifestyle, access to health services, etc. Income sufficient to support these basics is strongly related to life expectancy: internationally, annual per capita income above $5,000- $10,000 translates into decades of increased longitivity for the population[85]. For individuals, employment is directly related to positive health outcomes[86] and stress related to job loss, unemployment, and job instability is strongly correlated with self-report of poor health[87]. In addition, in the Untied States, health insurance access is directly related to employment for those under the age of 65. Loss of insurance can lead to decreased health care access and poorer health.

Increased economic activity of a region can increase tax revenues which in turn can be used to support public services, thereby enhancing community wellness. However, if an economy grows too fast, it can create excessive demands on public services and community wellness can suffer. In addition, housing prices and property taxes can rise in response to growing local economies and stress finances of local residents, particularly those on fixed incomes. Increased wages and growing populations associated with new industry can increase demand for all goods, can also create price inflation, which in turn can impact residents' ability to maintain health.

Furthermore, if economic booms are followed by economic busts, loss of resources and jobs can devastate community and individual wellbeing. Repeated boom/bust cycles, where jobs, wages, and services are recurrently out of balance, can lead to significant community stress.

4.6.2 Current Economic and Employment Conditions

Housing prices in Battlement Mesa have been rising steadily over the last decade and have increased faster than average income. In 2008, the estimated median value for a house or condominium was $201,116, nearly 150% higher than estimated values in 2000 ($136,100). Meanwhile, the estimated median household income in 2008 was $42,882—up 17% from the median income in 2000 ($36,680), but still lower than the estimated 2008 state average

($56,993)[88]. Housing price inflation was for the most part due to the regional natural gas boom. The decline of natural gas development in 2008-09 has relieved some pressure on housing prices and availability.

In 2008, Battlement Mesa had a lower poverty rate than Colorado (6.0% vs 9.3%). Primary industries for males is construction, mining, natural gas development and production, and accommodations, and for females health care, education, and food and beverage stores[88].

Residents in Garfield County generally rate themselves to be in good health. In 2008, the Saccommano Institute conducted a survey of Garfield County residents. The results found that 85% of residents surveyed perceived themselves to be in excellent or good health, and that about 76% of those surveyed reported feeling about the same or better level of health than one year prior. Similar results were recorded for the Battlement Mesa/Parachute zip code, with approximately 83% excellent or good health[23].

4.6.3 Antero Drilling Plans in Battlement Mesa and Economics and Employment

Natural gas development has created boom economies in Wyoming, Colorado and other regions of the West over the last decade, with mixed economic impacts to local residents and workers. Examination of natural gas boomtown economics in three towns in Wyoming, related to approximately 40-60 operating rigs in the county, revealed that itinerant workers in the natural natural gas development and production benefited the most from high industry wages, while local residents and workers experienced negative economic impacts associated with inflation, increased property taxes and decreased services[89-90]. This boomtown model predicts changes for other communities involved in the natural gas development and production. Some local businesses may benefit from an increase in commerce, but some may not be able to expand to meet demand and quality of service declines. Increased commerce may bring "box" stores and other new businesses, putting more strain on longtime local business, and some may end up closing. Local residents not earning high industry wages may not be able to keep up with rising cost of living, housing prices, property taxes, and other signs of inflation. Such a change in the economy can cause psychological stress to local workers and residents, resulting in possible mood disturbance, disturbance of thought, sleep disturbance, and immune system effects[91]. Because the gas well development phase is very labor intensive, boom economics associated with worker population influx predictably cycles to bust economics when the development phase for the area is over and development moves on to other regions.

The number of workers involved in well development can vary widely according to pad site topography and geology, number of wells per pad, characteristics of the gas, etc. Most workers are employees of companies subcontracted to perform very specific development jobs and remain on a given pad only as long as needed, sometimes only days, weeks or a few months. Antero plans to use two rigs to develop approximately 200 wells in the PUD over the course of five years. This kind of serial operation may keep many of the workers working within the PUD for much of that time, moving from one site to the next as development progresses. Influx of

workers associated with all stages of development during this period is likely to have the most significant economic impact to the area. Once all the wells in the PUD are developed, the workforce needed to maintain the wells over the 20 years of production is relatively very small.

When comparing the economics of the two rig operation in Battlement Mesa to the 40-60 rig boomtown economics of Wyoming and Colorado it becomes apparent that the Antero project is relatively small and the economic benefits and detriments are expected to be small as well. Furthermore, these impacts are not expected to be restricted to Battlement Mesa, but are more likely to be absorbed into the general Garfield County economy. Some workers may live in Battlement Mesa, thereby creating demand for housing, but many may live outside of the Battlement Mesa community as well. Tax revenues from the Antero project will be realized at a county level. By itself, this operation is not likely to create a significant boom economy

Antero estimates of number of workers needed for well development to be an average of 60-75 workers per rig operation .This number is necessarily an average and an estimate and actual numbers of workers are likely to vary significantly from day to day, and well pad to well pad. Once in production, only a small number of workers are needed for routine maintenance of wells.

Economic benefits of higher wages will be primarily realized by industry itinerant workers. The presence of 120-150 workers in the PUD will provide economic benefits to some local businesses, however, these businesses will also be negatively impacted when the development stages are over and the workers leave. Local residents not employed by the industry or supporting businesses may not benefit from economic growth but may be at risk for negative impacts of housing and goods price inflation, rising property taxes and potentially compromised services.

4.6.4 Characterization of the Economy and Employment Impacts on Health

The impact on the economy and employment due to the Antero project in Battlement Mesa on the health of local residents can be characterized as follows:

Impact	Direction of health effects	Geographic Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Employment and economy	Mixed (±)	Community wide	Yes	Long	Infrequent or constant	Unlikely	Low	±10.5*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

Based upon estimates of 100-200 workers for a 2 rig operation over five years, the health effects of the Antero project on Battlement Mesa citizens is likely to be **mixed** with positive effects of

higher wages for some residents and higher inflation and no wage increase for others. Economic impacts are likely to be experienced **community-wide** and those on fixed incomes are more **vulnerable** to the negative effects of inflation. The impacts of increased economic activity are likely to be **long**, lasting at least five years, and the frequency of having a health impact (stress, sleep disturbance) as a result of the economic activity is likely to be either **infrequent or constant**, depending upon the individual circumstances. Given the small economic size of Antero's plan and the probability that the economic impacts will be absorbed into the county, it is **unlikely** that there will be health impacts due to changing economic conditions and the magnitude of any health impacts will be **low**. Using the numerical ranking scheme, economic and employment impacts are expected to produce a mixed rank of ± 10.5 on a scale of ±6-15.

4.6.5 Findings and Recommendations from Economic and Employment Assessment

What we know: Boom and bust industries, such as natural gas development and production, can affect public health through rises and falls in the local economy and employment. However, Antero's project within the PUD is too small to initiate a boom and bust cycle.

What we do not know: We do not know the affect Antero's plan will have on housing prices within the PUD.

Recommendations to Reduce Impacts from Boom and Bust Cycles

Based on these findings, the following are some of the suggested ways to reduce the potential negative aspects and maximize potential positive aspects from economic and employment impacts.

1. Review local tax structure to ensure that revenue from natural gas development and production are used to mitigate impacts in areas most affected by the industry development in order for the community to realize the economic benefits.
2. Continue to consider public health as a high level priority when judging uses of local government revenues derived from the natural gas development and production to maximize protection of public health.
3. Engage in long term planning to maintain affordable housing, education, and public services to protect residents from sudden industry downturns (e.g. the bust).
4. Consider mechanisms for providing property tax relief for residents on fixed income should home values rise rapidly to reduce negative economic impacts.
5. Engage local educational institutions to provide industry related training so that local residents can be employed by the industry.
6. Engage local educational institutions to provide retraining for residents employed by the industry so that they can find future employment when industry development is complete and development jobs are no long available locally to reduce impacts from sudden industry downturns.

The recommendations to address information gaps are in Section 5.

4.7 Assessment of Impacts to Health Infrastructure in Battlement Mesa

> "What will be the impacts to health care in Battlement Mesa?
> *February 3 stakeholder meeting*

Health infrastructure can include private and public medical services, hospitals, and emergency transport services. Availability, access and quality of local clinical and public health services can be limited in small communities, due to small populations, low rates of insured patients, and limited public resources. New industry can lead to positive and /or negative impacts on the health care infrastructure. Industrialization of a rural community can increase the insured population and local revenues, which may provide resources for expansion of local clinical and public health care services. On the other hand, without substantial investment in health infrastructure, population and employment changes may increase both clinical and public health care utilization, stretching already limited resources. The citizens in the rural community of Battlement Mesa have expressed concerns that development of natural gas resources in their community may negatively impact available medical resources. Because the Battlement Mesa health infrastructure may be exposed to utilization changes, a review of potential health impacts is needed.

4.7.1 Private and Public Health Services and Health

Availability, access and quality of medical health services can have direct impacts on individual physical health. Research demonstrates that residents of rural communities often have decreased clinical health care services available to them, negatively impacting health [92-95]. Limited availability can be due to a combination of small population and low health insurance coverage, both of which limit the financial viability of both clinical and public services. As a result, residents of rural communities may need to travel long distances for care.

Increased economic activity in a community may bring more patients and insurance coverage which can support increased and diversified clinical medical services. On the other hand, a rapid increase in population, particularly uninsured population, can increase utilization of services beyond capacity and may strain the finances of small medical facilities and decrease incentive to increase services[77].

Public health programs provide services to the general community and can fill some gaps for the un-insured[96-97]. Vaccination programs, health screenings, and communicable disease clinics provide limited clinical health care to uninsured populations. Public health programs that focus on food safety programs and health education programs benefit the community at large. When the local population increases, particularly an uninsured population, local public health services

may experience increased utilization while capacity may lag or never catch up. Cyclical economic conditions may also cause intermittent strain on public health programs while making it difficult to adjust capacity to need. On the other hand, local revenues may be able to increase public health services, should tax and royalty structures and community priorities permit it. In some cases, severance taxes from extractive industries are sent to state agencies, with little benefit to the localities where the industrial activity is occurring[77].

4.7.2 Current Health Infrastructure Conditions

Currently, primary clinical health services in Battlement Mesa include a primary care clinic administered by the Grand River Hospital District, staffed five days a week by family medicine providers and visiting specialists. The clinic also provides physical therapy services three days a week. There is also separate chiropractic, orthopedic, and dental services in Battlement Mesa. There are four hospitals within 60 minutes of Battlement Mesa. The closest hospital is Grand River Medical Center in Rifle, 20 minutes away. This is a 12-bed hospital with an emergency room, surgical, acute care facilities, and outpatient clinics. Grand River Medical Center is a Level 4 trauma center; it does not provide have obstetric (baby delivery) services. Valley View Hospital in Glenwood Springs, 46 miles away, has 80 beds, a 24 hour emergency department, and obstetric services. Community Hospital in Grand Junction, 48 mile away, has 78 beds and does not provide obstetric services. St. Mary's Hospital in Grand Junction, 49 miles away, is a Level 2 trauma center and has obstetric services. The closest Level 1 trauma center is 4 hours away in Denver. Patients needing such services may be airlifted. Emergency response and transport is provided by the Grand Valley Fire Protection District. There is an occupational health clinic operated by Grand River Hospital District in Battlement Mesa that sees work related injuries five days a week.

There is a 40 room assisted living facility in Battlement Mesa. The closest skilled nursing facility is in Rifle and there are other nursing facilities in the county. Meals on Wheels is offered in Battlement Mesa and a senior center in Parachute offers lunch daily.

Public Health services for Battlement Mesa citizens are offered by GCPH. Services include vaccination clinics, communicable disease surveillance, health education programs, safety programs, health screening for Medicaid patients, and programs for underinsured children and low income families. The Environmental Health Program serves the public by evaluation and education regarding environmental health risks related to air and water quality, sewage treatment, mosquito control, and environmental sustainability. The GCPH offices are located in Rifle and Glenwood Springs.

Insurance coverage rates for Battlement Mesa residents are not available. According to the Colorado Household survey conducted in 2008-9 by the Colorado Department of Health Care Policy and Financing[98], 14% of Colorado residents were uninsured and in the five county region that included Garfield County, 21% of the population was uninsured (the highest in the state). In

Colorado, 15% of employed adults were uninsured. Insurance status for natural gas industry workers is unavailable.

4.7.3 Antero Drilling Plans in Battlement Mesa and Healthcare Infrastructure

The development of natural gas wells requires several labor intensive phases, which can last several years for large natural gas projects. Most health infrastructure impacts relate to the expanded workforce during the well development phase. Antero estimates an average of 120-150 workers will be working in Battlement Mesa.

Workers associated with natural gas development and production projects can increase utilization of emergency services due to increased work related and transportation related accidents associated with the injury[77]. Insured natural gas workers utilizing the health care system could provide positive support to the system as long as the utilization does not exceed capacity. Should utilization exceed capacity, then the availability of services may be negatively impacted. Uninsured workers strain the health care system. Public health programs may see an increase of utilization as a result of an increase the insured and uninsured population. On the other hand, pubic health programs may benefit from increased local revenues, as long as utilization does not exceed capacity. Should this happen without increased supporting revenue dedicated to public health, then services may be compromised. The cyclical nature of the natural gas development and production, which is dependent upon market influences, technological advances and regulatory forces, can make both clinical and public health infrastructure planning difficult and lead to a mismatch between needs and services.

Workers and their families are expected to utilize clinical and public health services in Battlement Mesa and other local services. According to Antero representatives, Antero workers are offered health insurance; however, information regarding health insurance coverage for subcontracted workers (the majority) is not available. Some clinical services may see a disproportional increase in utilization, including emergency, urgent care and trauma services and services related to pediatric care for young families. Depending on the insurance status of the workers, these services may or may not be directly supported by the industry. Clinical and emergency providers may be negatively impacted by uncompensated care, and public health services may see an increase in local needs without increased funding. Utilization of health services by insured gas workers will support the health system. Revenues to Garfield County could be used to support public health services, depending upon prioritization of needs.

4.7.4 Characterization of Healthcare Infrastructure Impacts

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects as a result of Project	Magnitude of health effects	Rank
Health Infrastructure	Mixed (±)	Community-wide	Yes	Long	Infrequent	Unlikely	Low	±10*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering anticipated impacts to local health infrastructure associated with the Antero development within the Battlement Mesa PUD, the increase in workforce and the associated potential health care utilization could have **mixed** health effects in Battlement Mesa community; however, impacts to the health care system are anticipated to be small given Antero's project only involves 120 to 150 workers, spread into a community of approximately 5,000 in Battlement Mesa and 55,000 in Garfield county. There is a potential for increased utilization of the health care services to strain existing services, however, the extent of such a strain may be small enough that it is unlikely to lead to decreased availability and quality of services. Likewise, insured workers will support local health services but the extent of such support may not be sufficient to lead to increased availability and quality of services. Local tax revenues from the Antero project will contribute to the overall county fund are not likely to be large enough to directly impact public health services in Battlement Mesa. Impacts of uninsured workers are likely to be noted by providers, but it is unclear that this would reach a level that would negatively impact either clinical or public health services. Should health services be impacted in Battlement Mesa, the impacts would affect the **entire community**, although those that utilize health care services most frequently such as the elderly, young children and disabled may be more **vulnerable** to negative impacts such as decreased availability. Likewise, those groups may benefit from expanded health care services. Should health service impacts occur, they are likely to be noted in the first few **years** of Antero's project as the health infrastructure adjusts to new needs. Impacts to the health care infrastructure are not anticipated to last the entire duration of Antero's project. The frequency of both positive and negative on impacts the health care system and therefore on the community are likely to be **sporadic**, given that the relatively small number of workers and families associated with the Antero project. It is possible that large financial strain to local providers, particularly emergency care providers, could occur should expensive emergent care become necessary for an uninsured worker, but this is anticipated to be an infrequent event. Potential impact to vulnerable groups, the community at large and the multiple years of potential exposure drive a high summary statistic, however, it is **unlikely** that Battlement Mesa citizens will experience positive or negative health impacts as a result of changes to the health care infrastructure related to the Antero project. The overall magnitude of health effects due to health infrastructure impacts are expected to be **low**. Using the numerical ranking scheme, healthcare infrastructure impacts are expected to produce a mixed rank of ±10.0 on a scale of ±6-15.

4.7.5 Findings and Recommendations Related to Health Care Infrastructure

What we know: The availability of healthcare facilities and professionals affects public health. The level of health insurance in an area affects health care infrastructure.

What we do not know: The level of health insurance in natural gas development and production is not known.

Recommendations to Prepare for Impacts to Health Care Infrastructure

Based on these findings, the following are some of the suggested ways to prepare for the potential impact to the Health Care infrastructure.

1. Monitor which companies, including Antero and subcontracting companies, provide health insurance to employees to determine direction of impact.
2. Review county tax structure for adequacy of revenues necessary to meet increased county services, including public health services.

The recommendations to address information gaps are in Section 5.

4.8 Assessment of Accidents and Malfunctions Impacts on Health

> Is there a plan to prevent pipeline leaks and explosions?
> *February3, 2010 stakeholders meeting*

Accidents and malfunctions can occur as a result of a variety of causes, including equipment failure, human error, and environmental hazards. Identification of potential sources of accidents and malfunctions can lead to effective prevention efforts, while recognition of potential health, community, and environmental effects can direct response strategies which can decrease impacts should an incident occur. COGCC addresses accident prevention (fire, explosion, hazardous materials release, pipeline maintenance) throughout the Rules Document[9]. The 600 series rules address safety regulations. For example, setbacks for pad locations are 150 feet in low population density areas, 350 feet in high population areas and 1000 feet for other facilities such as schools, hospitals, etc. Rule 906 specifies reporting, prevention and clean up requirements for spills and releases. Pipeline regulations are found in Rules 1101-1103, however, there is not a designated setback for pipelines in the COGCC rules.

According to the Denver Post, there were over 1,000 spills statewide and over 230 in Garfield County reported to the COGCC between January 2008 and June 2010[99]. There were 21 fires, loss of well control (including gas kicks), and explosions in Garfield County that were reported to the COGCC from January 1997 to August 2010 (COGCC database). The Battlement Mesa citizens have expressed concerns regarding the potential for accidents and spills and the potential

for related health and safety impacts. Because incidents of this nature happen with low, but predictable, regularity, an assessment of potential health impacts is warranted.

4.8.1 Accidents, Malfunctions and Health

Accidents and malfunctions can occur as a result of well installation errors, material failure, construction and operations accidents, equipment accidents and failures, third party activities, and environmental episodes. Incidents can manifest as fires, explosions, hazardous material losses, and/or spills. Fires and explosions may result from well blowouts, gas kicks, pipeline leak or rupture, ignition of flammable materials during storage, transportation or transfer. Hazardous materials spills/loss may be due to transportation accidents or equipment failure, during material transfer, leaking valves, fittings, etc in storage equipment, well blowouts, and improper disposal of hazardous materials. Environmental conditions such as wildfires, tornados, lighting, blizzards, and extreme heat and cold may cause or exacerbate incidents.

These incidents may result in release of contaminants into surface water, ground water, soil, and air. Releases associated with significant accidents and malfunctions are likely to be acute, high level emissions. Releases of produced water into soil and water sources contain salts, metals, VOC/BTEX, drilling fluids, muds and fracking chemicals. Spills of drilling and fracking materials could include a variety of chemicals such as diesel fuel and other hydrocarbons, BTEX, acids, glutaraldehyde, and other proprietary chemicals. Releases of natural gas into water or air contain VOC/BTEX. Combustion products of hydrocarbons released during fires contain PAHs, including naphthalene, sulfur oxides, nitrogen oxides, PM and other chemicals.

Examples of potential health effects of chemicals given sufficient exposure:

Chemical	**Acute health effect**
VOC	Irritant, neurological
Benzene	Neurological, anemia
Naphthalene	Anemia
Combustion Products	Respiratory, cardiovascular, irritants
Hydrochloric acid	Irritant
Glutaraldehyde	Irritant, allergic reactions

In addition to chemical exposures, accidents and malfunctions can expose nearby persons to injury or death. Although outcomes are potentially severe, these exposures are generally short-term, very rare and only those in close vicinity at the time of the accident are at risk. Employees on the well pad during a fire or explosion are at most risk for injury. Although the likelihood of an explosion involving a pipeline occur is very small, persons in the community may be at risk for injury should such an incident occur. An explosion occurred in a rural area of Johnson County Texas on July 7, 2010 when crews installing a communications pole hit a 36-inch gas transmission line. Newspaper reports indicated that one worker was killed, and seven injured.

The fire was reported to be 400-600 feet in circumference and intense heat was felt 900 feet away. The gas line valves were shut off 1.5 hours after the explosion, and the fire stopped. A more recent explosion of a 30 inch gas distribution line in San Bruno, California on September 9, 2010, destroyed 150 homes and killed four people. The cause of this explosion is still unknown. Other accounts of explosions related to natural gas development, production, and distribution can be found in newspaper accounts throughout the country.

4.8.2 Current Conditions for Accidents and Malfunctions

According to the Denver Post, 236 spills in Garfield County were reported to the COGCC between January 1, 2008 and June 15 2010, involving 66,386 barrels of fluids (primarily drilling liquids and produced water)[99]. During that time, Antero submitted approximately 5 percent of the gas permits in Garfield County, reported 15 spills to the COGCC (6 percent of the spills). Antero's contribution of 1707 barrels of fluids to the total barrels spilled in Garfield is small (2.6 percent). Five of Antero's 15 spills have required remedial action and one resulted in a notice of alleged violation (also known as NOAV) because of failure to report the spill to COGCC per the oil and gas rules.

Antero has received three other Notice of Alleged Violations since January 1, 2008. The latest, on July 14, 2010, was in response to several odor complaints filed during flow back operations on the Watson Ranch well pad. Another Notice of Alleged Violation issued on January 04, 2010, resulted from lack of secondary containment of condensate from fracking tanks and observation of condensate lying on the ground around fracking tanks and separation units. COGCC issued a third Notice of Alleged Violation because Antero spudded a well prior to permit approval in June 2009[100].

Local newspapers and COGCC databases have recorded incidents of well fires, blowouts, tanker spills, condensate tank emissions and pit discharges in Garfield County. These incidents have resulted in contamination of surface and ground water with BTEX, and other chemicals. Residents have reported a variety of health effects, including acute and long term neurological complaints, upper respiratory issues, headaches and fatigue, and nausea. There have been no reported fatal injuries related to accidents or malfunctions in Garfield County reported to COGCC.

4.8.3 Antero Drilling Plans in Battlement Mesa and Accidents and Malfunctions

Applying Antero's spill rate of 15 spills per 252 permit applications (6 percent) and rate of 5 remediations per 15 spills to the 200 wells proposed for Battlement Mesa it is estimated that approximately 12 spills of 5 gallons or more may be expected in Battlement Mesa. It can be expected that at least four of these spills may have some impact to soil, groundwater, or surface water requiring remediation and have the potential to impact public health.

As discussed in the Water and Soil Quality Assessment, Battlement Mesa residents use a municipal water system that draws water from the Colorado River. Secondary water supplies include four shallow ground water wells which were used prior to the establishment of the water treatment plant. These wells are monitored once a year for quality.

The Surface Use Agreement between Antero and The BMC specifies a temporary 50 foot easement for pipeline construction and a permanent 25 foot easement for gas gathering lines. Antero also plans to build a wastewater pipeline system along the same easements. The Surface Use Agreement states that the gas gathering lines will be 48 inches below the surface. The gas gathering lines in Battlement Mesa will be 12 inches in diameter. According to maps provided at community meetings, the pipelines primarily follow haul routes, however, a pipeline there is one pipeline that will cross an open space in a residential area between Valley View Village and Fairways Village. It is unclear from available maps how far this pipeline, or any other pipeline on the map, is from residences, schools and other buildings.

Although the COGCC rules allow for 350 foot well pad setbacks in densely populated areas, the Antero well pads in Battlement Mesa are all at least 500 feet from the nearest residence.

4.8.4 Characterization of the Impact from Accidents and Malfunctions

Impact	Direction of health effects	Geographical Extent of exposure	Vulnerable populations	Duration of exposure	Frequency of exposure	Likelihood of health effects	Magnitude of health effects	Rank
Accidents and malfunctions	Negative (-)	Local or Community wide	Yes	Short	Infrequent	Possible	Low to high	-10*

*For an explanation of the numerical ranking system used, see the chart at the beginning of Section 4.

When considering the possible health impacts due to an accident or malfunction of Antero gas operations in Battlement Mesa, the health effects are likely to be **negative**. Depending upon the size and nature of the incident, health and safety impacts may be felt only in close proximity (**local**) or throughout the PUD (**community-wide**). Again, depending upon the nature of the incident, certain populations may be more **vulnerable** to health impacts. For instance, elderly or frail and those living in the assisted living facility, may have difficulty evacuating an area quickly. Children in school may also be slower to evacuate. Those with underlying medical conditions such as pulmonary or cardiovascular disease, may have negative health effects to fires or air emissions at levels that are may not have significant impact to others. Accidents and malfunctions are likely to be **short in duration** and **infrequent.** Given the 6% rate of incidents in the industry and within Antero's other operations in Garfield County, incidents are likely to occur and it is **possible** that health impacts will occur. The health effects will be **low to high** in magnitude, potentially ranging from minor irritation to more severe exacerbation of underlying health conditions to severe injury or death. Using the numerical ranking scheme, accidents and malfunction impacts are expected to produce a negative rank of -10.0 on a scale of ±6-15.

4.8.5 Findings and Recommendations from Assessment of Accidents and Malfunctions

What we know: A small number of accidents and malfunctions occur on a regular basis in natural gas development and production. These accidents and malfunctions can have minor to catastrophic consequences and can impact air, water, and soil quality. Lack of adherence to rules and regulations, as well as regulatory oversight and enforcement can result in accidents and malfunctions.

What we do not know: We do not know if the current setbacks and placements of pads, pipes, and maintenance stations are sufficient to protect residents from catastrophic malfunctions. We also do not know if there are emergency plans in place that address catastrophic malfunctions.

Recommendations to Reduce Impacts from Accidents and Malfunctions

Based on these findings, the following are some of the suggested ways to reduce the potential public health impact from accidents and malfunctions.

1. Require review of evacuation, shelter in place and air intake plans for all locations with high concentrations of persons, such as the schools, the assisted living facility, and recreation center to protect the public health and reduce injury. Allow these entities an opportunity to comment on Antero and community emergency response plans.
2. Require emergency responders to review evacuation and shelter in place plans for Battlement Mesa community and Antero emergency response plans to protect public health and reduce injury.
3. Periodically test emergency communications systems. Consider siren, reverse 911, or other system of other mass alert to protect the public health and reduce injury.
4. Require periodic maintenance review of water and gas gathering lines to highest industry standards to reduce accidents and malfunctions.
5. Institute mechanism for reporting safety concerns, near-misses, etc to the appropriate designated county agency or department to reduce accidents and malfunctions. Ensure timely follow up of all concerns.
6. Review procedures for utility permissions to dig near line location to reduce accidents and malfunctions.
7. Require permanent gas line markers in the field, and other standard practice safety procedures to reduce accidents and malfunctions.
8. Review pipeline system for routes that avoid proximity to homes, schools or other areas used by residents to protect the public health and reduce injury.

The recommendations to address information gaps are in Section 5.

4.9 Summary of Assessments on Health in Battlement Mesa

The following table summarizes the characterization of stressors and the numerical ranking of impacts on the health in Battlement Mesa. By ranking the stressors we are able to conclude that air quality impacts are likely to produce important negative health impacts to residents throughout the community. Other stressors that may produce relatively important health impacts include traffic, and noise. Compromise of water supplies could produce important effects to health but are not likely to occur. Some stressors may produce both positive and negative impacts (mixed) but health impacts will be of low to medium magnitude. These include stressors to community wellness, the economy and health infrastructure. The driving force for those impacts is primarily the workforce associated with the five year development phase. Accidents and malfunctions may impact health but incidents of this nature are difficult to predict. Recent events demonstrate, that although accidents and malfunctions are infrequent, on rare occasions they can be devastating and significant care should be taken to prevent them.

Assessment	**Direction of health effects**	**Geographical Extent of exposure**	**Vulnerable populations**	**Duration of exposure**	**Frequency of exposure**	**Likelihood of health effects as a result of Project**	**Magnitude of health effects**	**Rank**
Air Quality	Negative (-)	Community-wide	Yes	Long	Frequent	Likely	Moderate to High	-14.5
Water and Soil Quality	Negative (-)	Community-wide	Yes	Long	Infrequent	Unlikely	Moderate to High	-11.5
Traffic	Negative (-)	Community-wide	Yes	Long	Frequent	Possible	Low to high	-13
Noise, Vibration, Light	Negative (-)	Local	No	Long	Frequent	Possible	Low-Medium	-10.5
Community Wellness	Mixed (±)	Community-wide	Yes	Long	Infrequent	Possible	Low to Medium	± 11.5
Employment and economy	Mixed (±)	Community-wide	Yes	Long	Frequent	Unlikely	Low	±10.5
Health Infrastructure	Mixed (±)	Community-wide	Yes	Long	Infrequent	Unlikely	Low	±-10
Accidents and malfunctions	Negative (-)	Local or Community-wide	Yes	Short	Infrequent	Possible	Low to high	-10

5 Next Steps

This HIA used the compiled baseline health characteristics of Battlement Mesa, current ambient environmental conditions in Garfield County and Antero's proposed gas development and production plans to evaluate probable and possible health impacts of Antero's project to the residents of Battlement Mesa. Through this process the CSPH has attempted to address the concerns of the citizens outlined in the BCC petition.

At the end of each assessment recommendations aimed at decreasing potential negative health impacts are provided. However, CSPH identified numerous gaps in information that limited this evaluation and may limit future evaluations of health in Battlement Mesa.

In order to fill the information gaps identified in this HIA, investigation is needed in the following areas. The immediate next step will be development of an environmental and health monitoring study (EHMS) that addresses some but not all, of these issues.

AIR

1. Conduct baseline measurement of ambient air concentrations for air toxics within the Battlement Mesa PUD. Continue ambient air monitoring through out the development of Antero's natural gas project. Detection limits should be at or below EPA Regional Screening Levels and air quality standards, when available and technically possible.
2. Conduct air sampling at COGCC setbacks (150 feet, 300 feet), Antero setback (500 feet) and set back requested by citizens (1000 feet) during well installation, completion, and production operations and at the proposed water storage facility.
3. Further characterize constituents of odors during odor events.
4. Determine how to enhance public health response should emission levels exceed health based standards.

WATER

1. Establish hydrogeological characterisics of the four back up groundwater wells and the well pads, the proposed central water storage facility in Battlement Mesa and in other areas of gas development in Garfield County.
2. Develop estimates of environmental fate and transport of chemicals used in natural gas development

TRAFFIC

1. Use Geographical Information System technology to overlay proposed truck routes on a map of Battlement Mesa with location of schools, school zones, school bus routes, bike and walking paths to determine if alternative truck routes will improve community safety.
2. Conduct baseline pedestrian/bike route survey to establish current use and to identify where these routes overlap with haul routes. Monitor use through out the five year development phase.
3. Identify existing traffic "hot spots" within the PUD and along the haul routes that will be susceptible to increased traffic.

NOISE

1. Conduct background noise monitoring for Battlement Mesa residential areas, schools, and along main traffic routes.
2. Conduct noise monitoring at COGCC setbacks (150 feet, 300 feet), Antero setback (500 feet), and set back requested by citizens(1000 feet) during well installation, completion, and production operations and at the proposed water storage facility.

COMMUNITY WELLNESS

1. Determine number of workers needed for various development operations, including operator and subcontractor employees.
2. Establish methods to monitor measures of community well-being (i.e., mental health, suicide, substance abuse, crime, educational opportunities) specific to Battlement Mesa/Garfield County.
3. Monitor access and use of public health and social services.

ECONOMY

1. Monitor economic effects of natural gas development in Battlement Mesa/Garfield County.

HEALTH CARE INFRASTRUCTURE

1. Convene county level health care forum with private and public health providers to assess health care services and anticipated needs related to the natural gas development and production.

ACCIDENTS AND MALFUNCTIONS

1. Use Geographical Information System technology to overlay pipelines, pigging stations, well locations within Battlement Mesa community to determine relationship to residences, schools, assisted living facility, etc.

2. Determine if standards of practice for gas line placement within residential communities exists.

The Antero project described in this HIA involves approximately 200 wells, which is only a fraction of the natural gas development that is occurring in Garfield County. Furthermore, natural gas development is and will continue to grow in other parts of the region and state, as well as other parts of the country. The results of the EHMS will likely have application beyond the study area and will contribute to filling some of the knowledge gaps about natural gas development and production and health.

6 Conclusions

In May, 2010, the Garfield County BOCC engaged the CSPH to perform a HIA to respond to citizen concerns about natural gas drilling in Battlement Mesa, Colorado. The CSPH has worked closely with the GCPH to ensure the scope of the HIA addressed the concerns outlined by the citizens in their letter to the BOCC as well as those voiced in citizen meetings. Along with the GCPH, the CSPH also met with the COGCC, the CDPHE, Antero, and the Colorado Hospital Association to ensure that all stakeholders with pertinent data and information had an opportunity to be involved in the HIA process.

To provide a scientific basis for the HIA we conducted a longitudinal review of multiple Garfield County air and water monitoring studies as well as COGCC reports of water contamination in the county. This information was used to conduct a Human Health Risk Assessment. We also obtained demographic, physical and social health outcome data and used it in a comprehensive review described in the Battlement Mesa Baseline Health Profile. We also reviewed all publicly available information on Antero's plans to drill in Battlement Mesa, as well information made available to us by request from Antero.

With this data we determined that natural gas development and production has the potential to create a variety of stressors that can impact health. Using the medical and social health literature, we reviewed the links between these stressors and health and then applied current conditions and Antero's natural gas development and production plans to assess the potential future impacts of these physical, psychological and social stressors. The HIA considers the mitigations that Antero has disclosed to decrease impacts, so the HIA is based on anticipated effects to current and future residents. These stressors include air emissions, water and soil contamination, traffic, noise/vibration/light, community wellness, economic/employment changes, health infrastructure stress, and industrial accidents/malfunctions.

Using this scientifically based, methodological approach we found that air emissions are likely to occur at levels that can cause human health impacts, especially to vulnerable populations. Increased traffic, particularly increased truck traffic, will be a safety risk to Battlement Mesa residents and contribute to increased air and noise pollution. Increased noise may annoy some residents, but at current and anticipated future levels it is not likely to cause health impacts. Should water contamination and industrial accidents/malfunctions occur they could also cause important health impacts to Battlement Mesa residents, but these events are not likely to occur.

Some stressors may have positive as well as negative social impacts. The Antero project may provide jobs for some Battlement Mesa residents and may provide increased economic activity for some local businesses, including health clinics. As long as these businesses are able to maintain services in the face of increased business, this increased economic activity can be positive for the community. If the quality of services, including medical services, diminishes,

then negative physical and/or social health impacts could occur. Other aspects of community wellness may be negatively impacted, and increased levels of substance abuse, crime, and sexually transmitted infections may occur, while opportunities for recreation and social cohesion could decrease. Both the positive and the negative effects of changing economics/employment, health care infrastructure, and community wellness will likely be small given the relatively small size of the Antero project and the likelihood that these affects will be generally absorbed into the County as a whole rather than affecting Battlement Mesa alone.

At the end of each assessment and Section 5, the CSPH investigators have provided several recommendations aimed at decreasing negative impacts or improving positive impacts. Central to decreasing the primary health stressor, air pollution, is continued efforts to decrease all possible emission sources. To bring emissions to the lowest possible level, it is important that the best available current technology be utilized, and new technologies be developed and adopted. To provide an adequate margin of safety, current COGCC emissions rules need to be strictly enforced. Ambient and well pad monitoring should be conducted to characterize emissions and their impacts on local air sheds and determine if further regulation is needed to protect public health. Likewise, because of the potential for important health impacts due to water contamination from accidents and/or malfunctions, effort should be focused on prevention of such events, the best available technologies required, new technologies adapted, and strict monitoring maintained. Traffic mitigation should also be a priority in order to reduce the inherent safety risk associated with large truck traffic in residential areas. Noise associated with Antero's project should be monitored and efforts to decrease noise due to drilling activities as well as truck traffic undertaken. Finally, efforts should be made to use economic benefits from Antero's project to mitigate the potential negative impacts of change in social structure. Planning should take place to provide services needed for increased population, as well as planning for the loss of the economic activity in five years when the development phase ends.

The CSPH investigators and the BOCC recognize that implementation of recommended impact mitigations may be insufficient to protect public health. To that end, the BOCC has provided funding to CSPH to design a long term EHMS in Battlement Mesa and/or Garfield County to address some of these issues. This long term study will: 1) further characterize air emissions associated with natural gas production; 2) characterize air emission exposure levels for persons living in close proximity to natural gas production; 3) further characterize emission sources during development and production phases; 4) develop methods to characterize surface and ground drinking water contamination; 5) conduct health surveillance of residents in areas impacted by natural gas and in similar comparison populations not affected by natural gas development and production; 6) conduct social and community health surveillance of areas impacted by natural gas development and production.

Because there are natural gas plays in other parts of the United States undergoing similar development as that occurring in the Piceance Basin, this HIA and future studies are likely to be broadly applicable. Communities in Texas and Wyoming have reported health and social impacts associated with natural gas development and production, while communities in

Pennsylvania, New York and other places are trying to anticipate and forestall impacts before drilling occurs. Use of this or other HIAs as a tool to summarize potential impacts can help communities prioritize mitigations and local resources. Local environmental and health monitoring can provide communities with information necessary to protect public health. This information can also contribute to the growing body of knowledge on chemical and psychosocial stressors and health impacts associated with natural gas development and production.

In Colorado, recent legislation will compel Front Range coal fired electrical plants to switch to cleaner fuels and alternative energies, thus enhancing the natural gas market. In Grand Junction, two fueling stations for natural gas vehicles are slated to be built in the next few years. These and other market enhancing projects and policies will mean Colorado natural gas development and production projects will continue to grow. The recently updated COGCC rules included provisions to protect health and environment. These rules should undergo regular review and update in order to reflect new understanding and technologies as they emerge.

Because development of domestic natural gas resource is part of the national policy to increase domestic energy production and reduce greenhouse gas emissions, a high level discussion of the health implications of this policy needs to take place. While municipal, county and state governments have begun to respond to citizen concerns, a national discussion of the benefits and risks associated with this policy is due. As outlined in this HIA, local economic benefits of energy development may not outweigh the negative local impacts to physical and social health of the community. Without understanding public health implications in the context of national priorities for domestic energy production, continued disagreements about the impact of drilling and its effects on local health are bound to continue.

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Part Two: Supporting Documentation

TABLES

Table 1: Identified Stakeholders

Stakeholder	Acronym	Stakeholder Role
Antero Resources Corporation	Antero	Natural gas operator, proposes development within the planned urban development of Battlement Mesa
Battlement Mesa Concerned Citizens	BMCC	Grassroots citizen group formed in response to the Antero gas project.
Battlement Mesa Company	BMC	Owner of mineral and surface rights in Battlement Mesa.
Battlement Mesa Service Association	BMSA	Home owners association for Battlement Mesa residential communities.
Colorado Department of Public Health and Environment	CDPHE	State health department; has consultative responsibility to the state permitting agency for comment health and environmental concerns, but has no regulatory responsibilities.
Colorado Oil and Gas Conservation Commission	COGCC	Colorado regulatory and permitting agency. Maintains databases for water quality, spills, and well locations Databases include federal and tribal lease owners as well as state lease owners. Provides permitting for state lease owners only.
Garfield County Board of County Commissioners	BOCC	Requested county environmental health to develop proposals to respond to citizens health concerns. Have indicated that HIA and health study proposals will satisfy this request.
Garfield County Oil and Gas Department	GCOG	County office that oversees county relationships with oil and gas operators.
Garfield County Oil and Gas Operators	GCOGO	Natural gas companies operating in Garfield County but not involved in the development within the Battlement Mesa PUD (Encana, Williams, Bill Barrett, Noble).
Garfield County Public Health	GCPH	County health agency with environmental health program. Environmental health program directed to respond to citizen concerns and has strong ties to all stakeholder groups. Environmental health program considered a regional leader in health and gas exploration and production.
Grand River Hospital District	GRHD	Primary hospital and Emergency department provider in Rifle, Colorado (28 miles east of Battlement Mesa) and operator of a primary care clinic in Battlement Mesa.
Grand Valley Citizens Alliance	GVCA	Grassroots community group, loosely tied to the Battlement Concerned Citizens.

Table 2: Stakeholder Meetings		
Date	**Location**	**Groups represented**
January 13, 2010	CDPHE, Denver	CDPHE
January 27, 2010	COGCC, Denver	COGCC
February 3, 2010	GCPH, Rifle	BMCC, BMC, BMSA, BOCC, CDPHE, COGCC, GCPH, GVCA, Encana Corporation, Williams Corporation
February 16, 2010	GC Board Chambers, Glenwood Springs	BOCC
April 22, 2010	Antero Field Office, Rifle	Antero Resources
June 15, 2010	Battlement Mesa Fire Station, Battlement Mesa	BMCC, BMC, BMSA, BOCC, CDPHE, COGCC, GCPH, GVCA, Antero Resources, EnCana Corp., Williams Corp
June 24, 2010	CDPHE, Denver	CDPHE

Table 3: Stakeholder Concerns and Questions	
Meeting Date	**Concern or Question**
Air Pollution/Quality	
February 3, 2010	Will PM10, VOC monitoring be included?
February 3, 2010	Parachute= Battlement Mesa when it comes to air monitoring?
February 3, 2010	Is PM2.5 a greater hazard?
February 3, 2010	Will the air quality assessment include all processes of the well development?
February 3, 2010	Do hydrocarbons evaporate from produced water ponds?
February 3, 2010	Are there BTEX emissions from trucks?
February 3, 2010	Will gathering pipelines with leaks be accounted for?
June 15, 2010	Is there enough water and air baseline data for Battlement Mesa?
June 15, 2010	Have air quality exposures in the summer when swamp coolers are being used? Will air pollution be concentrated indoors?
Water Quality	
February 3, 2010	Is there adequate monitoring of water?
February 3, 2010	How will impacts to the water supply (CO river, surface and spring) be assessed?
February 3, 2010	What if domestic supply is ½ mile from well pad, is it safe?
February 3, 2010	Will emergency wells within the PUD be impacted, are the pads close to the emergency wells?
February 3, 2010	Should the intake on the CO river have gates (like Rifle)?
February 3, 2010	Should real time monitoring instead of 3 month turn around for sampling results be implemented?
February 3, 2010	Can there be a quicker response to water issues?
February 3, 2010	Is there enough water for all needs, including fires?
February 3, 2010	Should there be a drill for potential water shut-down?
June 15, 2010	Will the effect of chemicals on the water supply be included in the study?
June 15, 2010	Will possible contamination of the Colorado River from upstream contamination be considered?
June 15, 2010	Is there enough water and air baseline data for Battlement Mesa?
Drilling and Fracking Chemicals	
June 15, 2010	Will fracking chemicals be considered?
June 15, 2010	How will chemical spills be considered?
June 15, 2010	Why can't Colorado require public release of fracking chemicals like Wyoming?
June 15, 2010	Will you be working with physicians and Grand River Hospital to obtain local data?
Pipeline Safety	
February 3, 2010	Is there a plan to prevent pipeline leaks/ explosions?
February 3, 2010	Does pipeline proximity to buried high voltage power lines pose a risk?
Occupational Hazards	
February 3, 2010	How will the development have social impacts: will it increase domestic abuse? Will workers have health insurance?

Table 3: Stakeholder Concerns and Questions	
Meeting Date	**Concern or Question**
Occupational Hazards Continued	
February 3, 2010	How does worker schedules impact families?
February 3, 2010	Will the health of workers on rigs be included?
February 3, 2010	What are the mental health impacts?
February 3, 2010	If economic security is tied to gas jobs, will fear of loosing a job prevent workers from speaking up about health problems? Grand Valley Citizens Alliance gets input from workers that wish to remain anonymous.
Concerns of Industry	
February 3, 2010	There is misinformation that drives fear. The health study will relieve the misinformation.
February 3, 2010	The industry will partner with local fire department.
February 3, 2010	Industry hopes to make Battlement Mesa to be a better place.
Concerns about Research and the HIA	
February 3, 2010	Hope that HIA will not be "inconclusive"
February 3, 2010	What is the difference between probability vs. predictability: What does probability mean?
February 3, 2010	How are acute vs. chronic diseases defined? This needs to be communicated.
February 3, 2010	Will the HIA include information on healthy individuals? Balanced picture of the community
June 15, 2010	Is there a formula that will tell us that the hazards are too high?
June 15, 2010	Will analysis be comparing results to other areas in Colorado such as Denver and Grand Junction?
June 15, 2010	Will illnesses be captured even if a resident goes to a hospital outside of Garfield County?
June 15, 2010	How will gaps in health outcomes be addressed?
June 15, 2010	Will there be another public meeting prior to the release of the draft report?
June 15, 2010	Be aware that the population has been trending to younger age groups during the 2000-2010 time period.
Community Concerns	
February 3, 2010	What will the impacts on county services be? Will there be more or less services? services Will there be an increase in STD's and other "social" diseases
February 3, 2010	Will the development impacts on education? Will class size be affected?

Table 3: Stakeholder Concerns and Questions	
Meeting Date	**Concern or Question**
February 3, 2010	Will there be adequate affordable housing? Sometimes there is not enough, sometimes too much.
Additional Exposures/Impacts	
February 3, 2010	Will decreased property value be included in the assessment?
Additional Exposures/Impacts Continued	
February 3, 2010	Will decreased aesthetics of the community be included?
February 3, 2010	Are set backs adequate to protect health?
February 3, 2010	Will other stressors including light, noise, traffic be considered?
February 3, 2010	Will concern include skin, respiratory, vertigo?
February 3, 2010	Will there be motor vehicle accidents and related injury and death?
February 3, 2010	What kind of impacts will fracking have?
February 3, 2010	Will remote frac'ing with high pressure pipelines be dangerous?
February 3, 2010	How will changing landscape and changing resident demographics be included?
February 3, 2010	Will a boom and bust cycle occur? We are now in a bust and the food banks drying up.
February 3, 2010	What are the impacts to health services and other community services in BM?
February 3, 2010	How will post drilling, post spill reclamation be handled?
February 3, 2010	What will be done with cuttings? Will they be buried onsite?
February 3, 2010	Will the sites be contaminated and be unsuitable for future use?
June 15, 2010	Will vibration be considered along with noise?
June 15, 2010	Have exposures to herbicides and dust been considered?
June 15, 2010	Will fires on the well pad be considered?
June 15, 2010	Will you consider all O&G activity in close proximity to the PUD? The project should expand beyond the PUD.
June 15, 2010	Mental health and social issues are important impacts.
Outside Agencies	
June 15, 2010	Does EPA have any interest in the work being done? What other studies have been done or are being conducted?
June 15, 2010	What role does Pew Charitable Trust play in the HIA?

APPENDICES

APPENDIX A: SUMMARY OF THE NATURAL GAS DRILLING PROCESS

APPENDIX B: NATURAL GAS DEVELOPMENT IN THE PICEANCE BASIN

APPENDIX C: BATTLEMENT MESA BASELINE HEALTH PROFILE

APPENDIX D: HUMAN HEALTH RISK ASSESSMENT

APPENDIX E: GENERAL RECOMMENDATIONS

APPENDIX A: SUMMARY OF THE NATURAL GAS DRILLING PROCESS

To transport natural gas that is diffusely embedded in sediment thousands of feet below the earth's surface to a commercial gas pipeline and into a household's gas stove is a complex process involving many different operations. While the description included in this HIA is far from complete, to understand the HIA and its recommendations requires some familiarity with natural gas drilling. For additional reading about the natural gas drilling process, please refer to the following documents:

- *Community Guide to Understanding Natural Gas Development*, written by the Garfield County Energy Advisory Board[101] and
- *Comprehensive Safety Recommendations for Land-Based Oil and Gas Well Drilling*[102]

Natural gas drilling involves the following processes.

Site Selection

A geological survey team collects information on the geology of potential sites to drill. The geological survey team and business managers discuss the benefits and risks of each potential site. Eventually, the business managers and geologists select a site or a group of sites to develop into well pads.

Site Preparation

Before drilling can begin, an operator must prepare the site. The operator typically contracts this task to earth moving companies that create a level surface on which to work. In addition to creating a level platform for drilling activities, site preparation companies often dig and dike any required reservoirs and excavate the cellar. The cellar is, essentially, a pit that collects fluids and accommodates the **blowout preventer** and other equipment. During the site preparation, contractors often transport heavy machinery to the site for earth moving operations and gravel/soil to create a level well pad. Site preparation also may include building roads to access the well pad and installation of pipes to transport natural gas and water.

Drilling

A subcontractor delivers and erects a load-bearing structure to support the weight of the **drill**, the **drill string** and other relevant equipment. Historically, contractors used a structure called a **derrick**. While many contractors still use derricks, contractors also use a different type of structure called a **mast**. Whereas derricks must be constructed on site, masts do not require as much assembly once they are delivered to the site. Masts are simply hoisted and secured into place.

When the load-bearing structure is secure, the drill creates an initial hole by a process commonly called "**spudding in**". As soon as "spudding in" is complete, the contractor inserts a section of metal pipe, called **conductor casing**, into the hole to prevent blowouts and ensure the well's integrity. The contractor secures the conductor casing into place by injecting cement between the sediment and the casing.

Once the conductor casing is securely cemented into place, the drill bores to a depth of approximately 900 feet below ground surface (bgs). This "surface hole" is also lined with casing (called **surface casing**), which like the conductor casing is cemented into place. Surface casing is the barrier between the well bore and groundwater reserves.

After surface casing is securely in place, the contractor continues to drill, meanwhile installing the subsequent layer of casing, called **production casing**. Production casing, like other forms of casing, is manufactured, transported and installed in thirty-foot sections. Eventually, the production casing runs thousands of feet deep to reach the hydrocarbon formations – as much as 10,000 feet bgs but in the Piceance Basin, more likely around 6,000 feet bgs. The production casing, as with the other sections of casing, is cemented into place.

During the drilling process, contractors transport the drill rig, casing, materials for drilling mud, water and other equipment to the well pad. After the production casing is securely in place, the drill rig is disassembled and the well completion process begins.

A couple of additional terms to be aware of include (but are not limited to):

Drilling Mud – Drilling contractors use drilling mud to lubricate the drill bit, carry cuttings (i.e. sediment) to the surface, and provide downward pressure in the well bore. Drilling mud is usually a complex mixture of liquids, reactive solids and inert solids. Mud often includes bentonite, a heavy clay material. The liquid might be comprised of freshwater, diesel oil, crude oil and/or "conditioners." The category of "conditioners" actually includes a wide variety of chemical compounds that serve various purposes in the drilling process[103]. Some conditioners stabilize the geologic formation as the operator drills deeper. Other conditioners lubricate the drill. Some conditioners make the drilling mud thicker. Others make the mud thinner. Characterizing the precise chemical composition of all of the conditioners available for Antero's use is beyond the scope of this HIA.

Directional Drilling – Drilling contractors now have the ability to drill at angles other than directly downward. The angle of the well bore relative to the surface can change during the drilling process. Sometimes, wells are started at an angle and drill practically horizontally. Other times, contractors drill straight down and change the angle of the well bore after the production casing is in place.

Well Stimulation

At the depth of the hydrocarbon formation, the production casing is pierced with explosive charges or bullets. Perforating the production casing itself and the surrounding layer of cement creates channels through which natural gas can pass. Well perforation is not the same as hydraulic fracturing, although it is a necessary precursor.

Natural gas contractors use **well stimulation** methods to increase the rate at which natural gas flows to the surface. One prominent stimulation method is **hydraulic fracturing**, whereby a contractor injects liquids under high pressure to create fissures in the sediment surrounding the well bore. By creating fissures in the sediment, hydraulic fracturing releases natural gas that was embedded in the tightly packed sediment. The gas enters the well bore through the perforated production casing and flows up to the surface. The liquids used in the hydraulic fracturing process are composed of water and various chemicals – some of which may be protected by trade secrets. Hydraulic fracturing fluids also may be called fracking or frac'ing fluid or water.

Well Completion

The pressure of the geologic formation and its heterogeneous contents necessitate the process called **well completion**. After a formation is hydraulically fractured, the natural gas operator must collect water, hydraulic fracturing fluids, sediment, condensate, oil and natural gas that is generated in the process. Well completion is a process by which the channels of the well are cleared so that natural gas can pass freely to the surface. The contents are typically collected into tanks and shipped off-site.

Well Production

After the well has been completed, the well pad shifts into production mode, whereby the recently-drilled well releases natural gas into the commercial line. However, to ensure the safety and the quality of the gas, the well production phase requires additional technologies. For instance, tanks collect water and additional condensate that the well may produce.

Reclamation

After a well is no longer producing gas, it is plugged and abandoned. According to the Colorado Oil and Gas Conservation Commission's regulations pertaining to well reclamation, the land surrounding the wellhead must be restored as closely as possible to its original condition. If the well pad is on cropland, the operator has three months to begin the reclamation process. Operators have 12 months to begin reclamation on non-crop land. To reclaim the well-pad, the operator needs to remove all of the equipment and waste from the site. They need to re-fill the hole in which the wellhead was located. Land needs to be re-graded and re-vegetated to its original condition, as do access roads. Prior to deeming the land "reclaimed" a COGCC inspector must investigate the land to ensure it has been properly re-graded and re-vegetated and that all of the waste and debris have been cleared.

APPENDIX B: NATURAL GAS DEVELOPMENT IN THE PICEANCE BASIN

B1 Geology

This brief summary of the area's geology provides additional context for understanding the potential drilling plan, in particular how the geology of the region relates to proposed drilling methods.

The Battlement Mesa PUD rests on top of a geologic formation known as the Piceance Basin. The Piceance Basin stretches underneath seven Colorado counties, including Garfield County, where Battlement Mesa is located. The Piceance Basin is a part of the larger Uinta-Piceance Province, which is 40,000 square miles in area. Of the larger Uinta-Piceance Province, the Piceance Basin is approximately 100 miles long and 40-50 miles wide. The Axial Uplift forms the Piceance's northeastern border and the White River Uplift forms the eastern border. The Douglas Creek Arch forms the Piceance Basin's western border. The southern border is roughly parallel with and north of the Uncompahgre Uplift axis.

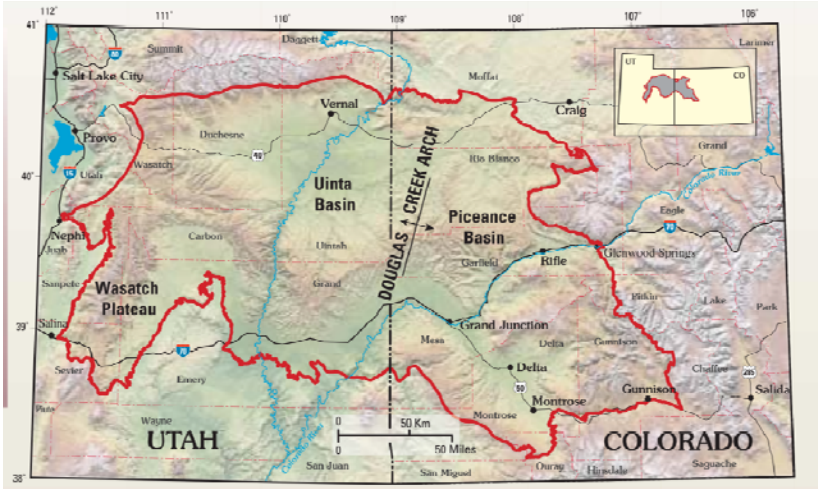

Figure 1. Uinta-Piceance Province located in northwestern Colorado and northeastern Utah. The Douglas Creek arch separates Piceance Basin from Uinta Basin. The Wasatch Plateau is included in this province.

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The Piceance Basin, however, is not simply an area of land, the Piceance Basin refers to the geology underlying the area previously described. Therefore, it is useful to consider the Basin as

being "deep" as well as "wide." At its deepest section, the Phanerozoic sedimentary rock* of the Piceance Basin extends 20,000 feet below the Earth's surface.

The Piceance Basin was formed during a period geologists call the Tertiary Period[105] – which ranges from approximately 65 million years ago to 1.8 million years ago[106]. The layers of rock and sediment that comprise the Piceance Basin include significant deposits of petroleum, much of which geologists term "unconventional" petroleum. As opposed to "conventional" reserves of hydrocarbons, that can be accessed using oil well technology from the 1800's, unconventional reserves such as tight sands, shale gas, coal bed methane and oil shale require more technologically advanced extraction methods. While all of the types of unconventional reserves previously listed are embedded in the Piceance Basin[105], the type of unconventional reserve that relates most directly to Antero's proposed drilling plan in Battlement Mesa are tight sands.

Tight Sands

Tight sands are deposits of compacted sediment or hard rock that are saturated with natural gas (also known as methane or methane gas). Operators require advanced technologies - particularly hydraulic fracturing and/or acidizing – to access the methane gas permeating tight sand formations.

According to a United States Geological Survey (USGS) assessment of the Uinta-Piceance Province, "Major resources of tight gas are present in the province."[105] The same USGS assessment highlights two notable tight gas plays in the Piceance Basin. Both tight sands plays are in the Mesaverde Group, and the USGS differentiates them from each other by the quality of the reservoirs, their respective depths and other geological characteristics (i.e. stratigraphy).

Williams Fork Play
Rivers and streams deposited the sediment in the Williams Fork Play. The play's thickness ranges between 1,500 feet and 4,500 feet. To access methane gas embedded in the Williams Fork Play, natural gas companies need to drill anywhere from 5,500 feet to more than 9,800 feet. The average drill depth for the Williams Fork Play in the Piceance Basin is 7,500 feet.

At the time the USGS assessment was performed, geologists from USGS and industry were "attempting to determine why water is being recovered from horizontal wells; whereas, vertical wells in the same areas do not produce significant amounts of water." The author hypothesized that the water was from open natural fractures. One implication of the recovered water, noted the assessment's author, is that "operators may need to attempt to dewater the wells through sustained production." Although Antero has indicated that their natural gas drilling within the PUD will primarily involve the Williams Fork Play they have also indicated that they are also going to explore the Mancos shale beneath the Williams Fork.

* I.e. sedimentary rock from the Phanerozoic Eon – the current eon of the geologic timescale – which covers the previous 542 million years

Iles Play
The Iles Play lies directly beneath the Williams Fork Play. Sediment in the Iles Play is marine and marginal marine (i.e. deposits from oceans, as opposed to rivers and streams). The Iles Play is approximately 500-1,500 feet thick. To access the Iles Play, natural gas companies would need to drill between 5,800 feet, in excess of 10,000 feet. On average, the drill depth in the Iles Play is 7,700 feet.

Mancos Shale[107]
In addition to the Williams Fork Play and the Iles Play, it's important to mention a shale formation commonly called the "Mancos Shale" formation. The Mancos Shale is comprised of mudrock (i.e. hardened mud) that was deposited by the Cretaceous Interior seaway between 90 and 85 million years ago. The Mancos Shale is interconnected with the Williams Fork Play and the Iles Play.

B2 Energy Development in the Piceance Basin: Past

The 1973 Organization of the Petroleum Exporting Countries (OPEC) oil embargo and subsequent fluctuations in the price of crude oil created strong financial incentives for the United States to reconsider its dependence on foreign oil. The United States' Government invested in programs, such as the Synthetic Fuels Corporation, to support research and development of alternative fuel sources (such as oil shale and coal gasification)[108]. Private energy companies also invested in what seemed to be a growing market for domestically produced fuels. In 1980, the Exxon Corporation announced its Colony Oil Shale Project, which involved developing the oil shale resource within Garfield County. They began building the Battlement Mesa Planned Urban Development (PUD) shortly thereafter. The Battlement Mesa PUD was originally created as a company town for Colony Project workers[3]. However, when crude oil prices dropped in the early 1980's, the economic viability of oil shale collapsed. On May 2, 1982, the Colony Project was shut down, thereby eliminating 2,200 jobs[3]. Following the oil shale bust and subsequent exodus of oil shale workers, Exxon marketed the Battlement Mesa PUD as a retirement community until December 1989 when it sold the PUD's surface rights and mineral rights to the Battlement Mesa Company (BMC)[3]. Though the BMC continues to operate rental properties (primarily town homes and mobile homes) for local workers and their families, the BMC continued to market Battlement Mesa as a retirement community. By 1998, more than two-thirds of Battlement Mesa's residents were retirees[109].

B3 Energy Development in the Piceance Basin: Present

The United States' dependence on fossil fuels has re-emerged as in issue of national political significance. As in the 1970's, policymakers in Federal and State agencies have been considering incentives to promote "alternative" sources of energy (i.e. energy sources that are neither conventional petroleum reserves nor coal reserves). One such energy source, which is

abundantly infused into the geology of Western Colorado's Piceance Basin[105], is methane – commonly referred to as "natural gas."

In April, 2010, Colorado House Bill 1365, referred to as the "Clean Air – Clean Jobs" initiative, became law. The new law is to provide resources to reduce emissions of air pollutants through retiring, retrofitting, or reprocessing Front Range coal-fired power plants by replacing them with facilities fueled by natural gas or other lower or non-emission sources. This action "will jumpstart our natural gas sector the same way we are driving Colorado's solar and wind industries, according to Governor Bill Ritter,"[110].The Governor went on to say that the "Clean Air-Clean Jobs" law will bring "economic, energy and environmental benefits together in one package."[110] Even before House Bill 1365 was signed into law, though, Colorado's natural gas industry had been expanding rapidly, in Garfield County, as well as other parts of the state. High oil prices and technological advances such as hydraulic fracturing and directional drilling were making Colorado's vast "unconventional" natural gas reserves increasingly viable economically. In Garfield County, Colorado, the increased demand for extraction of natural gas was most apparent between 2003 and 2008. As a rapid influx of new workers arrived in Garfield County, some of them bringing families, hotels and motels filled quickly. Temporary housing facilities, commonly referred to as "man camps" were established. The pace of development stressed local infrastructure, creating concerns at the local and state levels of government. In 2009, the Colorado State Legislature implemented revised regulations governing oil and gas development, in part, to minimize development's impact on public health and the environment[111]. Continued, and possibly accelerated expansion of the natural gas industry within Garfield County is expected with the passage of House Bill 1365.

B4 Antero's Plan in Battlement Mesa

This section of Appendix B gives a brief overview of what information Antero has shared with the community as to it Plan to drill for natural gas in the PUD. A review of the natural gas drilling process is presented in Appendix A.

In the Spring of 2009, Antero announced plans to purchase surface rights and mineral rights from the BMC. Along with this, Antero indicated its intent to drill for natural gas within the Battlement Mesa PUD. It is important to keep in mind that Antero's drilling plans have not and will not be determined entirely by Antero. In addition to the federal, state and local regulations, drilling activities in the PUD are subject to three separate Surface Use Agreements (which are legally binding agreements for the parties entering into them). This section briefly summarizes the Surface Use Agreements determining how and where drilling activities will occur in the PUD:

<u>Surface Use Agreement #1: Exxon and BMC – December 12, 1989</u>
This Surface Use Agreement will always be effective as a condition of BMC's purchase of the PUD. It requires that before mineral resources within the PUD are developed, a formal Surface

Use Agreement must be executed. This initial Surface Use Agreement also established "general" locations for 16 well pads – 15 of which are within the PUD. BMC agreed to accommodate necessary changes to the locations. This Surface Use Agreement also required that in the event that surface development and mineral resource development were in conflict, there needed to be alternate locations for the drill sites.

Surface Use Agreement #2: Barrett Resources and BMC – August 6, 1990
This Surface Use Agreement is only binding for the natural gas operator Williams (which is Barrett Resources' successor in the Surface Use Agreement). Various restrictive provisions exist within the Surface Use Agreement to dictate how Williams can develop resources in the PUD. Among them is a provision that wells be set back at least two hundred feet from existing structures.

Surface Use Agreement #3: Antero Resources and BMC
According to the Surface Use Agreement (Surface Use Agreement) entered into between Antero and the BMC, the Battlement Mesa PUD development project will utilize horizontal drilling techniques and hydraulic fracturing stimulation to develop approximately 200 gas wells on 10 pads distributed throughout the residential community. The full Surface Use Agreement is included in [Attachment 2].

While the Surface Use Agreement is a worthwhile basis for understanding Antero's plans, it is not a legally binding agreement with BOCC. Only the Major Land Use Impact Review will represent a contract between BOCC and Antero. The Surface Use Agreement includes provisions (in addition to compliance with existing regulations) that are intended to reduce any potential impacts on the Battlement Mesa community's health and quality of life.

This is a summary of some, but not all, provisions in the Surface Use Agreement # 3 between Antero and the BMC[7]:

Wellsite Locations
The Surface Use Agreement identifies ten locations where Antero will erect drilling rigs and one site where Antero will build a covered water handling facility.

Access Roads
Access roads Antero builds to and from its well pads must be 20 feet wide and gated. Antero agreed to keep the access roads clean and suppress dust generated on the access roads.

Pipelines
The pipelines that gather gas must be at least 48 inches deep except where BMC and Antero agree that the pipelines need to accommodate existing infrastructure (in particular, gravity-dependent facilities including but not limited to sewer lines). Antero was granted 25 foot easements to install, operate maintain and repair permanent pipelines. They were also granted 50 foot easements for pipelines during construction.

Power/Telephone/Transformers
The only situation in which power lines, transformers and data transmission lines can be installed at a pre-identified well location is when they are necessary for the operation of production equipment.

Hours of Operation
BMC does not restrict the times of day when Antero can be engaged in drilling, completing, re-completing, well workover or reservoir stimulation operations. For routine maintenance, development and production, the Surface Use Agreement requires Antero to work between 7 AM and 8 PM, except in the event of an emergency.

Noise Abatement
Antero needs to be in compliance with COGCC standards that relate to noise (e.g. COGCC Series 802 Noise Abatement Rule[48]). There will be no centralized compression stations, which could be sources of constant noise, in the PUD. Hospital-grade mufflers will be installed on high noise output machinery.

Lighting Abatement
Rigs will be oriented to direct light away from closest homes. Antero "shall use appropriate technology to minimize light pollution emanating from the Property, including, but not limited to, utilization of low density sodium vapor lighting."

Air Emissions and Odor Abatement
Antero will use mats, soil tack and/or liquid dust suppressants as necessary to suppress dust. Antero can not flare wells within 2,000 feet of an occupied dwelling, unless they take the measures specified in the COGCC rules to contain the flare or unless there is an emergency. Antero will comply with Colorado Department of Public Health and Environment (CDPHE)Air Quality Control Commission Regulations. At the "F" pad, there will be a centralized water handling facility that will be lined and covered.

Noxious Weed Management
Antero will implement a noxious weed management plan in accordance with Garfield County and COGCC requirements. While it is expected the weed management plan will be similar to weed management plans currently in place within the PUD, the plan was not available for review at the time of this HIA report.

Visual Impact Mitigation and Reclamation of Wellsite Locations
Antero will construct well pads that mitigate the visual impact using berms and trees to shield the pad from view. Some drill rigs will be shrouded.

Environment and Safety

Antero will comply with all applicable COGCC, CDPHE, United States Environmental Protection Agency (EPA), Comprehensive Environmental Response Compensation and Liability Act (also known as CERCLA), Resource Conservation and Recovery Act (also known as RCRA), Oil Pollution Act, and Clean Water Act regulations. These include, but are not limited to, stipulations pertaining to sanitary facilities; refuse, trash and solid waste disposal; hazardous materials; spills of oil, gas and other hazardous chemicals; spill prevention and control plans; employee training; and employee housing.

Emergency Communications
Antero will comply with local, state and federal reporting requirements in all emergency situations.

Operator's Sole Risk: Insurance
Antero assumes all risk and liability of "any natural incident to, occasioned by or resulting in any manner, directly or indirectly, from (Antero's) operations hereunder."

Owners' Utilities
If Antero requires any utility lines to service any of the well site locations, Antero will pay to locate the lines underground.

The Surface Use Agreement does not address environmental monitoring.

Antero has described a three-phase development plan for the Battlement Mesa project. (Battlement Mesa Website)

- Phase 1 will develop the Stierberger Pad, Pad E, Pad G and the water storage facility (Pad F) on the south side of the PUD.
- Phase 2 will develop the Parks and Rec Pad, Pad A, Pad B and Pad D on the north side of the PUD.
- Phase 3 will develop the L and M pads on the northeast side of the PUD.

Each phase will involve access road, pad and pipeline construction needed to develop the wells and tie them to the water movement system and the gas gathering lines at the eastern edge of the PUD. At this time, Antero anticipates that all three phases will be completed in five years. A slower development scenario is possible and could depend upon the natural gas economy, internal Antero priorities, regulatory impacts, etc. This HIA is based upon the five-year development concept currently favored by Antero.

APPENDIX C: BATTLEMENT MESA BASELINE HEALTH PROFILE

C1 Physical Determinants of Health

In order to describe the baseline of physical health for the residents of Battlement Mesa, the CSPH team obtained information regarding cancer, inpatient hospital diagnoses, mortality and births. By comparing Battlement Mesa data to the same data for Colorado, we were able to provide a relative picture of health for the time period 1998-2008.

C1.1 Methods

Public health practitioners often compare the number of observed events (i.e. disease, death, hospitalizations) to the number of expected events. This allows practitioners to determine if a certain group of people is experiencing an increased (or decreased) amount of disease. A Standardized Incidence Ratio is one method used to measure excess or decreased amount of disease, or when mortality is examined, a Standardized Mortality Ratio (SMR). These methods were used to describe disease incidence and deaths in the Battlement Mesa/Parachute zip codes (81635, 81636).

C1.1.1 Cancer Data Methods

The Colorado Central Cancer Registry at the Colorado Department of Public Health and Environment is mandated by state statute to collect all diagnosed cancers among state residents. This registry provided the CSPH HIA team with aggregated counts of cancer for residents living within the two zip codes and age adjusted standardized incidence ratios for selected cancers diagnosed during the time period of 1998-2008.

Standardized incidence ratios were calculated using the numbers of cancers diagnosed in the Battlement Mesa/Parachute zip code compared to an expected number of cancer cases based on statewide Colorado cancer rates. Colorado rates were obtained from the Colorado Central Cancer Registry for men and women of comparable race and age and were used to calculate expected number of cancers for the Battlement Mesa/Parachute zip code. Adjusting for age, sex, and race/ethnicity assures that any difference found is not due to differences in demographics. The state of Colorado was used as a comparison to provide a large population base to generate stable, reliable rates.

Cancers studied included those based on known association between a specific type or types of cancer and the exposures of concern, common cancers, and those for which community members voiced concerns. Cancers selected for these analyses included:

- Hodgkin Lymphoma

- Non-Hodgkin Lymphomas
- Multiple Myeloma
- Leukemias
- Melanoma
- Breast cancer
- Prostate cancer
- Bladder cancer
- Colorectal cancer
- Cancer of the adrenal gland

When the number of events is less than 3 the data are not reported to preserve confidentiality, this is a policy of the Health Statistics and Vital Record Division at CDPHE. Leukemias were originally requested by type: acute lymphoblastic leukemia, acute myeloid leukemia, chronic lymphocytic leukemia, and chronic myelogenous leukemia., Because fewer than 3 cases of each type of leukemia were diagnosed over the 10 year period, the Leukemias were grouped together for the analysis.

When interpreting an standardized incidence ratio/SMR, size and stability need to be taken into consideration. Standardized incidence ratios based on greater numbers of events produce estimates that are more stable, meaning that there is greater confidence in the conclusions being drawn from the information. Because the population of Battlement Mesa/Parachute is small and the number of diseases is small, determining the *statistical significance* is extremely important. Confidence intervals (CIs) were calculated, in order to determine if the number of observed cases is significantly different from the number of expected cases or whether the difference may be due to chance alone. For these analyses, a 95% confidence interval (CI) was calculated for each standardized incidence ratio.

The following table describes how the standardized incidence ratio/SMRs are interpreted and deemed statistically significant or statistically insignificant.

Interpretation of Statistical Measures

Ratio (SIR/SMR)	Interpretation	95% Confidence Interval	Significance
< 1.00	The number of events observed is less than expected	The lower and upper limits of the interval are < 1.00	Ratio is considered statistically significant.
		The upper limit of the interval is > 1.00	Ratio is not considered statistically significant.
= 1.00	The number of events observed is equal to the number of events expected for the population.		
> 1.00	The number of events observed is greater than expected	The lower limit of the interval is < 1.00	Ratio is not considered statistically significant.
		The lower limit of the interval is > 1.00	Ratio is considered statistically significant.

C1.1.2 Inpatient Hospital Diagnoses Data Methods

Inpatient hospitalization diagnoses data from the Colorado Hospital Association were analyzed by the Health Statistics Section at the Colorado Department of Public Health and Environment and provided to the CSPH. The Colorado Department of Public Health and Environment provided aggregated inpatient hospitalization counts and standardized incidence ratios of select diagnoses using the International Classification of Diseases, ninth revision or ICD-9 codes for the time period of 1998-2008. The ICD-9 is the official system in the United States of assigning codes to diagnoses and procedures associated with hospital admissions during the 1998-2008 time period.

The Colorado Hospital Association collects discharge data for inpatient hospitalizations from participating hospitals throughout the state of Colorado. Each hospital discharge record collected can contain up to 15 diagnoses. For purposes of this analysis, the total hospitalizations were counted by including ICD-9 codes listed in any of the 15 diagnoses fields.

The Colorado Department of Public Health and Environment provided the CSPH team with aggregated numbers of hospitalizations by major category as well as standardized incidence ratios computed using indirect adjustment of age based on the 2000 Census populations for the zip codes 81635 and 81636.

Major categories of ICD-9 codes included those based on known association between disease and the exposures of concern, and those for which community members voiced concerns of elevated occurrence of disease. Major diagnosis categories analyzed included:

- Depression
- Nervous system

- Ear nose and throat (ENT)
- Vascular system
- Pulmonary

Similar to the cancer analyses, a 95% CI was calculated for each standardized incidence ratio to determine statistical significance and data are suppressed when less than 3 cases were recorded for the time period.

C1.1.3 Mortality Data Methods

Mortality data were analyzed by the Health Statistics Section at the Colorado Department of Public Health and Environment and provided to the CSPH.

The Colorado Department of Public Health and Environment provided aggregated mortality counts and standardized ratios of select underlying causes using the International Classification of Disease, tenth revision or ICD-10 codes for determining diagnoses. Mortality data were provided for the time period of 1999-2008. Data for the year 1998 were not included due to a switch from ICD-9 codes in 1998 to ICD-10 codes in 1999.

Mortality data were presented as number of deaths by primary underlying cause as well as SMRs computed using indirect adjustment of age based on the 2000 Census populations for the zip codes 81635 and 81636.

Major categories of ICD-10 codes were chosen based on diseases of interest. Major mortality categories included seven major categories:

- Suicide
- Nervous system diseases
- Major cardiovascular diseases
- Chronic lower respiratory diseases
- SIDS
- Cancers
- Leukemias

Similar to the cancer and inpatient hospitalization analyses described above, a 95% CI was calculated for each SMR to determine statistical significance. Also, data are suppressed when less than 3 deaths were recorded for the time period.

C1.1.4 Birth Outcomes Data Methods

The Colorado Department of Public Health and Environment provided CSPH data from the Colorado Birth Registry for the analyses of birth outcomes.

CSPH analyzed data from 1998 to 2008 for incidences of negative birth outcomes in zip codes 81635 and 81636 based on total births. Incidences of negative birth outcomes in the remainder of Colorado were used to determine expected incidences.

Birth outcome data are presented as the number of observed and expected birth outcomes, as well as standardized incidence ratios adjusted for maternal age and race.

Two negative birth outcomes were analyzed:

- Preterm birth (Gestational age less than 37 weeks)
- Low Birth weight (Gestational age 37 weeks or greater and birth weight less than 5.51 pounds)

Birth defects were not analyzed because the birth registry may not accurately reflect the number of birth defects. Birth detects will be evaluated at the later date using data from the Colorado birth defects registry, given that more than three events exist for the recorded time period.

Similar to the cancer and inpatient hospitalization analyses, a 95% CI was calculated for each standardized incidence ratio to determine statistical significance. Data suppression was not necessary because greater than three events were recorded for the time period.

C1.2 Population/Demographics

For all analyses listed within the physical health outcomes section, the population of Battlement Mesa Planned Urban Development (PUD) was defined as the population living within one of two zip codes: 81635 and 81636. The zip code 81635 denotes physical addresses in both the Battlement Mesa PUD and the town of Parachute, which is just north of the Battlement Mesa PUD. The zip code 81636 is used for Post Office (PO) boxes and therefore the 81635 zip code was used for population counts. Because the town of Parachute shares zip codes with Battlement Mesa, we included the Parachute population in our analyses.

The 2000 U.S. census was used to obtain the most accurate population counts as well as information on age, gender, and racial composition for the Battlement Mesa/Parachute zip code. According to the 2000 U.S. census estimates, 49.3 percent of the Battlement Mesa/Parachute population was female and 50.7 percent male. The median age was 37.5 years. Twenty-six percent of the population were under 18 years of age, 7.2 percent under five years, and 19.8 percent were 65 years and older. For people reporting race in Battlement Mesa/Parachute, 98.0 percent reported a single race: 93.4 percent identified as White, 0.5 percent as Black or African American, 0.9 percent as American Indian and Alaska Native, 0.2 percent as Asian, 0.2 percent as Native Hawaiian and Other Pacific Islanders and 2.8 percent as another race. Two percent of the population reported two or more races and 9.7 percent of the population identified as Hispanic or Latino (of any race). (Table 1) The most dramatic difference between the population for the 81635 zip code and the state of Colorado as a whole is in the over 65 age group. In Colorado in 2000, 9.7 percent of the population was 65 years and over compared to 19.8 percent of the population in the Battlement Mesa/Parachute zip code. Demographic/Population information for the zip code 81635 is provided in the table below.

Demographic/Population information for the zip code 81635

Subject	Number	Percent
Total population	**5,041**	**100**
SEX		
Male	2,487	49.3
Female	2,554	50.7
AGE		
Under 5 years	361	7.2
5 to 9 years	407	8.1
10 to 14 years	347	6.9
15 to 19 years	310	6.1
20 to 24 years	252	5
25 to 34 years	661	13.1
35 to 44 years	690	13.7
45 to 54 years	510	10.1
55 to 59 years	245	4.9
60 to 64 years	258	5.1
65 to 74 years	613	12.2
75 to 84 years	333	6.6
85 years and over	54	1.1
Median age (years)	37.5	(X)
18 years and over	3,730	74
Male	1,833	36.4
Female	1,897	37.6
65 years and over	1,000	19.8
Male	479	9.5
Female	521	10.3
RACE		
One race	4,939	98
White	4,709	93.4
Black or African American	23	0.5
American Indian and Alaska Native	43	0.9
Asian	11	0.2
Asian Indian	0	0
Chinese	1	0

Subject	Number	Percent
Filipino	2	0
Japanese	8	0.2
Korean	0	0
Vietnamese	0	0
Other Asian	0	0
Native Hawaiian and Other Pacific Islander	11	0.2
Some other race	142	2.8
Two or more races	102	2
Race alone or in combination with one or more other races		
White	4,808	95.4
Black or African American	37	0.7
American Indian and Alaska Native	94	1.9
Asian	18	0.4
Native Hawaiian and Other Pacific Islander	13	0.3
Some other race	181	3.6
HISPANIC OR LATINO AND RACE		
Total population	**5,041**	**100**
Hispanic or Latino (of any race)	488	9.7
Mexican	372	7.4
Puerto Rican	17	0.3
Cuban	4	0.1
Other Hispanic or Latino	95	1.9
Not Hispanic or Latino	4,553	90.3
White alone	4,413	87.5

Source: U.S. Census Data, 2000.

C1.3 Vulnerable populations

It is important to note that within a population there are individuals and groups of individuals which are at increased risk or more Vulnerable to disease. Increased Vulnerability is dependent upon a number of factors that can be categorized as demographic factors, genetic factors, and acquired factors.

Demographic factors include age, sex, race and ethnicity. Age is an important factor in determining Vulnerability. As noted in the population/demographics section, the U.S. Census data for the 81635 zip code indicate that greater than 45% of the population, in the year 2000, may be considered to be more Vulnerable to certain exposures, based on age (26 % under the age of 18 and 19.8 % over the age of 65).

Acquired factors (pre-existing disease, and behaviors such as smoking history, alcohol use, pregnancy, and nutrition) and genetic factors require a more in-depth analysis of individual history, including detailed information such as lifestyle behaviors, occupation, and residential history. Although these factors can contribute significantly to a person's Vulnerability to disease, such information is not available to the HIA team.

C1.4 Cancer, Death, Birth, Hospital Inpatient Data

Data for Cancer, Inpatient Hospital Diagnoses, Mortality and Birth data are reported below.

C1.4.1 Cancer Data

The counts listed in the tables below provide a summary of disease frequency. The incidence analyses determine whether a certain number of diagnosed cancers is greater or less than expected, and whether that difference is statistically significant. The results do not allow conclusions to be made about causal relationships between exposure and any cancer.

Tables 2-4 display the number of diagnosed cancers (types) in the Battlement Mesa/Parachute zip codes, the expected number of cases based on the population of male and female residents, stratified by race and age, and the calculated standardized incidence ratios with 95% CIs.

Male/Female Cancers Combined- As displayed in Table 2, the five most common cancers diagnosed in the Battlement Mesa/Parachute zip code during the 1998-2008 time period were prostate, breast, lung, colorectal, and melanoma. (Table 2) The only statistically significant difference between the number of diagnosed cancers and the number of expected cancers was shown for prostate cancer. Over the 10-year period, 79 cases of prostate cancer were diagnosed, compared to the calculated 61.897 expected cases, which yielded a ratio of 1.28 and a confidence interval of 1.01-1.59. However, caution should be exercised when interpreting standardized incidence ratios based on a small number of cases. In this case, if 2 fewer cases of prostate cancer were diagnosed over the 10-year period, the standardized incidence ratio would not have been significant. In addition, when multiple independent tests are compared, there is a statistical chance that 5 % of the tests will be abnormal by chance alone.

Table 2- Number of Males and Females Diagnosed with Selected Cancers Compared to the Expected Number in Battlement Mesa/Parachute Zip Codes 81635 and 81636 by Cancer Site, 1998-2008

Cancer Site	Cancers Diagnosed	Cancers Expected	SIR	95% C.I.
Hodgkin Lymphoma	+	0.880	NC	NC
Non-Hodgkin Lymphoma	8	7.645	1.05	0.45-2.06
Multiple Myeloma	5	2.442	2.05	0.66-4.79
Leukemia	5	6.017	0.83	0.27-1.94
Lung	29	23.958	1.21	0.81-1.74
Melanoma	17	14.190	1.20	0.70-1.92
Prostate	79	61.897	1.28*	1.01-1.59
Bladder	13	13.200	0.99	0.52-1.68
Colorectal	20	19.954	1.00	0.61-1.55
Adrenal Gland	+	0.120	NC	NC
Hodgkin Lymphoma	+	0.880	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: diagnosed/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
* = ratio is statistically higher than expected
Source: Colorado Central Cancer Registry, Colorado Dept. of Public Health & Environment, July, 2010

Cancers (Male Group) – As displayed in Table 3, the five most common cancers diagnosed in **males** Battlement Mesa/Parachute zip code during the 1998-2008 time period were prostate, lung, colorectal, melanoma, and bladder. The only statistically significant difference between the number of diagnosed cancers and the number of expected cancers when adjusted for age, and race was calculated for prostate cancer.

Table 3 – Number of Males Diagnosed with Selected Cancers Compared to the Expected Number in Battlement Mesa/Parachute Zip Codes 81635 and 81636 by Cancer Site, 1998-2008

Cancer Site	Cancers Diagnosed	Cancers Expected	SIR	95% C.I.
Hodgkin Lymphoma	+	0.880	NC	NC
Non-Hodgkin Lymphoma	8	7.645	1.05	0.45-2.06
Multiple Myeloma	5	2.442	2.05	0.66-4.79
Leukemia	5	6.017	0.83	0.27-1.94
Lung	29	23.958	1.21	0.81-1.74
Melanoma	17	14.190	1.20	0.70-1.92
Prostate	79	61.897	1.28*	1.01-1.59
Bladder	13	13.200	0.99	0.52-1.68
Colorectal	20	19.954	1.00	0.61-1.55
Adrenal Gland	+	0.120	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: diagnosed/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
* = ratio is statistically higher than expected
Source: Colorado Central Cancer Registry, Colorado Dept. of Public Health & Environment, July, 2010

Cancers (Female Group) - As displayed in Table 4, the five most common cancers diagnosed in **females** Battlement Mesa/Parachute zip code during the 1998-2008 time period were breast, lung, colorectal, melanoma, and bladder. No statistically significant differences were observed between the number of diagnosed cancers and the number of expected cancers when adjusted for age and race.

Table 4 - Number of Females Diagnosed with Selected Cancers Compared to the Expected Number in Battlement Mesa/Parachute Zip Codes 81635 and 81636 by Cancer Site, 1998-2008

Cancer Site	Cancers Diagnosed	Cancers Expected	SIR	95% C.I.
Hodgkin Lymphoma	+	0.693	NC	NC
Non-Hodgkin Lymphoma	4	6.215	0.64	0.18-1.65
Multiple Myeloma	+	1.562	NC	NC
Leukemia	+	3.773	NC	NC
Lung	19	18.656	1.02	0.61-1.59
Melanoma	7	9.218	0.76	0.31-1.57
Breast	56	56.452	0.99	0.75-1.29
Bladder	6	3.663	1.64	0.60-3.57
Colorectal	14	16.335	0.86	0.47-1.44
Adrenal Gland	+	0.088	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: diagnosed/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
* = ratio is statistically higher than expected
Source: Colorado Central Cancer Registry, Colorado Dept. of Public Health & Environment, July, 2010

C1.4.2 Inpatient Hospital Diagnoses Data

The counts listed in the tables below provide a summary of inpatient hospital diagnoses data. The results provide a summary of diagnoses given patients while in the hospital. The results determine whether diagnoses are greater or less than expected, and whether that difference is statistically significant. The results do not allow conclusions to be made about causal relationships between exposure and any hospital diagnoses.

Tables 5-7 display the number of diagnoses in the Battlement Mesa/Parachute zip code, the expected number of diagnoses per category based on the population of male and female

residents, stratified by race and age, and the calculated standardized incidence ratios with 95% CIs

Inpatient Hospital Diagnoses (Male/Female Group) - As displayed in Table 5, there are no inpatient ICD-9 code groups in which the standardized incidence ratio is >1.00 and statistically significant. Table 5 does show ICD-9 groups with fewer diagnoses than expected that are statistically significant, those groups include:

- Depression
- Nervous system
  - brain and CNS
  - dizziness
  - vertigo
- Ear, nose, and throat (ENT)
- Vascular (blood vessel related)
  - cardiovascular
  - cardiac dysrhythmia (abnormal heart rhythm)
  - heart failure
  - hypertension (high blood pressure)
  - stroke
- Pulmonary
  - bronchospasm-airway obstruction
  - asthma
  - other diseases with symptoms of the lung

Table 5- Inpatient Hospital Diagnoses (male/female combine group) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636 by sex and selected diagnoses: Colorado residents, 1998-2008.

Disease	Hospitalizations	Expected	SIR	95% CI
Depression	491	569.16	0.86	0.79-0.94
Nervous system	377	427.229	0.88	0.8-0.98
Brain and Central Nervous System (CNS)	44	60.189	0.73	0.53-0.98
Peripheral Nervous System (PNS)	99	101.571	0.97	0.79-1.19
Headaches	47	49.115	0.96	0.7-1.27
Seizure, epilepsy	167	184.211	0.91	0.77-1.05
Dizziness, vertigo	40	60.106	0.67	0.48-0.91
Ear, Nose and Throat (ENT)	224	272.762	0.82	0.72-0.94
Vascular	2,454	2,897.65	0.85	0.81-0.88
Cardiovascular disease	891	1,120.45	0.8	0.74-0.85
Cardiac dysrhythmia	669	846.962	0.79	0.73-0.85
Heart failure	539	723.47	0.75	0.68-0.81
Hypertension	1,688	1,914.51	0.88	0.84-0.92
Stroke	202	234.681	0.86	0.75-0.99
Arterial disease	90	85.952	1.05	0.84-1.29
Pulmonary	1,184	1,402.48	0.84	0.8-0.89
Bronchospasm, airway obstruction	894	1,068.22	0.84	0.78-0.89
Chronic bronchitis	172	191.802	0.9	0.77-1.04
Asthma	307	348.671	0.88	0.78-0.98
Reactions to external agents	+	0.941	NC	NC
Other diseases, symptoms of the lung	384	494.032	0.78	0.7-0.86

+= Data are not reported when the value for the time period is fewer than 3.

NC = Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Hospitalizations/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Note: A single hospitalization event may be represented in more than one diagnosis category.
Source: Hospital Discharge Data, Colorado Hospital Association
Prepared by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Inpatient Hospital Diagnoses (Male Group) - As displayed in Table 6, there are no inpatient ICD-9 code groups in which the standardized incidence ratio is >1.00 and statistically significant. Table 6 does show ICD-9 groups with fewer diagnoses than expected that are statistically significant, those groups include:

- Depression
- Vascular disease
  - cardiovascular
  - heart failure
  - hypertension (high blood pressure)
- Pulmonary
  - bronchospasm-airway obstruction
  - chronic bronchitis
  - asthma
  - other diseases with symptoms of the lung

Table 6- Inpatient Hospital Diagnoses (male) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636 by sex and selected diagnoses: Colorado residents, 1998-2008.

Disease	Hospitalizations	Expected	SIR	95% CI
Depression	146	199.205	0.73	0.62-0.86
Nervous system	178	192.663	0.92	0.79-1.07
Brain and CNS	19	29.116	0.65	0.39-1.02
PNS	55	48.653	1.13	0.85-1.47
Headaches	13	9.316	1.4	0.74-2.39
Seizure, epilepsy	86	95.26	0.9	0.72-1.11
Dizziness, vertigo	15	22.243	0.67	0.38-1.11
ENT	112	123.6	0.91	0.75-1.09
Vascular	1,112	1,456.82	0.76	0.72-0.81
Cardiovascular disease	531	710.133	0.75	0.69-0.81
Cardiac dysrhythmia	336	466.968	0.72	0.64-0.8
Heart failure	233	368.404	0.63	0.55-0.72
Hypertension	696	867.24	0.8	0.74-0.86
Stroke	112	118.67	0.94	0.78-1.14
Arterial disease	47	50.935	0.92	0.68-1.23
Pulmonary	527	700.505	0.75	0.69-0.82
Bronchospasm, airway obstruction	376	536.028	0.7	0.63-0.78
Chronic bronchitis	72	104.377	0.69	0.54-0.87
Asthma	97	122.566	0.79	0.64-0.97
Reactions to external agents	+	0.541	NC	NC
Other diseases, symptoms of the lung	178	247.538	0.72	0.62-0.83

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population

Note: Hospitalizations/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Note: A single hospitalization event may be represented in more than one diagnosis category.
Source: Hospital Discharge Data, Colorado Hospital Association
Prepared by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Inpatient Hospital Diagnoses (Female Group) - As displayed in Table 7, there are no inpatient ICD-9 code groups in which the standardized incidence ratio is >1.00 and statistically significant. Table 7 does show ICD-9 groups with fewer diagnoses than expected that are statistically significant, those groups include:

- Nervous system diseases
- ENT
- Vascular disease
  - cardiovascular disease
  - cardiac dysrhythmia
  - heart failure
  - stroke

- Pulmonary disease

Table 7- Inpatient Hospital Diagnoses (female) compared to expected number, in Battlement Mesa/Parachute zip codes 81635 and 81636 by sex and selected diagnoses: Colorado residents, 1998-2008.

Disease	Hospitalizations	Expected	SIR	95% CI
Depression	345	365.566	0.94	0.85-1.05
Nervous system	199	235.072	0.85	0.73-0.97
Brain and CNS	25	31.015	0.81	0.52-1.19
PNS	44	52.968	0.83	0.6-1.12
Headaches	34	40.1	0.85	0.59-1.18
Seizure, epilepsy	81	90.114	0.9	0.71-1.12
Dizziness, vertigo	25	36.953	0.68	0.44-1
Ear, Nose, and Throat (ENT)	112	149.617	0.75	0.62-0.9
Vascular	1,342	1,448.91	0.93	0.88-0.98
Cardiovascular disease	360	436.398	0.82	0.74-0.91
Cardiac dysrhythmia	333	390.491	0.85	0.76-0.95
Heart failure	306	358.627	0.85	0.76-0.95
Hypertension	992	1,033.64	0.96	0.9-1.02
Stroke	90	117.158	0.77	0.62-0.94
Arterial disease	43	36.563	1.18	0.85-1.58
Pulmonary	657	717.134	0.92	0.85-0.99
Bronchospasm, airway obstruction	518	547.509	0.95	0.87-1.03
Chronic bronchitis	100	91.099	1.1	0.89-1.34
Asthma	210	225.193	0.93	0.81-1.07
Reactions to external agents	+	0.409	NC	NC
Other diseases, symptoms of the lung	206	248.615	0.83	0.72-0.95

+= Data are not reported when the value for the time period is fewer than 3.
NC: Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population

Note: Hospitalizations/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Note: A single hospitalization event may be represented in more than one diagnosis category.
Source: Hospital Discharge Data, Colorado Hospital Association
Prepared by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

C1.4.3 Mortality Data

The counts listed in the tables below provide a summary of mortality data. The results determine whether deaths categorized by underlying disease are greater or less than expected, and whether that difference is statistical significant. The results do not allow conclusions to be made about causal relationships between exposure and any cancer.

Tables 8-10 display the number of deaths by underlying disease in the Battlement Mesa/Parachute zip code, the expected number of deaths based on the population of male and female residents, stratified by race and age, and the calculated SMRs with 95% CIs.

Mortality (Male/Female group combined) - As displayed in Table 5, there are no groups of underlying cause of death in which the SMR was >1.00 and was statistically significant. However, Table 5 does show two categories of underlying disease where there were fewer deaths than expected. The following categories were less than expected (statistically significant):

- Nervous system diseases
- Major cardiovascular disease

Table 8- Deaths (Males/Females) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636, by sex and selected underlying causes: Colorado residents, 1999-2009.

Disease	Deaths Observed	Expected Deaths	SMR	95% CI
Total deaths	381	499.799	0.76	0.69-0.84
Suicide	11	7.81	1.41	0.7-2.52
Nervous system diseases	18	30.724	0.59	0.35-0.93
Major cardiovascular diseases	114	162.546	0.7	0.58-0.84
Chronic lower respiratory diseases	27	37.062	0.73	0.48-1.06
Sudden Infant Death Syndrome (SIDS)	+	0.501	NC	NC
Cancers				
Breast	7	7.843	0.89	0.36-1.84
Prostate	7	7.12	0.98	0.4-2.03
Lung and bronchus	30	28.094	1.07	0.72-1.52
Colon/rectum	7	11.359	0.62	0.25-1.27
Melanoma	3	1.943	1.54	0.32-4/51
Bladder	+	2.712	NC	NC
Adrenal gland	+	0.1	NC	NC
Non-Hodgkin's lymphoma	4	4.654	0.86	0.23-2.2
Hodgkin's lymphoma	+	0.255	NC	NC
Multiple myeloma	3	2.446	1.23	0.25-3.58
Leukemia	4	4.68	0.85	0.23-2.19
Acute lymphocytic leukemia	0	0.261	NC	NC
Chronic lymphocytic leukemia	3	1.024	2.93	0.6-8.56
Acute myeloid leukemia	+	1.846	0.54	0.01-3.02
Chronic myeloid leukemia	+	0.277	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.

Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Deaths/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
ICD-10 codes used to identify selected diagnoses[112], Table C
Source: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Mortality (Male Group) - As displayed in Table 9, there were no groups of underlying cause of death in which the SMR was >1.00 and was statistically significant. There were also no groups of underlying disease in which the SMR was <1.00 and statistically significant.

Table 9- Deaths (Males) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636, by sex and selected underlying causes: Colorado residents, 1999-2008

Disease	Deaths Observed	Expected Deaths	SMR	95% CI
Total deaths	223	272.783	0.82	0.71-0.93
Suicide	9	6.295	1.43	0.65-2.71
Nervous system diseases	9	14.17	0.64	0.29-1.21
Major cardiovascular diseases	71	86.902	0.82	0.64-1.03
Chronic lower respiratory diseases	13	21.324	0.61	0.32-1.04
Sudden Infant Death Syndrome (SIDS)	+	NC	NC	NC
Cancers				
Breast	+	NC	NC	NC
Prostate	7	8.377	0.84	0.34-1.72
Lung and bronchus	21	16.728	1.26	0.78-1.92
Colon/rectum	4	6.355	0.63	0.17-1.61
Melanoma	+	1.373	NC	NC
Bladder	+	2.187	NC	NC
Adrenal gland	+	0.051	NC	NC
Non-Hodgkin's lymphoma	3	2.8	1.07	0.22-3.13
Hodgkin's lymphoma	+	0.165	NC	NC
Multiple myeloma	3	1.479	2.03	0.42-5.93
Leukemia	+	2.997	NC	NC
Acute lymphocytic leukemia	+	0.159	NC	NC
Chronic lymphocytic leukemia	+	NC	1.47	NC
Acute myeloid leukemia	+	NC	0.87	NC
Chronic myeloid leukemia	+	0.173	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.
NC = Not calculated.

Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Deaths/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
ICD-10 codes used to identify selected diagnoses[112], Table C
Source: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

Mortality (Female Group) - As displayed in Table 10, there are no groups of underlying cause of death in which the SMR was >1.00 and was statistically significant. Table 10 shows that there were fewer total deaths and deaths due to cardiovascular disease than expected and this was statistically significant.

Table 10- Deaths (Female) compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636, by sex and selected underlying causes: Colorado residents, 1999-2008

Disease	Deaths Observed	Expected Deaths	SMR	95% CI
Total deaths	158	231.569	0.68	0.58-0.8
Suicide	+	1.642	NC	NC
Nervous system diseases	9	16.36	0.55	0.25-1.04
Major cardiovascular diseases	43	76.496	0.56	0.41-0.76
Chronic lower respiratory diseases	14	16.667	0.84	0.46-1.41
Sudden Infant Death Syndrome (SIDS)	+	0.189	NC	NC
Cancers				
Breast	7	7.329	0.96	0.38-1.97
Prostate	+	0	NC	NC
Lung and bronchus	9	12.083	0.74	0.34-1.41
Colon/rectum	3	5.139	0.58	0.12-1.71
Melanoma	+	0.636	NC	NC
Bladder	+	0.73	NC	NC
Adrenal gland	+	0.049	NC	NC
Non-Hodgkin's lymphoma	+	1.97	NC	NC
Hodgkin's lymphoma	+	0.096	NC	NC
Multiple myeloma	+	1.03	NC	NC
Leukemia	+	1.857	NC	NC
Acute lymphocytic leukemia	+	0.113	NC	NC
Chronic lymphocytic leukemia	+	0.38	NC	NC
Acute myeloid leukemia	+	0.759	NC	NC
Chronic myeloid leukemia	+	0.112	NC	NC

+= Data are not reported when the value for the time period is fewer than 3.

NC = Not calculated.
Note: Expected counts computed by applying age-and sex-specific statewide mortality rates to 2000 based study population
Note: Deaths/expected ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
ICD-10 codes used to identify selected diagnoses[112], Table C
Source: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

C1.1.4 Birth Outcome Data

The counts listed in the tables below provide a summary of birth outcome data. The results determine whether birth outcomes are greater or less than expected, and whether that difference is statistically significant. The results do not allow conclusions to be made about causal relationships between exposure and any birth outcome.

Table 11 presents a comparison of maternal age and race between the Battlement Mesa/Parachute zip code and the rest of Colorado.

Table 11- Maternal demographics in Battlement Mesa/Parachute zip codes 81635 and 81636 compared to Colorado, 1998-2008.

Race	Battlement Mesa/Parachute	Colorado
Hispanic	240 (23.98)	213842 (28.84)
White	727 (72.63)	455285 (61.41)
Other Race	34 (3.4)	72245 (9.74)
< 20 years	154 (15.38)	77679 (10.48)
20-40 years	833 (83.22)	643619 (86.81)
> 40 years	14 (1.4)	20074 (2.71)

Table 12 displays the number of a particular birth outcome observed in the Battlement Mesa/Parachute zip code, the expected number of birth outcomes, based on the number of total births in the Battlement Mesa/Parachute zip code, stratified by maternal race and age, and the calculated standardized incidence ratios with 95% CIs

As displayed in Table 12, there are no birth outcomes for which the standardized incidence ratio is >1.00 or <1.00 and statistically significant. There is no statistical difference between the number of negative birth outcomes observed and the number expected.

Table 12- Negative birth outcomes compared to expected number in Battlement Mesa/Parachute zip codes 81635 and 81636 to Colorado residents, 1998-2008.

Outcome	Observed	Expected	SIR	95% CI
Preterm Birth	92	93	0.99	0.68 – 1.4
Low Birth Weight	30	34	0.88	0.43-1.6

Note: Expected counts computed by applying age-and race-specific statewide incidence rates to births in zip codes 81635 and 81636 between 1998 and 2008
Note: standardized incidence ratios that have a 95% confidence interval that brackets the value 1.00 are not considered statistically high or low.
Source: Data from Colorado Birth Registry provided by: Health Statistics Section, Colorado Dept. of Public Health & Environment, July, 2010

C.1.5 Health Data Gaps/Limitations

In determining baseline health for the Battlement Mesa/parachute area, it was not possible to obtain some important information regarding physical health. This missing information is referred to as *Data Gaps.*

Some medical conditions are routinely treated on an outpatient basis, with rare hospital admissions. Asthma, hypertension, diabetes, mental health disorders and other conditions are such examples. While the CSPH team made several attempts to obtain outpatient and emergency department information, it was not possible to do so in the time frame of this report. Therefore, this information is not included in the baseline health assessment. In addition, the CSPH team was unable to include injury information in the baseline health assessment. Injury information is best found in emergency room data, outpatient and occupational health clinics.

All data sets have important limitations. It is important to understand the limitations of the data that was used for this baseline health assessment. Understanding the limitations helps researchers and readers interpret the data correctly.

C1.5.1 Cancer data

Cancers may sometimes be associated with residential history, lifestyle behaviors, occupation, or genetics. Cancers are typically diseases of long latency, often years to decades, therefore current incidence is not necessarily indicative of current exposure. We did not have information regarding individual residential history, lifestyle behaviors, occupation, or genetics.

C1.5.2 Inpatient hospitalization data

Hospital discharge records do not capture information about personal risk factors, such as weight, smoking, family medical history, which are all important in considerations when assessing health. Hospital discharge records often contain detailed information for each patient discharge record, such as demographic information, however, the CSPH team did not have access to hospital discharge records, and therefore no demographic information was obtained.

Some diseases may take years to be actively reflected hospital diagnoses numbers. As mentioned above these diseases may be treated primarily on an outpatient basis and are therefore not captured by hospital diagnoses. In addition, like cancer, some diseases have long latency and are not captured in hospital discharge records until years after pertinent exposures.

Medical practice patterns and payment mechanisms may affect decisions by healthcare providers to hospitalize patients, to correctly diagnose disease, and/or to list the condition as a discharge diagnoses.

The ICD-9 codes abstracted from the discharge records include all diagnoses made during that particular hospital stay. As a consequence of this method, the sum of the diagnoses across a series of diagnosis subcategories (i.e. stroke, cardiovascular disease) may be greater than the total count for a parent category (i.e. vascular disease) because a single hospitalization record may have provided more than one subcategory when containing multiple diagnoses. It should also be noted, that it is possible that a patient was admitted more than once during our time frame and therefore the diagnoses associated with that patient would have been counted more than once. Diagnoses, therefore, may be higher than prevalence of disease.

C1.5.3 Mortality Data

Mortality data provide information on fatal illness only, not on current rate of disease. In addition, there are often multiple causes that act synergistically to cause death, or the cause of death is not clear. For this analysis, only the primary cause of death was considered.

C1.5.4 Birth Data

Birth data provide information from birth certificate, which may not have been verified and are not always consistently recorded. They do reflect the current rate of disease. In addition, there are often multiple causes that act synergistically to cause negative birth outcome.

C1.6 Conclusions for Physical Health

In order to provide the residents of Battlement Mesa with a baseline picture of physical health, the CSPH obtained analyzed data from state and hospital databases, as well as birth outcomes data, from CDPHE.

For the time period of 1998-2008 the Battlement Mesa/Parachute residents were found to be in better health than people of similar age, race and gender elsewhere in the state of Colorado. The slightly higher than expected rate of prostate cancer is felt to be a chance occurrence. The residents of Battlement Mesa had the same number or fewer as expected of other common cancers and leukemia; the same number or fewer than expected hospital discharge diagnoses related to depression, nervous system conditions, ear/nose/throat conditions, vascular conditions, and pulmonary conditions. These residents also had the same as expected or fewer than expected total deaths and deaths related to suicide, nervous system diseases, cardiovascular diseases, chronic lower respiratory diseases, and sudden infant death syndrome, as well as common cancers. Finally, the negative birth outcomes preterm birth, low birth weight, and congenital malformations all occurred at rates no higher or lower than those elsewhere in Colorado.

Data gaps and limitations make this baseline profile incomplete. Future investigations should focus on establishing data sharing agreements with local hospitals to obtain emergency room and outpatient data. Furthermore, collection of primary data, through surveys, medical record review and reanalysis of existing databases would also yield a more complete picture of physical health in Battlement Mesa.

C2 Social Determinants of Health

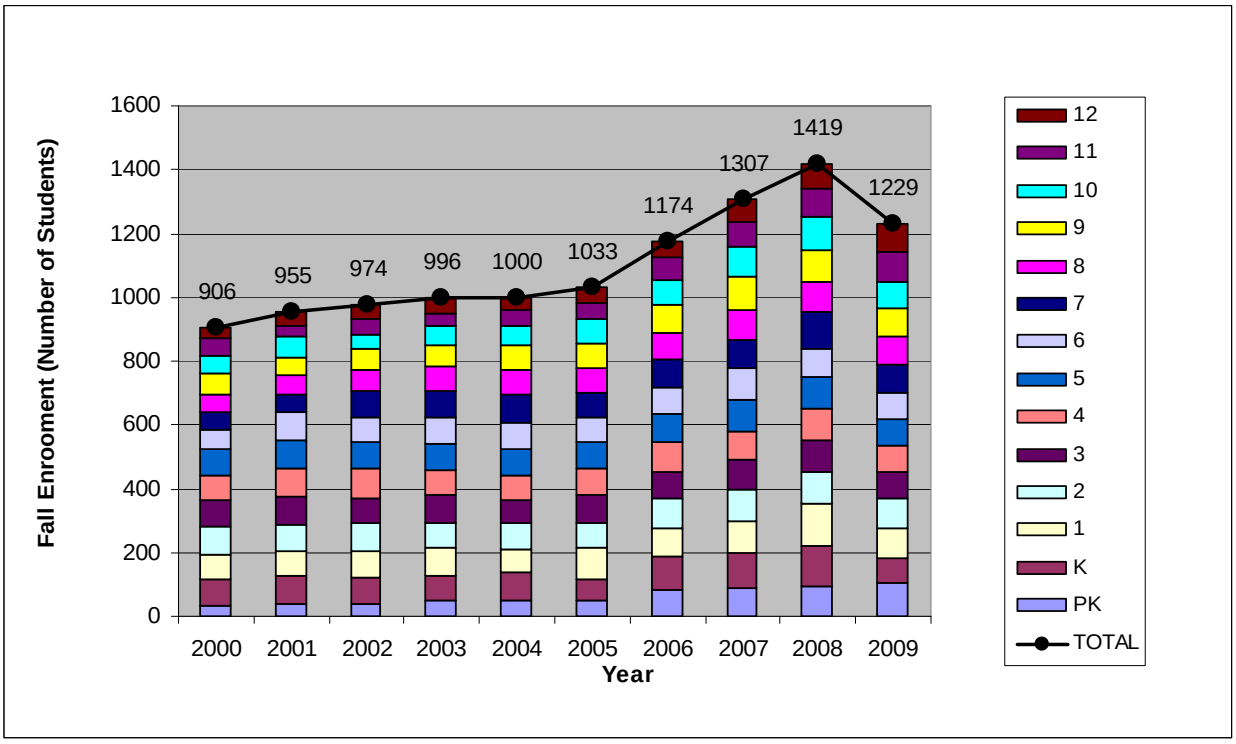
The following sections summarize key data evaluations conducted as part of the Community Wellness Assessment.

C2.1 Education/School Enrollment

Education for children in the towns of Battlement Mesa and Parachute is provided by Garfield County School District 16. Currently, the district is comprised of four schools, Grand Valley High School (9^{th}-12^{th}), Grand Valley Middle School (6^{th}-8^{th}), St. John Elementary School (4^{th}-5^{th}), and Bea Underwood Elementary School (1^{st}-3^{rd}). Additionally, the Grand Valley Center for Family Learning hosts the districts Head Start, Pre-Kindergarten and Kindergarten programs[113].

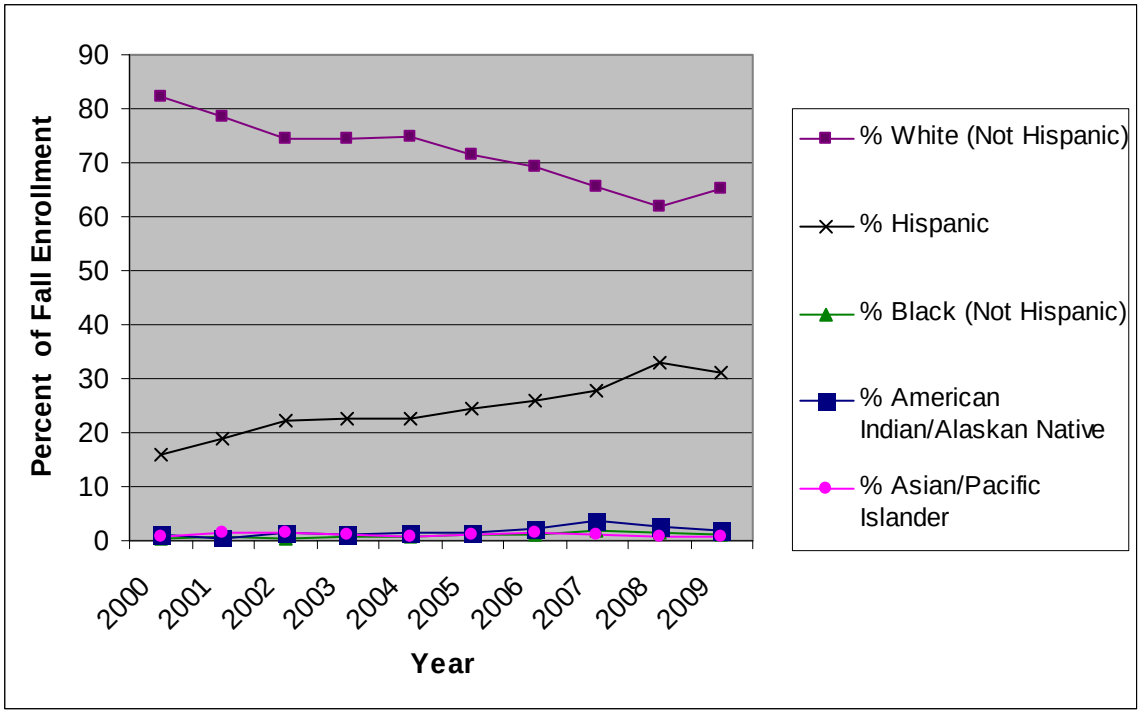
Data on school enrollment was collected from the Colorado Department of Education (http://www.cde.state.co.us/ index_stats.htm). In 2009, there were 1,229 students enrolled in the district, an increase of 19.0% since 2005 and 35.7% since 2000. Figure 1 displays annual district enrollment stratified by grade. While total enrollment has increased significantly, with an increase of nearly 400 students during the period 2005-2008, proportional enrollment by grade appears to have remained relatively stable.

Figure 1: Garfield County District 16, School Enrollment by Grade 2000-2009



Since 2000, there has been a change in the racial and ethnic profile of students enrolled in the district schools (Figure 2). The percentage of Hispanic children has doubled from approximately 15% in 2000 to 30% in 2009. At the same time, the percentage of White children has decreased from 82% to 65%. Proportions of African American, American Indian, and Asian children have remained relatively stable.

Figure 2: Garfield County School District 16, Enrollment by Race/Ethnicity 2000-2009



C2.2 Crime

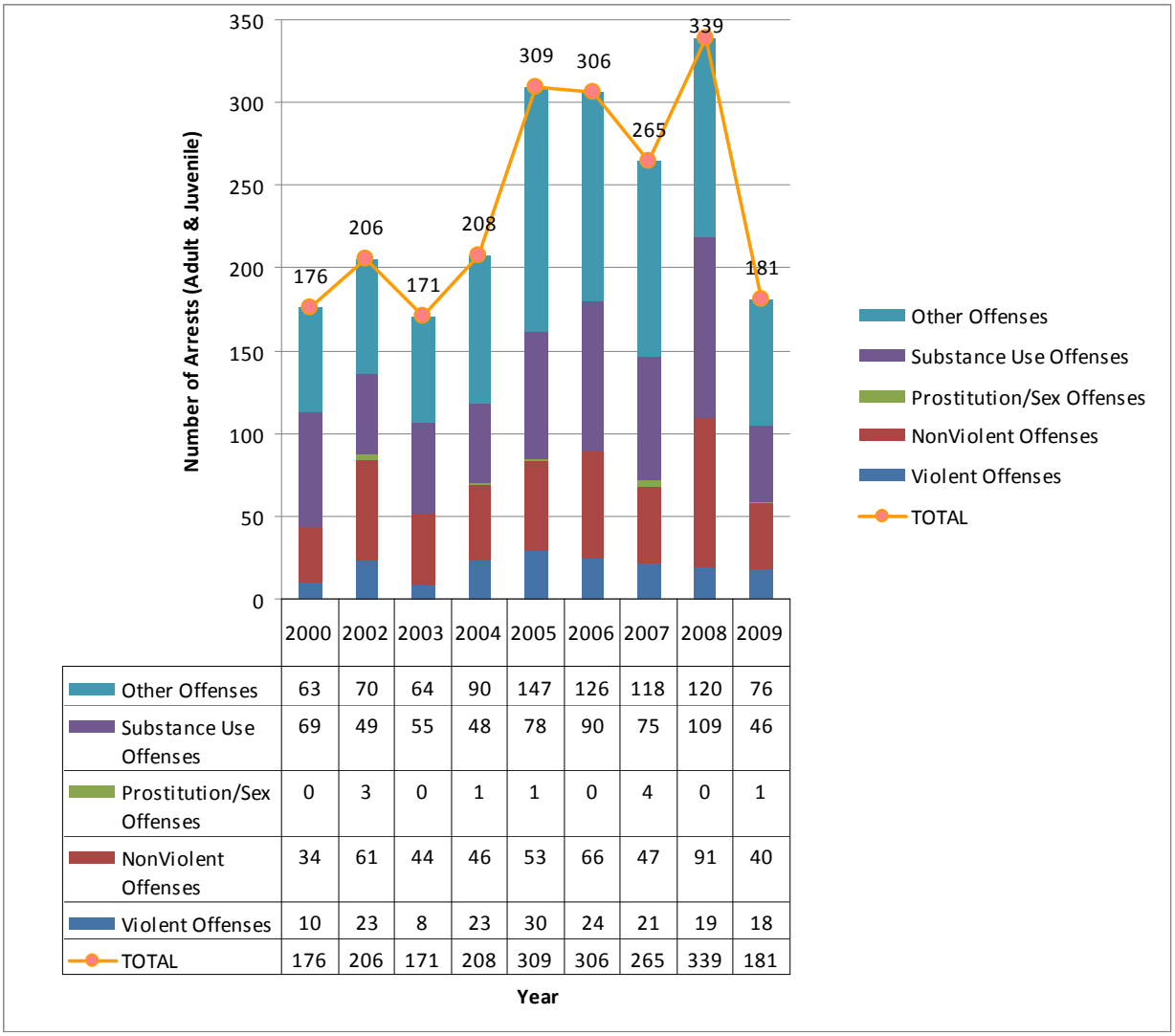
Data on criminal activity is publically available through the Colorado Bureau of Investigation (CBI) in the annual Crime in Colorado report. All Colorado law enforcement agencies are required to submit crime and arrest data to the CBI through the federally mandated Uniform Crime Reporting (UCR) Program. Incident data follow the national UCR Summary Hierarchy Rules and the National Incident-Based Reporting System (NIBRS) reporting and counting guidelines, broadly interpreted to mean the arrest for the most serious charge is counted[114].

Due to its unincorporated status and lack of a designated police force, criminal investigation for events in the Battlement Mesa PUD is under the jurisdiction of the Garfield County Sheriff's Office (GCSO). Statistics for crimes occurring in Battlement Mesa are reported to CBI by the GCSO and thus become part of the larger pool of data reported to the NIBRS database by that agency. For this HIA report, the GCSO was contacted and agreed to attempt retrieval of crime statistics specific to Battlement Mesa. These attempts were not successful due to recent changes in their internal electronic systems and also restrictions on mechanisms for agencies to retrieve data from the NIBRS system. The neighboring town of Parachute, which shares a zip-code with Battlement Mesa, operates a stand-alone police department and maintains NIBRS reporting separate from the GCSO. Due to its close proximity and similar community composition, CBI data from the Parachute PD was analyzed as a surrogate for criminal activity in Battlement Mesa. These data may also include crime occurring in Battlement Mesa which the Parachute Police force responded to and resolved. Adult and juvenile arrests were included.

In Figure 3 below, violent arrests consisted of crimes such as assault and forcible rape, nonviolent arrests included crimes like burglary, theft and vandalism, substance use offenses

included DUI and drug violations. The category of other arrests was not well-characterized in the source data, but includes various and numerous other crimes such as weapons offenses, fraud and forgery. There is no consistent trend apparent across the entire period of 2000-2009; however crime rates appear somewhat elevated during the period 2005-2008, then decreased to baseline frequency in 2009. This includes clear increases in the categories of substance abuse and other offences. While these data are not sufficient to establish a causal relationship between the boom of drilling activity in 2003 and crime rates, the higher crime numbers over the 2005-2008 period suggest additional monitoring in this area is warranted during times of high industry activity and in-migration of workers and other population shifts. Though not possible to do with publically available data, evaluation of crime rates by season or month may facilitate better understanding of whether criminal activity is correlated with increased drilling activity and workforce numbers.

Figure 3: Arrests Recorded by the Parachute Police Department, 2000-2009*



	2000	2002	2003	2004	2005	2006	2007	2008	2009
Other Offenses	63	70	64	90	147	126	118	120	76
Substance Use Offenses	69	49	55	48	78	90	75	109	46
Prostitution/Sex Offenses	0	3	0	1	1	0	4	0	1
NonViolent Offenses	34	61	44	46	53	66	47	91	40
Violent Offenses	10	23	8	23	30	24	21	19	18
TOTAL	176	206	171	208	309	306	265	339	181

*2001 data not available

C2.3 Mental Health, Substance Abuse and Suicide:

Significant efforts were made to obtain data on mental health, substance abuse and suicide specific to residents of Battlement Mesa. We identified the Colorado West Regional Mental Health, Inc. as a potential source of this information due to their wide-reach in the region with numerous local outpatient clinics, including Rifle and Glenwood Springs[115]. Outpatient services offered by Colorado West include key treatment approaches for mental health such as, emergency and critical incident consultation, counseling for families, children & adults, psychiatric evaluation and medication management, as well as being a major provider of Employee Assistance Programs. While data on clinical usage and outpatient visits is maintained centrally across all clinics in the Colorado West system, they were unable to provide data for analysis requested for this project due to recent changes in their electronic system rendering retrospective data inaccessible in the time-frame required for this report. Colorado West and the authors of this report are also aware of the highly sensitive nature of data on mental health measures, and were prepared to implement information sharing agreements as necessary to safe-guard any identifying protected health information.

As primary data from Colorado West was not available, nor does Colorado West track visit data specific to substance abuse, Community Health Initiative (CHI) was identified as a potential source of baseline data on this topic[116]. CHI is a public service organization with locations in Glenwood Springs and Carbondale. Working with partners from area agencies and organizations, such as Garfield County's Public Health Department and School District, its primary mission involves reducing substance abuse by sponsoring workplace and community prevention programs and providing outpatient treatment services for youth. While primary data were not available from CHI, several reports are publically available which detail recent projects in community prevention and provide summary statistics for measures pertaining to these issues.

One of these reports is the Garfield County Public Health Department's 2006 assessment on community needs[68]. Through their Health and Quality of Life Survey, conducted during the period of September-October 2005, the GCPH identified four types of health/quality-of-life problems most common to survey respondents. One of these common issues was the challenge associated with mental health and substance abuse. This topic was identified to be widespread across households of Garfield County, affecting a greater number of households than issues pertaining to medical/dental service access or environmental risk. Further, the survey found that when respondents reported mental health problems (defined as experiencing depression or stress), they also reported issues with substance abuse in the home and difficulties/restrictions to engaging in physical activity. Within the mental health and substance abuse domains, depression, anxiety and stress along with tobacco smoking and alcohol abuse were the top indicators of the burden of these conditions (Table 13).

Table 13: Data from the Garfield County Public Health Department 2006 Community Needs Survey

Health/Quality of Life Domain Assessed	Three Most Prevalent Conditions Reported	% All Respondents (n=740)
Household with member(s) affected by mental health issues	a) Depression/anxiety	17.2%
	b) Stress	15.4%
	c) Eating disorders	3.0%
Household with member(s) affected by substances abuse issues	a) Smoking using tobacco	10.4%
	b) Alcohol abuse	6.9%
	c) Drug abuse	1.5%

It is important to note that the survey respondents were self-selected through survey distribution at libraries, city halls, community centers, health clinics, and mailings to some randomly selected homes. Thus, the respondents did not represent a statistically chosen sample of Garfield County, however the authors noted that response came from a wide-range of individuals and were probably the "most valid information available on residents' health and quality-of-life experiences."

Another study available through CHI provides an analysis of discharge data from four Garfield County regional hospitals during the period 2003-2005 for persons whose diagnoses included either alcohol/drug abuse or suicidal behavior[69]. This study showed that of the 275 persons attributed to these discharge diagnoses during this period, 47 (17.1%) had an alcohol/drug abuse diagnosis and 228 (82.9%) had a diagnosis of suicidal behavior. (Table 14) This study only looked at count data of hospital admissions, so we cannot assess trends or compare rates of these conditions to expected rates or rates of other discharge diagnoses. While these data cannot be attributed directly to residents of Battlement Mesa, they suggest that substance abuse and suicidal ideation exist in the surrounding community. As such, they should be monitored and prevention measures should be implemented where possible.

Table 14: Data from the Garfield County Colorado Prevention Partners 2006 Local Needs Assessment Report on Alcohol./Drug Abuse and Suicidal Behavior

Hospital	Diagnostic Group		Total
	Alcohol/Drug Abuse	Suicidal Behavior	
Aspen Valley Hospital	12	32	44
Grand River Medical Center	0	8	8
Vail Valley Medical Center	17	133	150
Valley View Hospital	18	55	73
Total	**47** (17.1%)	**228** (82.9%)	**275**

Further analysis in this report showed fewer admissions for alcohol/substance abuse and suicidal behavior treatment during the summer months, with the highest numbers occurring in December and the late winter months. Also seen in this data were that significantly more men were treated for substance abuse and significantly more women for suicidal behavior; the mean ages of the two diagnoses groups were 41 and 39 respectively.

C2.4 Sexually Transmitted Infections

In Colorado, several sexually transmitted infections (STIs) are reportable to the state health department, including Chlamydia, Gonorrhea, Syphilis and HIV. De-identified sexually transmitted infection data were available by request from the Colorado Department of Public Health and Environment (CDPHE). Incident sexually transmitted infection cases were obtained for the years 2005-2009 for all zip codes in Garfield County.

Table 15 displays frequency of cases for the two sexually transmitted infection's of greatest prevalence in Battlement Mesa and Garfield County. Due to small numbers, it is difficult to draw conclusions about proportion or distribution of cases among Battlement Mesa residents, or make valid comparisons to a larger cohort such as Garfield County. However, these data show that Chlamydia is more prevalent in the female population, with between 70-85% of the Garfield County cases and 60-100% of the Battlement Mesa cases occurring in females. During the period 2005-2007, between 46-60% of Gonorrhea case occurred in Garfield County females, yet that proportion has decreased to around 20% in recent years. A similar assessment of Battlement Mesa cases cannot be made due to low numbers.

Table 15: Chlamydia and Gonorrhea Cases by Gender, Garfield County and Battlement Mesa, 2005-2009

sexually transmitted infection	Year	Garfield County N (% of Total)			Battlement Mesa N (% of Total)		
		Male	Female	Total N	Male	Female	Total N
Chlamydia	2005	13 (25.0)	39 (75.0)	52	2 (33.3)	4 (66.7)	6
	2006	12 (16.7)	60 (83.3)	72	0 (0.0)	6 (100.0)	6
	2007	25 (28.1)	64 (71.9)	89	7 (36.8)	12 (63.2)	19
	2008	27 (22.5)	93 (77.5)	120	0 (0.0)	10 (100.0)	10
	2009	21 (29.2)	51 (70.8)	72	1 (10.0)	9 (90.0)	10
Gonorrhea	2005	2 (50.0)	2 (50.0)	4	1 (100)	0 (0)	1
	2006	4 (40.0)	6 (60.0)	10	0 (0)	1 (100)	1
	2007	7 (53.9)	6 (46.1)	13	0 (n/a)	0 (n/a)	0
	2008	4 (80.0)	1 (20.0)	5	0 (n/a)	0 (n/a)	0
	2009	3 (75.0)	1 (25.0)	4	1 (100)	0 (0)	1

Using epidemiologic methods described below, we calculated rates of sexually transmitted infection for Battlement Mesa residents (defined as zip codes 81635 and 81636) as well rates for all residents of Garfield County combined.

Rather than assess only a count of the number of cases, evaluating a rate provides perspective on the measure of the frequency with which a disease occurs in a population over a specified period of time. Population incidence rates can be calculated using the number of new cases observed in the numerator and the mid-year population as the denominator. Using this method, sexually transmitted infection rates for Garfield County were calculated using population estimates from the U.S. Census Bureau, which produces annual mid-year estimates of total population for states, counties and other sub-county units (Table 16) [4]. For the period 2005-2009, these population estimates were derived from 2000 U.S. Census base data.

Within the Garfield County sexually transmitted infection dataset, Battlement Mesas cases were defined as occurring for residents of zip codes 81635 and 81636. Zip code 81635 denotes physical addresses in both the Battlement Mesa and the town of Parachute, while 81636 is used solely for Post Office (PO) boxes. Because the town of Parachute shares a zip code with Battlement Mesa, we were not able to exclude the population from these analyses. Because U.S. Census Bureau mid-year population estimates are not available for unincorporated places, such as the Battlement Mesa PUD, the population for 2005-2009 was calculated using the equivalent percentage changes as provided for Garfield County, described above and in Table 16.

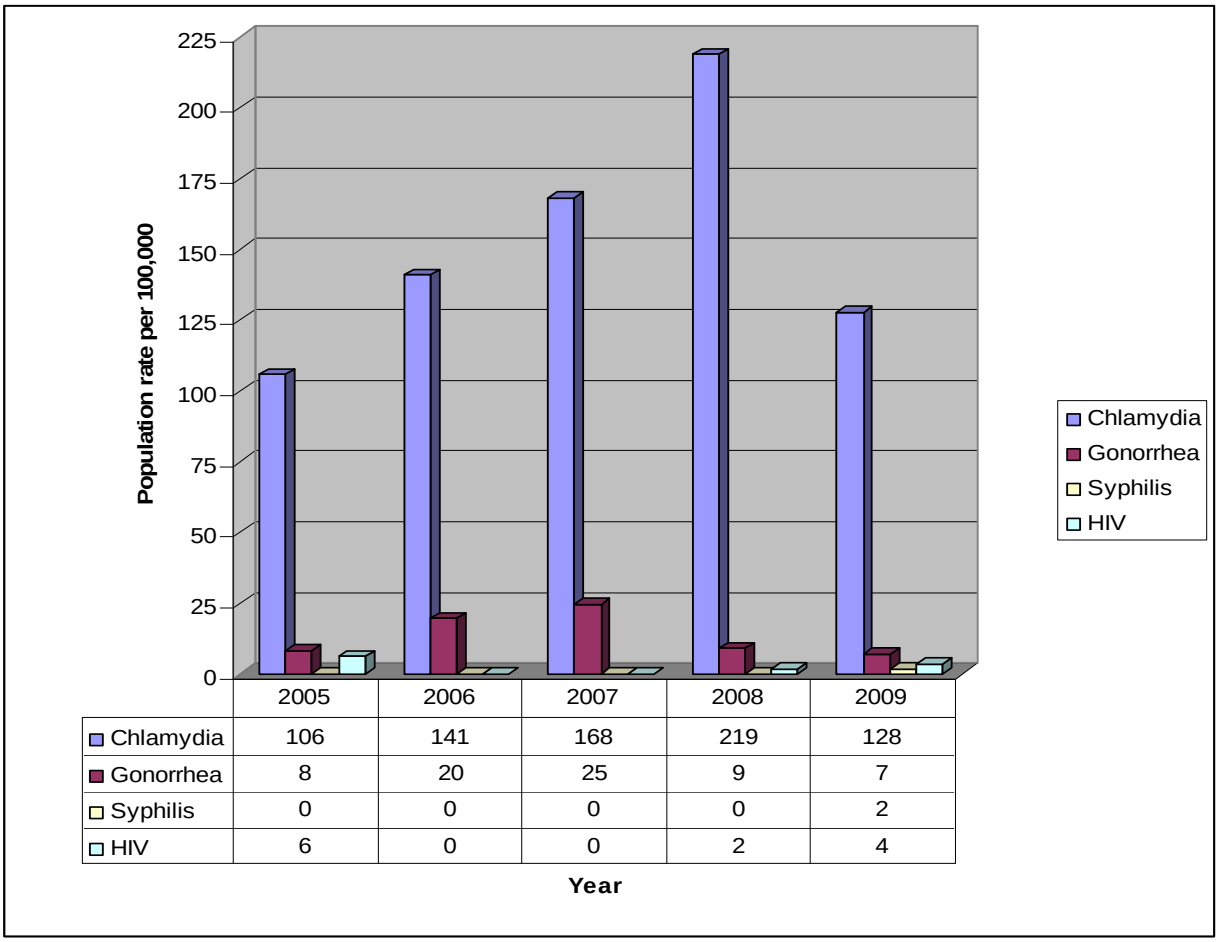
Table 4: Population Estimates for Garfield County and the Battlement Mesa PUD, 2005-2009

	2000 U.S. Census Population Estimate	2005	2006	2007	2008	2009
Garfield County Population Est. Provided by the US Census	43,791	49,177	51,111	52,965	54,838	56,298
Percent Change in Garfield County Population, Calculated & Applied to Battlement Mesa	(Baseline)	12.3 %	3.93 %	3.63 %	3.54 %	2.66 %
Battlement Mesa PUD Population Est.	5,041	5,661	5,884	6,097	6,313	6,481

Because the oil & gas industry boom occurred in 2003, in-migrant populations who have since remained in Garfield County and Battlement Mesas were not counted in the 2000 Census data. As such, these mid-year population estimates may be underestimate of the true population levels and may potentially inflate the observed the rates. Additionally, these population estimates for are not age adjusted. Never-the-less, this method represents the most accurate estimate available to assess trends in sexually transmitted infection incidence rates over time.

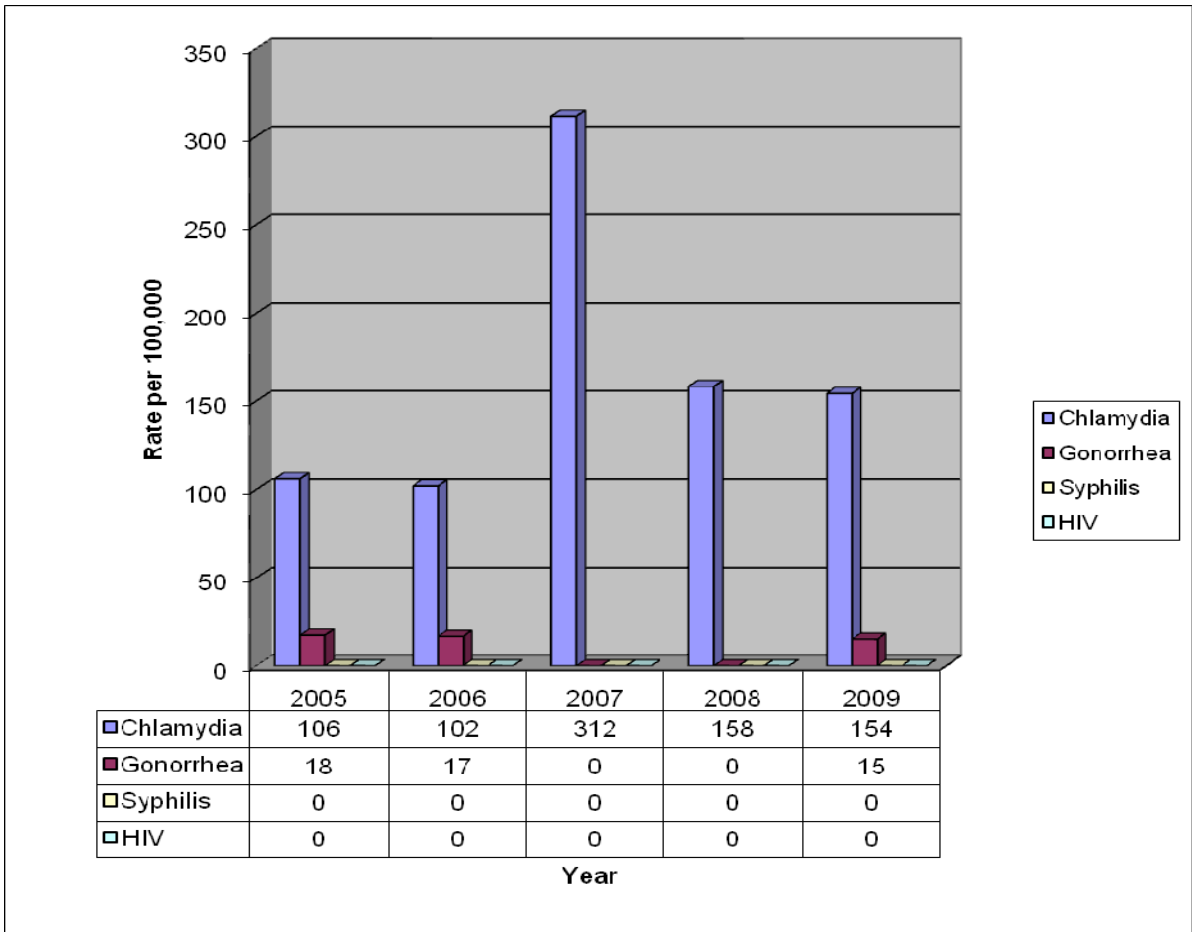
Garfield County experienced a steady increase in Chlamydia rates for the period 2005-2008, yet there was a noticeable decline in incidence in 2009. (Figure 4) In comparison, Battlement Mesa residents experienced stable rates of Chlamydia in 2005-06, yet saw a sharp increase in the case rate in 2007, which then decreased and remained stable in 2008-09. (Figure 5) In tandem with the increase of Chlamydia, rates of new Gonorrhea also increased significantly in Garfield County from 8 cases/100,00 population in 2005 to 25 cases/100,000 population in 2007, but declined and have remained stable since 2008. (Figure 4) The Gonorrhea case rate for Battlement Mesa did not experience the same trend, and has not increased over 18 cases per 100,000 population since 2005, the equivalent of < 1 case per 5,000 people. (Figure 5) It is worth noting that the numbers of cases for Battlement Mesa are very small, making it difficult to assess population trends and comparison with the larger cohort of Garfield County. Rates of Syphilis and HIV are extremely low for both Garfield County and Battlement Mesa. In fact, there were no cases of either recorded for residents of Battlement Mesa during this evaluation period.

Figure 4: Rates of Sexually Transmitted Infection, Garfield County, 2005-2009



	2005	2006	2007	2008	2009
Chlamydia	106	141	168	219	128
Gonorrhea	8	20	25	9	7
Syphilis	0	0	0	0	2
HIV	6	0	0	2	4

Figure 5: Rates of Sexually Transmitted Infection, Battlement Mesa Zip Codes 81635 & 81636, 2005-2009



	2005	2006	2007	2008	2009
Chlamydia	106	102	312	158	154
Gonorrhea	18	17	0	0	15
Syphilis	0	0	0	0	0
HIV	0	0	0	0	0

C2.5 Limitations of Social Determinants of Health

Data on measures of community well-being are rife with limitations, with the repeating theme being lack of primary data available for systematic review and analysis, especially at the level of a small community such as Battlement Mesa. For many key-indicators of community health, aggregate data may very well be available at the county, state or national level, yet these may not be representative of the local community due to local customs, culture and social structure in place in microcosms of a bigger community. In this case report, data sources were mostly limited to Garfield County and we were unable to locate data specific to the residents and the localized area of the Battlement Mesa PUD. Some additional limitations are as follows:

- U.S. Census and other types of nationally complied statistics are not available to the level of unincorporated areas, such as the Battlement Mesa PUD. Incorporating the Battlement Mesa PUD may increase access to health statistics collected and disseminated by the federal government.

- Data on student-teacher ratios for the local school district are not publically available beyond 2004, and so are not included as part of this baseline assessment. This information is crucial in order to fully characterize impact of the project on the local education system.

- While crime statistics from the Parachute Police Department represent a reasonable surrogate for the Battlement Mesa PUD, it is not possible to assess data only on crimes specifically occurring in Battlement Mesa. With publically available data, it is also not possible to evaluate criminal conduct on the basis of residence location or length of residence.

- Community level data on outpatient treatment for mental health, substance abuse and suicide are not readily available for public access. Analysis of hospital discharge data (in-patient) may provide additional perspective on the burden of these conditions.

- While local data on sexually transmitted infections was available, incidence rates were calculated using population estimates, which may not accurately reflect the true population at any given time. It is also difficult to assess statistical significance of the sexually transmitted infection data due to very low numbers.

C2.6 Summary and Conclusions for Social Determinants of Health

Of all the potential indicators of community health, only certain data were publically available and readily accessible in the time frame of this project to evaluate the health of resident of the Battlement Mesa PUD. As such, we were able to analyze data on education, criminal activity and sexually transmitted infections, obtained through web-based reports or by request of local agencies. The years 2005-2008 appear to be a period of increase for all three of these indicators, with apparent rises in local school enrollment as well as criminal activity. Incidence rates of sexually transmitted infection in Garfield County (Chlamydia and Gonorrhea) also increased during this period, accompanied by a noteworthy increase in the rate of Chlamydia observed in the Battlement Mesa population in 2007. Numbers in all categories appear to decrease in 2009. The mechanisms for obtaining and reviewing the community health indicators of education, crime and sexually transmitted infection are adequate for timely and prospective monitoring. Comparative review of these data should continue in a similar fashion to evaluate any changes and trends. Future analysis should focus on potential causal associations correlated with shifts in population or community environment that may be brought about by nearby industrial development.

Longitudinal source data for mental health, substance abuse and suicide were not available for analysis, however the 2006 survey data indicates upwards of 17% of residents were burdened by one of these conditions. Additional efforts to evaluate these issues should focus on pursuit of a relevant data source for outpatient visits or investigation of another source for surrogate data that are representative of these measures.

APPENDIX D: HUMAN HEALTH RISK ASSESSMENT

Attachments

Attachment 1: BCC letter
Attachment 2: Surface Use Agreement