# LARIMER COUNTY ENVIRONMENTAL ADVISORY BOARD

## 2008 Annual Report

LARIMER COUNTY

COMMITTED TO EXCELLENCE

ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

January, 2009

Board of County Commissioners:

Attached is the annual report for the Environmental Advisory Board. The report outlines the Advisory Board's activities in 2008 and sets out our goals and direction for 2009. Several issues were referred to this Board from the Commissioners' office in 2008. Additional information about the Advisory Board, including minutes for the meetings, is available on the County website at www.larimer.org/boards/brd_info.cfm?board=5.

We would like to thank the County staff for their continued help and commitment to sound environmental management. In 2008 representatives from the Departments of Engineering, Health and Environment, Planning, Public Works and Solid Waste attended EAB meetings to assist and inform members of the Advisory Board.

We hope that the feedback we provided was useful for the County. Please feel free to contact any of our members if you would like to discuss these issues in greater detail.

Dale Lockwood, Chair for 2008

Devin Odell, Chair for 2009

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# 2008 ANNUAL REPORT OF THE LARIMER COUNTY ENVIRONMENTAL ADVISORY BOARD

**January 2009**

## I. INTRODUCTION

The Larimer County Commissioners established the Environmental Advisory Board (EAB) in 1993. The Board consists of 12 at-large members, appointed by the County Commissioners.

The role of the Advisory Board is to advise the Board of County Commissioners and appropriate departments on environmental issues that affect Larimer County. A specific objective is also to promote institutionalization of the County's Environmental Responsibility Policy. Items considered by the EAB in 2008 came from the Commissioners, staff, citizen suggestions and from our own members.

The Advisory Board meets regularly on the second Tuesday of each month and on an as-needed basis for special work sessions. The first agenda item of each meeting is devoted to hearing citizen's comments about environmental issues. The list of speakers and guests that attended meetings is presented in Section V of this report.

Important topics and actions considered by the Advisory Board are noted in Section II. Section III outlines the status of issues related to written correspondence. The actual recommendations are included in the Appendix.

The Advisory Board utilizes an Issue Index to keep track of the various issues that the board addresses. The index is updated on a monthly basis.

Randy Eubanks was the County Commissioner liaison to the Environmental Advisory Board in 2008. Doug Ryan, from the Department of Health and Environment, served as staff facilitator.

## II. IMPORTANT TOPICS IN 2008

| MONTH | TOPICS |
|---|---|
| **February** | North I-25 EIS – review the status of the Environmental Impact Statement preparation for this transportation planning project<br><br>Uranium Mining – consider the final draft of the EAB report to the County Commissioners |
| **March** | North I-25 EIS – develop a letter with recommendations addressed to the County Commissioners<br><br>Ozone Air Quality – review progress on development of a Colorado Ozone Action Plan to address ozone air quality in the current non-attainment area |
| **April** | North I-25 EIS – final authorization of a letter to the County Commissioners<br><br>Recycling – a report from Mr. Bob Boggio, a resident who requested to discuss recycling issues with the Advisory Board. |
| **May** | NISP EIS – initial review of the draft Environmental Impact Statement for the proposed Northern Integrated Supply Project |
| **June** | NISP EIS – final review of the draft Environmental Impact Statement for the proposed Northern Integrated Supply Project |
| **July** | 1041 Regulations – update on proposed County regulations for power plants and electric transmission facilities<br><br>New Member Orientation – overview of EAB issues & priorities<br><br>Environmental Stewardship Awards – process for the 2008 awards |
| **August** | Owl Canyon Corridor Project – an update on the County's transportation project<br><br>Election of vice-chair – to fill the current vacancy |
| **September** | Solid Waste – update on current activities<br><br>Ozone Air Quality – update on the summer ozone season and progress on the Ozone Action Plan |

| MONTH | TOPICS |
|---|---|
| **October** | Environmental Stewardship Awards – review of nominations & recommendations to the County Commissioners |
| **November** | North I-25 EIS – review and comment to the County Commissioners on the draft EIS<br><br>1041 Regulations – update on the recently adopted regulations pertaining to power plants and electric transmission facilities in anticipation of a future wind farm application and the planned EAB review |
| **December** | Issue Index – an evaluation by members of the current status and planned action on the list of action items contained in the EAB Issue Index |

Note: Copies of any formal correspondence resulting from these items are included in the Appendix.

## III. STATUS OF EAB RECOMMENDATIONS IN 2008

The table below outlines the formal recommendations made by the EAB in 2008, and provides a brief statement about the status of those recommendations. As an advisory board, all of the EAB recommendations are submitted to the Board of County Commissioners or a requesting County department. The actual correspondence is in the Appendix.

| Issue | Principle EAB Actions and Recommendations | Status |
|---|---|---|
| Uranium mining in Weld County | The EAB prepared a background report on the potential environmental impacts associated with in-situ and surface uranium mining in response to a request from the County Commissioners. | At the time of this annual report, the Powertech Uranium Corporation had plans to make their formal application for mining permits on their Weld County site in mid to late 2009. |
| Recycling and solid waste management | The EAB heard from a concerned citizen regarding the need to increase recycling and reduce the amount of waste going to the landfill. | The EAB passed the citizen concerns to the County Commissioners and the Solid Waste Department in accordance with their role as an advisory board. |
| North I-25 EIS | The EAB provided preliminary written comments to the County Commissioners in April, and technical review comments on the actual draft EIS in December. The public comment period for the draft EIS closes on December 30, 2008. | The County Commissioners considered input from staff and the EAB and prepared their official written comments regarding the draft EIS. The Colorado Department of Transportation plans additional meetings in early 2009 as part of the process for selecting the preferred alternative. *….Continued on next page* |

| Issue | Principle EAB Actions and Recommendations | Status |
|---|---|---|
| NISP EIS | The EAB reviewed the draft EIS for the Northern Integrated Supply Project and provided written comments to the County Commissioners. | The County Commissioners held a series of public meetings and consultations with staff and prepared their written comments regarding the draft EIS. The Army Corps of Engineers intends to decide on the process for responding to comments received and gathering additional technical information in early 2009. A Record of Decision is not expected until late 2009. |
| 1041 Regulations | The EAB indicated its support for proposed regulations pertaining to power plants and electric transmission facilities. | The County Commissioners adopted regulations in November 2008. |
| Owl Canyon Corridor Project | The EAB indicated its general support for the principle findings regarding the need for County roadway improvements, and offered to review the environmental assessment for the final route alternative as it becomes available. | The County Commissioners adopted the Owl Canyon Corridor Plan in November 2008. Future design and improvements will be dependant on funding availability. |

## IV. ENVIROMENTAL STEWARDSHIP AWARDS

In December, the Board of County Commissioners presented five Environmental Stewardship Awards. These awards annually honor the environmental efforts of county residents, businesses, organizations and agencies. The EAB reviews the nominations and makes recommendations to the Board of Commissioners. Begun in 1995, this year's recipients bring the total number of awards given to 49. This year 25 nominations were received. The recipients for 2008 were:

**Big Thompson Watershed Forum's Volunteer Monitoring Program**, for their collaboration with community volunteers to collect water samples. The Big Thompson Watershed is crucial for providing water for drinking, agriculture, recreation and natural habitat. Water samples collected as a result of this program allow the Forum to compare sample results with water quality standards and to identify water quality trends within the watershed. The volunteer monitoring program also increases community awareness and understanding of watershed issues and the importance of good stewardship. The result is an effective blend of science and community involvement that benefits the Big Thompson River.

**FortZED Task Group of UniverCity Connections**, for their success in organizing a diverse group of public and private entities around the goal of creating a net zero energy district. The goal of FortZED is to create a district where all of the energy used is created locally via sustainable non-polluting sources such as wind and solar that provide for long term stewardship of the environment by reducing carbon emissions produced through traditional energy production. A combination of technology, education, financing and most of all commitment will be needed in order to achieve success. While the complexity of the work ahead should not be underestimated, the Task Group represents unprecedented grassroots community collaboration aimed at one of the most important issues of our time.

**Jim Reidhead**, for an important body of work that includes both environmental and historic preservation. Jim was instrumental in the creation of the 1,600 acre Phantom Canyon under the Nature Conservancy. That model for success was expanded during his tenure as Director of the County's Rural Land Use Center. Under that program more than 11,000 acres have been protected using voluntary agreements with landowners who develop a small portion of their property in exchange for preserving large tracts of valuable natural resources and agricultural lands. The skills necessary to accomplish these tasks include technical knowledge about environmental values, an understanding of legal conservation practices, and exceptional personal skills to develop good relations with land owners. Jim also has a record of accomplishment in renovation and historic preservation efforts in Old Town Fort Collins. The results of Jim's dedication and skill will benefit the community far into the future.

**Darlene Halvorsen,** for her work with River Watch at Loveland High School. Science teacher Darlene Halvorsen coordinates the activities of the River Watch club. Weekly meetings center around monitoring the biological, chemical and physical health of the Big Thompson Watershed. The River Watch students perform monthly water analyses at designated river locations and share that information with the Colorado Division of Wildlife. They also organize river cleanup events and provide educational presentations. The nomination received for this award notes that "Mrs. Halvorsen has been the driving force behind River Watch at the school for 9 years. She devotes countless hours organizing and planning activities for River Watch. In addition, she sets an outstanding example of being a responsible steward in how she lives her life and gives back so much to others. Her passion for preserving the environment and teaching others truly sets her apart".

**Legacy Land Trust**, for their efforts that have resulted in the conservation of 25,000 acres of important lands since the Trust's founding in 1993. The Legacy Land Trust is a non-profit organization which works with local land owners, the community, and local government to conserve important wildlife habitat, farm and ranch lands and scenic areas in Larimer, Weld and Jackson Counties. All of the conservation easements held by the trust were negotiated as a result of voluntary agreements with willing landowners. The emphasis in these situations needs to be on maintaining a trust and mutual dialogue. The Legacy Land Trust has demonstrated that they have the technical, management and personal skills necessary to partner with our region on these important conservation projects.

## V. GUESTS AND INVITED SPEAKERS

| MONTH | PERSON | TOPIC |
|---|---|---|
| **February** | Randy Eubanks<br>County Commissioner | |
| | Michael Beshore<br>Terry Walsh<br>Jim Licko,<br>Powertech Uranium Corp | Uranium mining |
| | Nick Young | |
| | Jim Woodward | |
| | Carol Parr<br>Colorado Dept. of Transportation | North I-25 EIS |
| | Gina McAfee<br>Carter and Bergess Inc. | North I-25 EIS |
| | Tyler Keck<br>Colorado State University | |
| **March** | Bob Boggio<br>Colorado Assoc. for Recycling | Recycling |
| **April** | Bob Boggio<br>Colorado Assoc. for Recycling | Recycling |
| **May** | Bob Boggio<br>Colorado Assoc. for Recycling | Recycling |
| | Melissa Chalona | |
| **June** | Melissa Chalona | |
| | Lloyd Brown | |
| **July** | Jill Bennett<br>Planning Department | 1041 Regulations |

*….continued on next page*

| MONTH | PERSON | TOPIC |
|---|---|---|
| **August** | Marc Engemoen<br>Public Works | Owl Canyon Corridor Plan |
| | Martina Wilkinson<br>Engineering | Owl Canyon Corridor Plan |
| | Kyle Arend<br>Engineering | Owl Canyon Corridor Plan |
| **September** | Steve Harem<br>Solid Waste Department | Solid waste issues |
| | Rose Watson<br>Solid Waste Department | Recycling issues |
| | Doug Ryan<br>Health and Environment | Ozone air quality |
| | Cara Blake<br>Kristen Narren<br>Tarah Fowler,<br>Colorado State University | |
| **December** | Molly Somes<br>Nick Kiggins<br>Sean McCarthy,<br>Colorado State University | |

## VI. ENVIRONMENTAL ADVISORY BOARD MEMBERS

| | |
|---|---|
| Melissa Chalona | Appointed July 2008 |
| Mike Erickson | |
| David Gilkey | Retired June 2008 |
| Michael Lee Jones | Appointed July 2008 |
| Jennifer Lee | |
| Dale Lockwood | |
| Todd McCowin | |
| Vic Meyer | Retired June 2008 |
| Kate Muldoon | |
| Devin Odell | |
| Tom Sneider | |
| Heidi Steltzer | |
| Sherman Worthington | |
| William Zawacki | |

*Note: This list includes all Advisory Board members who served during the year. At any given time, the Board consists of twelve members.*

## VII. YEAR 2009 WORKPLAN

This section provides information about the general direction the Advisory Board contemplates taking in 2009. Because conditions or priorities in the County can change, some degree of flexibility needs to be maintained.

**Overall:** The EAB strives to influence county governmental policies, decisions and actions that have environmental implications. To that end the EAB will:

1. Serve as an informational resource that provides science-based recommendations to the County Commissioners and departments, points out areas of uncertainty and suggests appropriate ways to address them;

2. Identify environmental issues and opportunities for the consideration of the County Commissioners so that the BCC can be proactive in their responsibilities towards the environment. To that end, the EAB will solicit from its membership their ideas with respect to a proactive environmental agenda and then develop a studied consensus of the most relevant issues and opportunities that will be forwarded to the BCC;

3. Develop and maintain an attitude of trust and respect among the EAB, the Commissioners, County departments and other boards and commissions.

**Response to Referrals or Requests:**

1. Respond in a timely manner to issues raised by the Board of County Commissioners, the County departments and EAB members.

2. Facilitate the response to citizen comments received by the Advisory Board with the Board of County Commissioners and appropriate County departments.

**Current Environmental Topics:**

1. Consider the regional implications of important environmental issues, and facilitate ways to address those issues across local jurisdictional boundaries. Examples of current issues include the North I-25 Transportation Environmental Impact Statement, and the proposed Northern Integrated Supply water project.

2. Monitor important water issues including watershed planning and proposed water projects. The Big Thompson Watershed Forum, the Northern Integrated Supply (NISP) Project and the Halligan-Seaman Water Management Project continue to be examples of current issues. It is anticipated that the draft Environmental Impact Statement for Halligan Seaman may be released for review late in 2009.

3. Monitor solid waste management issues such as landfill operations, recycling and hazardous waste disposal.

4. Participate in the review of relevant transportation-related issues with an emphasis on the North I-25 Front Range Environmental Impact Statement which is scheduled for further public discussion in early 2009.

5. Monitor important air quality trends, especially with regard to the issue of ozone nonattainment in the region.

**Stewardship Awards:**

1. Coordinate the 2009 Environmental Stewardship Awards in partnership with the County Commissioners.

**Communications and Process:**

1. Request a discussion, at the appropriate time, with the new County Commissioner liaison assigned to the Environmental Advisory Board. The purpose would be to discuss topics of mutual interest, and to gain a current understanding of environmental concerns or issues as seen by the County Commissioners.

2. Continue the process of coordinating open communications about environmental issues between selected County departments and advisory board representatives.

3. Promote implementation of the County's Environmental Responsibility Policy.

4. Utilize the Commissioners' Administrative Matters meetings for communicating on important environmental issues and to establish consensus on what should be considered high-priority review items.

5. Continue the practice of assigning interested EAB members to monitor select environmental activities and provide updates to the full Advisory Board.

## APPENDIX: WRITTEN CORRESPENDENCE

These documents were prepared by the Environmental Advisory Board as part of their activities conducted in 2008.

- April 9, 2008 memo to the County Commissioners regarding recycling and solid waste management issues referred to the EAB by an interested citizen.
- April 23, 2008 memo to the County Commissioners regarding technical issues and status of the North I-25 EIS.
- June 23, 2008 memo to the County Commissioners concerning the EAB technical review of the NISP draft EIS.
- July 11, 2008 memo to the County Commissioners regarding the proposed County 1041 regulations relating to power plants and electric transmission facilities.
- August 20, 2008 memo to the Public Works Director concerning the Owl Canyon Corridor Project.
- December 1, 2008 memo to the County Commissioners with analyses and recommendations concerning the North I-25 EIS.
- February 12, 2008 Report to the County Commissioners on In Situ Leach and Open-Pit Uranium Mining.


# ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

To: Board of County Commissioners

From: Dale Lockwood, Chair

Date: April 9, 2008

Subject: Recycling and Solid Waste Management Issues

Recently the Environmental Advisory Board was contacted by a citizen with a request to appear on the EAB's agenda to discuss recycling issues. That request was granted, and Mr. Bob Boggio addressed the Advisory Board at our April 8 meeting. He also provided the attached background letter, dated March 27. It appears that one of the principle issues of concern for Mr. Boggio was the lack of a formal plan to decrease waste land filled and increase recycling. Our members pointed out that the recycling center and the updated contract for its management do demonstrate a commitment to recycling in the County. Mr. Boggio made the point that he would like to see a more formalized system with measurable goals for progress. The Advisory Board let Mr. Boggio know that we would pass his concerns along to the Commissioners.

During our discussion, Doug Ryan indicated that it was his understanding that the Solid Waste Department is planning to convene a Solid Waste Summit in the future. Our members agreed that a summit would present a good opportunity to discuss the vision for the future of the solid waste system. As a group, the Advisory Board also indicted that they would be interested in participating in a summit if requested to do so by the Commissioners or the Solid Waste Department.

I hope that this feedback from a citizen contact with the EAB is useful. I am available if you would like to discuss this issue in more detail.

Attachment: March 27, 2008 letter from Mr. Bob Boggio

cc: Steven Gillette
Bob Boggio

ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

To: Board of County Commissioners

From: Dale Lockwood, Chair

Date: April 23, 2008

Subject: North I-25 Environmental Impact Statement (EIS)

The North I-25 EIS is scheduled for release in draft form in the summer of 2008. The Colorado Department of Transportation (CDOT) project team has worked hard to identify and evaluate the potential environmental impacts of each of the decision packages. Each of the two principal options under consideration include substantial roadway improvements to I-25, together with a suite of measures intended to address mobility, safety, infrastructure and modal option needs of the region. Both options incorporate significant, although very different, transit components. Package A includes regional rail along the existing Burlington Northern Santa Fe alignment through Fort Collins, Loveland and Berthoud with service to Longmont and ultimately downtown Denver. It also includes commuter bus service from Weld County into Denver. Package B incorporates bus rapid transit in defined lanes on I-25.

The environmental analyses address important issues such as air quality, wetlands, floodplains, wildlife habitat, historic structures, parklands and farmlands. The preliminary findings indicate that the impacts of each major option are fairly equivalent. For example, both options are protective of air quality and would not be expected to cause exceedances of air quality standards. Additional information on the EIS project is available on the CDOT website at www.dot.state.co.us/northi25eis/. For quick reference a graphic for each of the EIS decision packages is attached to this document. When the draft EIS is released this summer, it will not identify a preferred alternative. That step will come at a later date and will reflect to a large extent the response received from the community.

One area where the two options differ substantially relates to land use. Under package A, commuter rail would shift growth towards urban centers. Under package B, bus rapid transit along I-25 would provide less incentive for transit oriented development and market-driven growth would continue to be focused

along 1-25. Based on these preliminary findings, the implications for land use in the region may be one of the key criteria for selecting the preferred alternative.

The implications of these transportation alternatives are incredibly important. It is likely that the final choices could result in a legacy project similar to the Colorado Big Thompson (CBT) water project from the 1950's. However, the North I-25 project will likely have far broader and deeper impacts to the environment and economy of Larimer County and the region than the CBT project.

Because the scope of this project is larger than any single jurisdiction, the Environmental Advisory Board believes that the pending release of the Environmental Impact Statement offers a valuable opportunity for the Larimer County Commissioners to provide the leadership needed to arrive at final decisions that best address the transportation needs but that also respect and promote both the land use visions for and environmental quality of the region.

While the County has been actively involved on the project's Technical Advisory and Regional Coordination committees, the opportunity to coordinate among participants can help those groups come together around a preferred alternative. Either option is going to require funding from a variety of sources. By working together, it is also more likely that consistent regional voices can influence funding decisions from federal government. Leadership from the Commissioners can strengthen the voice from other municipalities. One suggestion would be to communicate with the cities and towns along the potential commuter rail line in order to determine if there are common interests that would tend to support one option over the other.

Therefore the EAB recommends that you consider initiating coordination with the other communities in order to develop a consensus regarding both the long-range transportation and land use implications of the two options. Providing effective regional leadership now would appear to offer the best path to meet our future transportation and land use needs while maintaining regional air and water quality.

We would also like to comment on the recent summit hosted by the North Front Range MPO focuses on regional transit and transportation issues. Both the North I-25 plan and the potential Regional Transportation Authority will require significant planning and funding and bringing this issue to the region's voters and policy makers will allow for potential synergistic opportunities for both processes. Coordination of both transportation projects should be considered from the earliest opportunity.

Thank you for the opportunity to be involved as an advisory board on this project. Our Board will continue to follow the progress of EIS and work to provide you with our best technical advice throughout the decision making process.

LARIMER COUNTY
COMMITTED TO EXCELLENCE

ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

To: Board of County Commissioners

From: Dale Lockwood, Chair

Date: June 23, 2008

Subject: NISP draft EIS Review

The Environmental Advisory Board has reviewed the draft Environmental Impact Statement (EIS) for the proposed Northern Integrated Supply Project (NISP) and it is the board's opinion that several outstanding issues with the document that should be addressed.

**Principle Findings:**

- All Action alternatives will result in environmental impacts to the Poudre River from the diversion point downstream. The impacts are a function of the reduced stream flows and the loss of variability in the size of flow over annual and longer time periods. Although the EIS indicates the impacts are a potential outcome, the current state of ecological research indicates that the impacts are very likely to occur in the absence of any mitigation. The river will experience increased channelization, flow obstructions, reduced bank erosion and a buildup of sediment among other effects. Rivers are highly complex ecosystems and the EIS minimizes this complexity by separating stream morphology, wildlife, plants, and invasive species from one another. The effects on stream morphology will result in changes to the plant and animal community structure in the river. The community changes in the river coupled with the morphology changes and changes in the variability of flow will change the community of plants and animals on the land adjacent to the river. Many of these effects will result in feedbacks so that, for example, as the river morphology change induces changes in the plant community, the plant community changes will further alter the river morphology. The reduction in flow will have negative impacts to dominant plant species along the river corridor. This can allow for the increase of invasive plants such as tamarisk and Russian Olive. These changes affect animal species in the river corridor. For example tamarisk alters the habitat for many bird species.

The Action alternatives will likely result in the loss of biodiversity and put at further risk plant and animal species listed under the Endangered Species Act and the Colorado Natural Heritage Program, including, but not limited to, the Preble's Jumping Mouse and Bell's Twinpod.

Commitments for significant and meaningful mitigation need to be developed in order to preserve the river's ecological functions. Such commitments need be based on sound technical input and should include minimum streamflows and periodic spring flushing flows. Institutional arrangements to accomplish these commitments need to include monitoring, management and funding.

- The No Action alternative has not been completely and accurately analyzed. The document contains a number of estimates about the potential impacts of this alternative that the board could not see as substantiated. Examples include the number of irrigated acres that could be dried up (up to 69,200 acres), the cost of the No Action alternative ($830 million), and the assumption that the No Action alternative would result in only negligible changes in stream flows. These precise sounding, yet very uncertain, estimates cloud the comparison with the more definitive analyses developed for the action alternatives. The EIS is written such that the worst case values for the No Action alternative are used in all discussions after the range of values is given. With no discussion as to the most likely value for the ranges given, this introduces a bias against the No Action alternative. The danger in such an uneven analysis is that the No Action alternative may be prematurely rejected. The analysis of the No Action alternative and its comparison with the action alternatives should be updated and strengthened for the final EIS.

  The board is also concerned with the current analysis of the relative effects of the Action and No Action alternatives on agriculture. In particular, the EIS does not analyze any effect that exercising the Grey Mountain right will have on junior rights, and at least some fraction of these rights are agricultural. Thus the claim that the No Action alternative will have a negative impact on agriculture while the Action alternatives will not does not appear to be correct without a complete audit of the current water usage of the Poudre River. Likewise as detailed below, drying up of agricultural lands could occur if exchanges are canceled after the project is completed.

**Discussion:**

The principle findings and recommendations outlined above were developed based on the Environmental Advisory Board's review of the draft EIS. The following discussion points expand on those issues and provide details on some other topics the Commissioners may wish to consider.

- The analysis does not address the possibility that the decreases in water flows associated with NISP my result in crossing a threshold in channel morphology that will fundamentally alter the physical and ecological functions of the river as is currently exists. In many natural systems, gradual changes can result in a sudden shift in the state of the system. With such threshold changes, it is not the case that simply reversing those changes will cause the system to shift back. More changes are required to restore the original function of the system.

- The mitigation strategies that are mentioned in the draft EIS do not account for alterations to the Poudre River from the Halligan-Seaman project. Mitigation planning should be based on the combined effects of the two projects.

- The draft EIS states that noxious and invasive species are considered to be reduced in the Glade Reservoir site. This analysis does not take into account that the shallow mud flats associated with the north end of the reservoir would be subject to frequent water level changes, and that these conditions are ideal for invasive plant species as this would create an area exposed to large disturbances.

- The issue of invasive animal species is not addressed in the draft. Invertebrates such as the zebra mussels are a serious threat to reservoirs and the pipeline infrastructure that are currently problems in front-range reservoirs. NISP would create new network connections among various reservoirs and canals and an analysis of the potential increase in risk to those systems from adding another point source for invasions is not addressed.

- A number of significant geologic risks have been identified related to the Glade Reservoir site. These include the location of the North Fork and Bellvue faults, the potentially liquefiable soils in the proximity of the dam, and the soluble rock units in the lower Lykins formation that underlie the dam axis. These are important technical issues that demand adequate planning and oversight. The cost of maintenance under a range of circumstances should be figured into the total costs of the Glade Reservoir to present a range of costs per household for the users. The evaluation of the risks involved with costs not currently projected can only be adequately addressed after these potentialities are accounted for.

- The cost projections for user fees are based on projections of past growth rates. Given the current state of the economy as it relates to the housing market and fuel costs, the total and per capita cost of the project may be significantly higher than the current estimates. Again, the economic modeling should provide a range of values based on variation in the projections of

economic growth, cost structure and other factors. A single value is misleading and may not allow for a proper evaluation of all alternatives.

- Water quality impacts may in fact impact drinking water providers and sewage treatment plant operations. The City of Fort Collins has a huge economic commitment in these services, and is preparing an extensive analysis of this issue. That information needs to be fully considered and utilized in the final decision on permitting this project. It is not clear if and when water from the NISP reservoirs would enter Horsetooth or Carter Lakes. The EIS suggests that the quality of water in the NISP storage would not be the same as that in CBT storage.

- It is not clear how in-stream flows in Fort Collins and the stretch near the fish hatchery will be protected. The EIS states that as part of the adjudication of the Grey Mountain Right Northern "subordinated" to the right for the Watson Fish Hatchery and two rights held by the City of Fort Collins. Board members have looked at that Water Resources technical report and decree and the associated stipulation with Fort Collins for the Grey Mt. Right and do not see where or how they "subordinated" their right.

- A review of the water resources technical report shows that Northern may ultimately end up having to "buy up and dry up" agricultural rights under its proposed alternative. This would happen if the farmers on the Larimer-Weld or New Cache Canals decided to stop farming and thus end the "exchange" with Northern of water from these ditches for water from Galeton. The report states that if Northern thought this would happen, it would move to acquire those rights from the farmers first. It should be noted that the participants ultimately could decide to buy up agricultural rights in any case, if a period of low flows (Glade will receive water in only 4 out of 10 years, according to the EIS) means that the reservoir is not filling regularly. These potential impacts are not considered in the EIS.

- The draft EIS does not evaluate the fact that the urban growth that is to be enabled by NISP will also remove agricultural lands from production (perhaps as much as 95,000 acres of land based upon data in the DEIS). That distinct possibility needs to be included in the crucial balance sheet of whether or not the No Action alternative or the Action Alternatives would be more benign vis a vis protecting our agricultural lands. In particular, if the land that will be converted from agriculture is also the land from which water rights would be secured under the No Action alternative, then there is a discrepancy in the relative amounts of agricultural land affected by the various alternatives.

- Although the draft EIS states that no community cohesion or quality of life impacts are associated with any of the action alternatives, the source is not referenced or documented. It would seem that the esthetic, visual, cultural, recreational, and growth impacts of this project upon the est. 276,000 citizens

in Larimer County and the est. 188,000 citizens in the NISP participant communities must be seriously and scientifically analyzed and actual data factored into any conclusion before one can simply assert “no quality of life impacts are associated with any of the action alternatives”.

**Recommendations:**
Before the Board of County Commissioners can properly evaluate the NISP project the following items need to be addressed in the EIS.

- The determination of specific values in the No Action alternative need to be justified. If a range of values is used, then all discussion regarding the values must include the effects of the range and not one endpoint of the range.
- Economic models that predict a single value need to be evaluated for a range of possible outcomes based on sound economic modeling. Given the highly volatile fluctuations in energy and other market sectors, it is not clear that the costs or benefits stated in the EIS remain valid.
- The EIS mitigation strategies are inadequate. There are no clear plans for mitigation for many parts of the project and where mitigation strategies indicate collaboration with concerned entities the board could not identify specific written agreements with affected agencies. All mitigation strategies need to be developed more completely with specific responsibilities of the partners clearly defined. Any mitigation strategies that rely on collaborations or partnerships need to have draft agreements presented in the EIS.
- Mitigation costs are not addressed in the EIS. These are likely to be substantial and without a method for determining the cost and acquiring assurances that partners will provide the necessary funding the EIS is inadequate.
- Given the concerns expressed in the EIS regarding the geology and soils at the reservoir sites, the EIS needs to include the costs and plans for maintaining the infrastructure.
- The EIS needs to address in detail the potential effects of the chemical leakage of the Atlas Missile Silo that is located in proximity of the Glade forebay. Mitigation strategies for the toxic plume include timelines that would carry through to the operational phase of the Glade reservoir.
- The EIS must consider the combined effects of other water projects on the Poudre, including but not limited to Halligan and Seaman projects.
- The subordinated rights held by Fort Collins and for the Watson Fish Hatchery need to be fully explained.
- The EIS indicates that a complete survey for endangered species was not conducted due to the failure to survey private lands. Given that the project will include disturbing these properties as pipelines are placed, a complete survey needs to be conducted.

ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

To: Jill Bennett, Larimer County Planning Department

From: Dale Lockwood, Chair

Date: July 11, 2008

Subject: 1041 Regulations for Power Plants and Transmission Facilities

The Environmental Advisory Board reviewed the proposed 1041 regulations pertaining to power plants and electric transmission facilities at our regular meeting on July 8, 2008. Jill Bennett from the Planning Department provided an overview and answered questions from the members. The main part of the discussion focused on the general criteria for all 1041 permits and on the additional specific criteria for these initial uses.

The Board indicated that in their view the regulations are well thought out and have the potential to be a valuable tool for ensuring that power plants and transmission facilities are planned and built in a way that protects the environment and increases compatibility with nearby uses.

We do have one suggested addition related to the requirements for re-vegetation and mitigation of construction related impacts. It is important that the seed mixture chosen for re-vegetation purposes is compatible with the surrounding native vegetation. If not carefully selected, those mixtures can result in the introduction of invasive grasses that out-compete the more desirable native plants. The Advisory Board's recommendation is to add a sentence (shown in bold) to the standard in 14.10.D.9 which would read as follows:

…The applicant must mitigate any construction impacts to county roads, bridges and related facilities. Construction assess must be re-graded and re-vegetated to minimize environmental impacts. **The seed mixture selected shall be based on native seeds, or if the disturbed area is relatively small a mixture containing sterile hybrid grasses designed to ultimately be replaced by the more desirable adjacent native grasses may be utilized.**

Thank you for the opportunity to review the proposed regulation. The EAB appreciates being involved in this important project.

cc: Randy Eubanks, BCC Liaison to the EAB

ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

To: Marc Engemoen, Public Works Division Director

From: Dale Lockwood, Chair

Date: August 20, 2008

Subject: Owl Canyon Corridor Project

I am writing to thank you and your staff for the update on the Owl Canyon Corridor Project that was provided at our August 12 meeting.

It was clear to the Advisory Board that current traffic levels and maintenance needs indicated that roadway improvements, including paving on the western segment, are needed now. We also understand that the plan is to maintain the corridor as part of the County level transportation system with roadway configuration and speeds designed accordingly.

Our discussions at the meeting noted that the reliance on mostly existing traffic corridors is a positive way to avoid additional environmental impacts. It was the consensus of the Advisory Board that the public process and technical evaluation is on the right track in terms of identifying the most appropriate alternatives. We understand that the next phase of the project will involve more extensive evaluation of three route alternatives that were selected based on the initial analysis, and that a detailed environmental review will be conducted once the final route is selected.

The EAB would be interested in reviewing the final environmental analyses for the selected route. The level of detail available at that stage allows for fine-tuning the roadway design and selection of the most appropriate avoidance or mitigation strategies for protecting sensitive environmental resources.

Thank you for the opportunity to review the proposed regulation. The EAB appreciates being involved in this important project.

cc: Randy Eubanks, County Commissioner Liaison to the EAB

ENVIRONMENTAL ADVISORY BOARD

Post Office Box 1190
Fort Collins, Colorado 80522-1190

To: Board of County Commissioners

From: Dale Lockwood, Chair

Date: December 1, 2008

Subject: North I-25 Draft Environmental Impact Statement (EIS)

The Larimer County Environmental Advisory Board has reviewed the draft Environmental Impact Statement and offers the following comments for consideration by the Board of County Commissioners.

**Background**

The North I-25 EIS is a project to consider the transportation and mobility needs of the north I-25 corridor through the year 2030. The EIS was prepared by the Colorado Department of Transportation (CDOT) in cooperation with federal highway and transit agencies. The draft includes an analysis of the "no-build option", and two "decision packages".

Each of the decision packages include substantial roadway improvements along I-25 together with a suite of measures intended to address the mobility, safety, infrastructure and modal option needs of the region. Both options incorporate significant – although very different – transit components. Package A includes regional rail along the existing Burlington Northern Santa Fe alignment through Fort Collins, Loveland and Berthoud with service to downtown Denver. It also includes commuter bus service along Highway 85 from Greeley into Denver. Package B incorporates bus rapid transit in defined lanes on I-25. A graphic showing the two decision packages is attached to this memo. The full EIS is available for review at www.dot.state.co.us/northi25eis/.

The public comment period on the draft EIS ends on December 30. After that time, CDOT will identify a preferred alternative and prepare the final EIS. The Environmental Advisory Board was asked to review the draft and provide recommendations to the County Commissioners.

**Recommendation**

Support Package A – providing multi-modal improvements including I-25 lane additions, commuter rail on the west, commuter bus on the east and bus feeder service in between – as the preferred alternative.

**Reasons for the recommendation**

The draft EIS addresses important environmental issues such as air quality, wetlands, floodplains, wildlife habitat, historic structures, parklands and farmlands. The findings indicate that the impacts for the two decision packages are fairly equivalent. For example, both options are protective of air quality and would not be expected to cause a violation of air quality standards. Package A and Package B each result in the loss of approximately 18 acres of wetlands, and would impact about 2 acres of sensitive wildlife habitat. One reason for the similar level of impacts is that the majority of transportation improvements would take place within existing highway or rail corridors.

One area where the two options differ substantially relates to land use. Under package A, commuter rail would shift growth towards urban centers. Under package B, bus rapid transit along I-25 would provide less incentive for transit oriented development and market-driven growth would continue to be focused along I-25. Based on these findings, the implications for land use in the region constitute one of the key criteria for selecting the preferred alternative.

It is our conclusion that the combination of commuter rail, highway expansion and bus service in Package A better serves existing development patterns and more adequately responds to the North Front Range Metropolitan Planning Organization (MPO) emphasis on a multi-modal system.

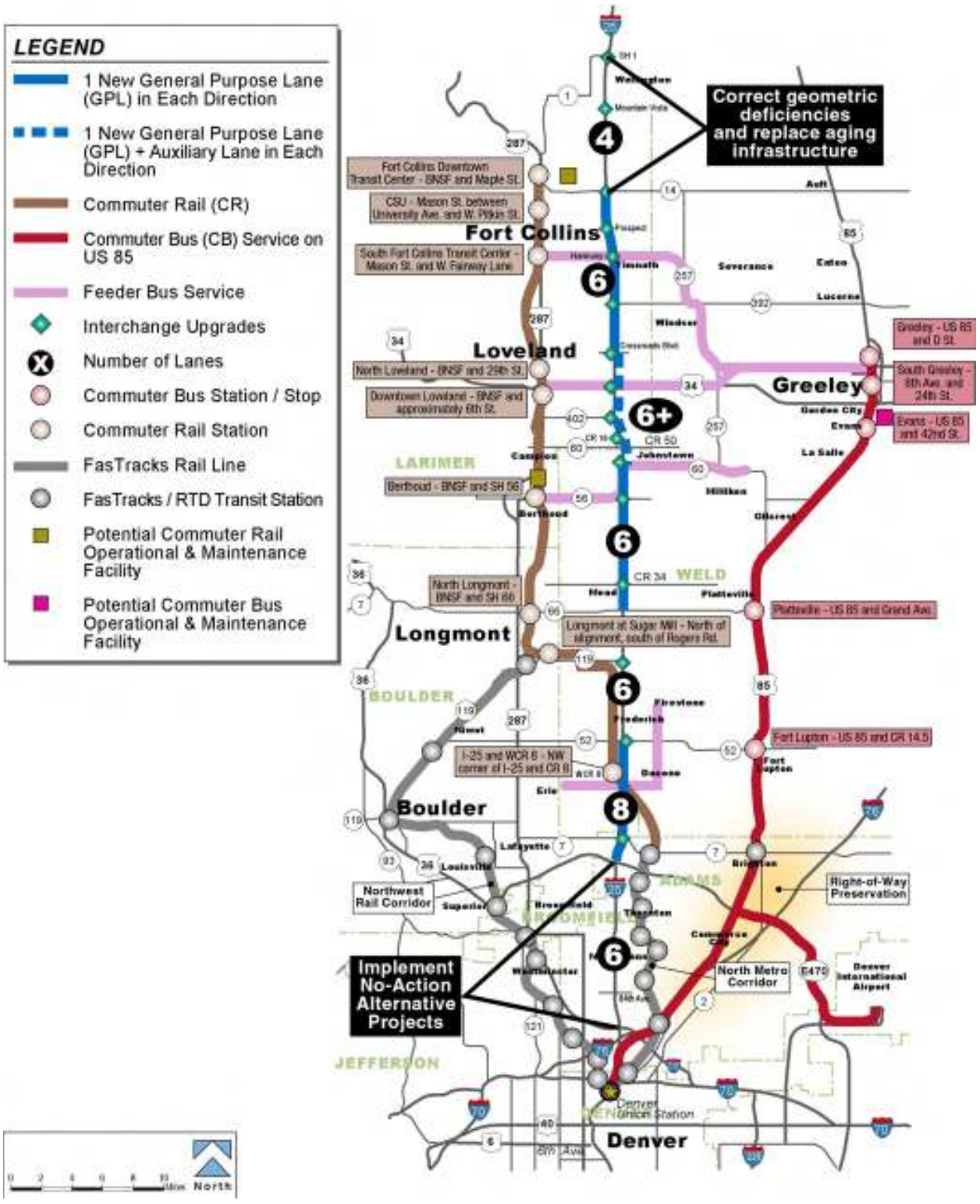
The land use implications identified in the EIS support a more sustainable development pattern resulting in reduced sprawl and less automobile-dependant development while providing opportunities for economic vitality by facilitating the movement of people through the centers of urban development. That pattern would be more consistent with the County's goal of preserving rural agricultural lands. Our members also noted that the commuter rail service is inherently expandable as congestion grows and demand for transit increases in the future. Rail service can be added in a serial fashion while increasing automobile services required the addition of parallel development of additional lanes.

While both of the major transit options provide service between Fort Collins and Denver, commuter rail is more likely to capture intra-regional travel between local communities due to the track's proximity to existing population centers. Because rail systems are generally considered more attractive to the public, ridership would be expected to increase beyond initial planning expectations.

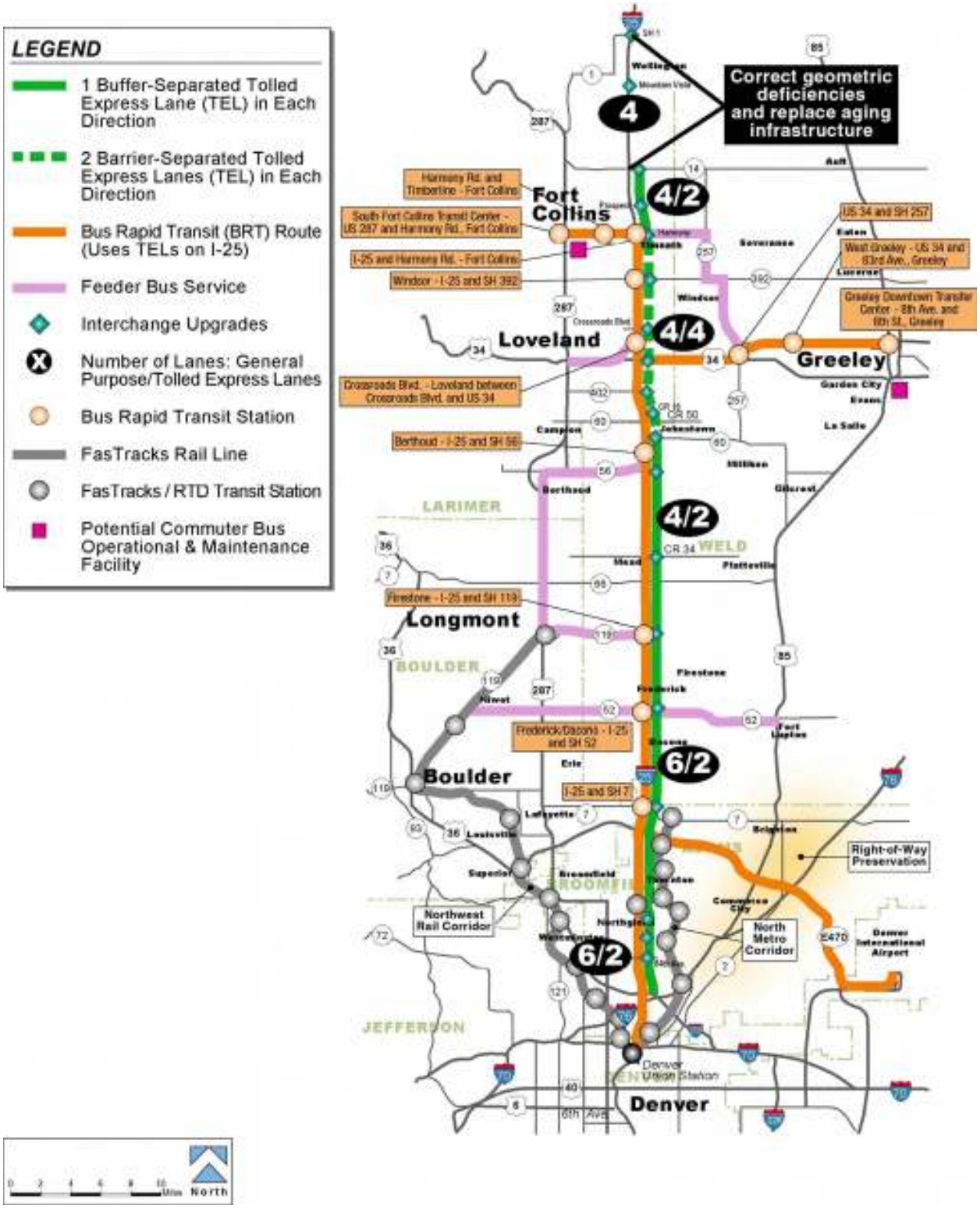
The recently added FasTracks light rail lines in the Denver metro area are an example of this type of success. Commuter rail provides the best opportunity to link with both the FasTracks RTD light rail system and the Mason Corridor project, thus providing more regional transportation options for County residents.

The capital cost estimates for the two decision packages differ by about 20%, with Package A being more costly, likewise the maintenance cost estimates are more for Package A. Studies have shown that commuter rail provides a better opportunity to recoup the additional investment due to strong public support for rail service, the potential for transit oriented development to result in expanded business revenues, increased property values, redevelopment opportunities, public/private development projects and a higher tax base.

The implications of these transportation alternatives are very important. The vision outlined in Package A would likely result in a legacy project similar in scope, vision and value to the infrastructure of Larimer County and Northern Colorado as the Colorado Big Thompson (CBT) water project from the 1950s.


LEGEND
1 New General Purpose Lane (GPL) in Each Direction
1 New General Purpose Lane (GPL) + Auxiliary Lane in Each Direction
Commuter Rail (CR)
Commuter Bus (CB) Service on US 85
Feeder Bus Service
Interchange Upgrades
Number of Lanes
Commuter Bus Station / Stop
Commuter Rail Station
FasTracks Rail Line
FasTracks / RTD Transit Station
Potential Commuter Rail Operational & Maintenance Facility
Potential Commuter Bus Operational & Maintenance Facility
Correct geometric deficiencies and replace aging infrastructure
Implement No-Action Alternative Projects
Fort Collins
Loveland
Greeley
Longmont
Boulder
Denver
Northwest Rail Corridor
North Metro Corridor
Right-of-Way Preservation
Fort Collins Downtown Transit Center - BNSF and Maple St.
CSU - Mason St. between University Ave. and W. Pitkin St.
South Fort Collins Transit Center - Mason St. and W. Fairway Lane
North Loveland - BNSF and 29th St.
Downtown Loveland - BNSF and approximately 6th St.
Berthoud - BNSF and SH 56
North Longmont - BNSF and SH 66
Longmont at Sugar Mill - North of alignment, south of Rogers Rd.
I-25 and WCR 8 - NW corner of I-25 and CR 8
Greeley - US 85 and D St.
South Greeley - 8th Ave. and 24th St.
Evans - US 85 and 42nd St.
Platteville - US 85 and Grand Ave.
Fort Lupton - US 85 and CR 14.5
LARIMER
WELD
BOULDER
ADAMS
JEFFERSON
North

**PACKAGE A**


LEGEND
1 Buffer-Separated Tolled Express Lane (TEL) in Each Direction
2 Barrier-Separated Tolled Express Lanes (TEL) in Each Direction
Bus Rapid Transit (BRT) Route (Uses TELs on I-25)
Feeder Bus Service
Interchange Upgrades
Number of Lanes: General Purpose/Tolled Express Lanes
Bus Rapid Transit Station
FasTracks Rail Line
FasTracks / RTD Transit Station
Potential Commuter Bus Operational & Maintenance Facility
Correct geometric deficiencies and replace aging infrastructure
4
4/2
4/4
4/2
6/2
6/2
Fort Collins
Loveland
Greeley
Longmont
Boulder
Denver
Harmony Rd. and Timberline - Fort Collins
South Fort Collins Transit Center - US 287 and Harmony Rd., Fort Collins
I-25 and Harmony Rd. - Fort Collins
Windsor - I-25 and SH 392
Crossroads Blvd. - Loveland between Crossroads Blvd. and US 34
Berthoud - I-25 and SH 56
Firestone - I-25 and SH 119
Frederick/Dacono - I-25 and SH 52
I-25 and SH 7
US 34 and SH 257
West Greeley - US 34 and 83rd Ave., Greeley
Greeley Downtown Transfer Center - 8th Ave. and 8th St., Greeley
Right-of-Way Preservation
Northwest Rail Corridor
North Metro Corridor
Denver International Airport
Denver Union Station
LARIMER
WELD
BOULDER
JEFFERSON
North

## PACKAGE B

# Report on In Situ Leach and Open-Pit Mining

Prepared for the Larimer County Commissioners
By
The Larimer County Environmental Advisory Board

February 12, 2008

The report was prepared by the Uranium Mining Subcommittee of the Environmental Advisory Board (Dale Lockwood, David Gilkey and Michael Erickson) with comments received from two outside reviewers and other board members. It was presented to the full board at the February 2008 meeting. The board unanimously approved releasing the document to the Board of County Commissioners.

## Executive Summary

The Larimer County Environmental Advisory Board was tasked by the County Commissioners to investigate the use of in-situ and open-pit mining operations for the extraction of uranium. Concern has been raised about the potential for such operations occurring near the county. To date, no applications have been submitted and no permitting processes have begun regarding the Centennial Project, although Powertech has submitted various documents to both Department of Natural Resources (DNR) and Colorado Department of Public Health and Environment (CDPHE) to be able to drill monitoring wells and overhaul some of the previous test bores on the Centennial site. No specific plans or precise information has been made available by the parties that have expressed interest in potential mining operations. Due to the early nature of the project and the request for a review prior to specific information becoming available, the EAB report focuses on uranium mining in a general sense and the risks that are associated with both in-situ and open pit mining.

Uranium mining has been conducted in Colorado for an extended period and active uranium mines are currently extracting ore in other counties. Larimer County had an active uranium mine, the Copper King mine, up from 1951 to 1953. The centennial mine would not be the first In situ leach (ISL) operation in northern Colorado, as Wyoming Mineral Corporation briefly conducted ISL operations in Weld County in the 1980s.

Uranium is not a highly radioactive mineral. The isotope used for energy production, U235, occurs at a rate of about 0.7% in uranium ore extracted from the earth. Uranium, like other heavy metals is toxic at sufficiently high doses, but unlike many other elements, the dosage for toxicity is rather large – on the order of grams.

The radioactive elements of radium and radon are both found in conjunction with uranium (both are the products of the radioactive decay of uranium). These elements are more radioactive than uranium. Radon occurs naturally as a gas and is easily wind dispersed. Radium occurs in very small quantities but is a serious environmental and public health issue.

A number of risks are identified with ISL operations. The environmental impact of these risks can affect the soil, air and water of the region. Water contamination is the most serious risk posed by ISL operations. The probabilities of any of these risks at a proposed site in Colorado remain unknown. Without baseline information regarding the operation geology and water quality, the EAB is unable to determine the chances that Larimer County will be adversely affected by the operation. There is a probability that the quality of ground water which supplies rural residences and agricultural businesses can be adversely affected. Most municipal water supplies for Larimer County are derived from water sheds to the west in the mountains and thus would have a very low chance of being affected by ISL operations.

Open pit mining operations present higher risks to the environment than ISL operations with the potential for serious land degradation and surface and ground water contamination as well as health impacts to mine workers, nearby residents and the ecosystem in whole. The minerals, such as selenium, released in such operations have been linked to deformities in birds.

Although the current permitting and regulation processes are extensive and requires monies to be set aside for remediation of any environmental damage, the end result is that the risks to the mining operators are strictly financial while the risks to the community are potentially financial, health and environmental with costs that may exceed any capabilities of the operations to rectify.

The effects of such operations, even if they have a relatively low risk of environmental degradation can damage the socioeconomic structure of the region. It is unclear what the short term or long term effects to the communities both socially and economically will be. Economic effects are not necessarily based on rational processes and can impact the region on a larger scale than the actual mining operations.

It is often the standard that entities other than the principle operators must show that harm will result in order for permitting to be halted. Given the seriousness of the potential risks (many of which appear to have low probabilities of occurring), the board would expect that those proposing the mining operation, provide a reasoned and scientifically based risk assessment of the operations as well as the risks of not mining, making public all data collected. The risks and the ability of the mine operator and local governments to address these risks should be weighed against the benefits that may be derived.

## Introduction

The Environmental Advisory Board (EAB) of Larimer County was tasked by the Board of County Commissioners to investigate the mining processes that may be used at a proposed uranium mine in Weld County near the border with Larimer County. The two forms of mining that are discussed with respect to the Powertech Centennial Project are In Situ Leaching (ISL) and open-pit mining. Although at the time of completion of this report, Powertech has begun the permitting process, no detailed documents regarding the specifics of the Centennial Project were made available to the EAB.

This report is not exhaustive in nature. The EAB is a volunteer board and as such was limited in time and resources that could be devoted to the task. The board interviewed researchers with expertise in the subject, attended a symposium on the topic and read through a large body of primary literature on uranium mining in developing this report.

The EAB decided to investigate the methods of uranium extraction and to focus on the potential impacts of the process on the environment. The board recognizes that there are three main areas of impact: water, air and soil. Each of these is subject to risks due to mining operations and this report describes the known effects.

Although there has been much information presented regarding the proposed Centennial Project by a variety of interested parties, the EAB report is based on factual information. The scientific literature is somewhat limited in the analysis of ISL operations but a substantial literature of government reports provides a solid basis for understanding the issues regarding uranium mining and the impacts it may have to the environment of northern Colorado.

## A Brief History of Uranium Mining

In Colorado, uranium was discovered in 1871 in Gilpin County and uranium oxide (later named carnotite) was discovered in Montrose County in 1881; but no major mining of uranium occurred in the 19$^{th}$ Century. Uranium was first actively sought in the 20$^{th}$ Century as a source of radium. Much of this mining occurred in the Uravan district in Montrose County. At about the same time production of vanadium started in Colorado and the carnotite ores also contained significant quantities of vanadium.

Not until the 1940s were uranium bearing ores actively mined for uranium, first as a source for weapons and later as fuel for reactors. Mining continued in Uravan and new sites were discovered across Colorado with the largest uranium deposit mined in Jefferson County. During this period uranium was mined in Larimer County near Red Feather Lakes at the Copper King mine. The EPA lists at least 25 other mines or occurrences of uranium in Larimer County. A confluence of factors led to the steep decline in the price of uranium in the 1980s and 1990s and the concomitant cessation of most mining operations in the state. The major production of uranium in Colorado has been via open pit and underground mines. Currently underground mining continues at the Sunday Mine in Montrose County. In situ mining of uranium began in the 1960s in Eastern Europe. In situ mining is currently used in Europe, Australia and in the U.S. in

Texas, Nebraska and Wyoming. ISL extraction was briefly conducted in northern Colorado near Grover, but the operation was halted apparently due to the low price of uranium at the time.

**Uranium Mining**

Uranium is extracted by three main processes, underground mining, open-pit mining and in situ leaching. Underground mining is not common currently. Underground mining prior to a complete understanding of the effects of radon, and improved techniques was associated with numerous cases of cancer in the miners. Underground mining would not be feasible for recovering uranium at the Centennial site. Both in situ and open-pit mining are apparently being considered for extracting uranium at the Centennial site and this report will describe both processes.

*In Situ Leaching*

The In-Situ Leaching (ISL) process involves the drilling of a series of wells into the aquifer containing the deposits. Often the aquifer that contains the deposits is below the aquifer that is used as a source for domestic, industrial and agricultural needs. In such cases it is very important that a sufficient low-permeability zone, such as a layer of shale, separate the production and drinking water aquifers (See Figure 1). A concentrated leaching solution (oxygen rich) called the lixiviant, is then pumped into the aquifer containing the deposits to oxidize, dissolve and mobilize the uranium minerals from the surrounding rock, so that the uranium concentration in the water increases and thus more uranium can be pumped back to the surface for extraction at a processing plant. The wells are divided into injection and extraction wells, and a number of extra wells are located outside the area where active pumping occurs to monitor any escape of the mining solutions. There are a variety of leaching solutions that can be used to dissolve the uranium, as well as numerous configurations for pumping and monitoring wells.

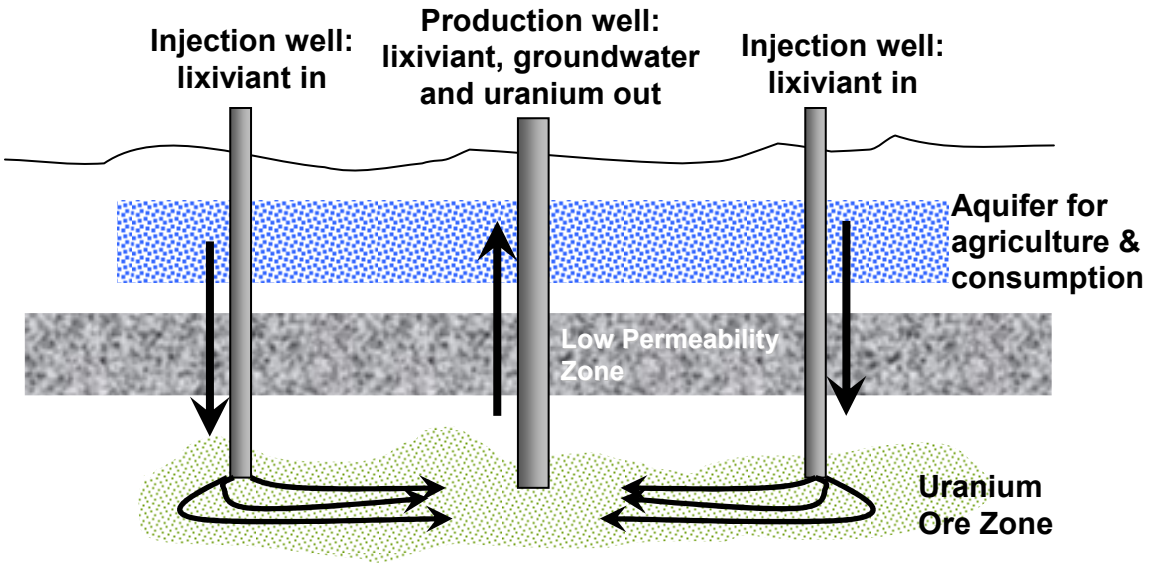



Figure 1: Schematic of ISL operations

Currently in the United States, all ISL uranium production is with alkaline leaching chemistry using carbon dioxide or sodium-carbonate and oxygen (lixiviant). The most common acid used in ISL is sulfuric acid. Acid leaching was only used once in the United States (in Wyoming) but is used in other countries.

One of the critical operational principles of any ISL mine is to control both the horizontal and vertical movement of leaching solutions within the groundwater area being mined. Not only is it important from an economic standpoint, but it is of importance for environmental protection so that the groundwater surrounding the mine site can continue to be used in the manner it was prior to ISL operations. An escape of leaching solutions, referred to as an *excursion,* and can result in contamination of soil, surface water or ground water. The main techniques used to prevent excursion are the engineering of groundwater bores to prevent leakage via the bore, and maintaining a negative pressure gradient on the injection wells relative to the production well. This means pumping out more water than the quantity of lixiviant injected into the ground.

The configuration of injection and extraction wells is also quite important for the successful control of the mining solutions. The main principle behind the patterns is that four (or six or twelve) injection wells surround one extraction well. A 5-spot pattern is thus square shaped, while a 7-spot pattern is hexagonal shaped.

ISL operations require a well designed groundwater monitoring system that can detect any excursion. It is intended that the wells are closely spaced so that any excursion of lixiviant will be detected by a monitoring well, detected by routine sampling and remedial action can be planned and undertaken. Monitoring wells need to be located with the uranium ore zone on order to detect horizontal excursions, and within any drinking water aquifers to detect vertical excursions into the domestic use aquifer.

After the pregnant (uranium rich) lixiviant is extracted from the ore zone, it is pumped to the processing plant, which is typically on the mine site. Here the uranium is extracted from the solutions using standard metallurgical techniques. The extracting solution is generally cycled through the well field, orebody and processing plant numerous times before being replaced by fresh lixiviant. The processing of pregnant lixiviant is very similar to standard uranium milling techniques.

*Waste Stream*

The ISL process leads to the formation of liquid and solid waste streams. These are produced from the bleed solutions, waste processing solutions, solid residues that build up due to the precipitation of minerals from the highly concentrated solutions involved, solid waste from the processing plant (such as contaminated clothing and equipment), and other normal wastes from industrial facilities. Due to the nature of ISL mining, quite large volumes of wastewater are created, which are often highly saline and contain toxic levels of heavy metals, process chemicals, and radionuclides. Excess ISL process water that is not re-injected is typically either directed to an evaporation pond, or injected into a deep disposal well to an aquifer below the uranium deposit and domestic aquifers.

Solid wastes are generally disposed of at an approved radioactive waste management site, or in an engineered facility on site. Since the ore body itself is not extracted, there are no tailings or residual rock material remaining in a large tailings dam. Treatment

methods for the liquid waste incorporate strategies including biological treatment in wetlands, evaporation ponds, and reactive barriers. All of these strategies are designed to isolate the toxic waste into a solid sludge and to then dispose of the sludge recovered according to regulations. For the Centennial project, solar evaporation ponds would likely be used. These are shallow, lined ponds that allow for water to evaporate, condensing the waste.

*Restoration*

After the orebody has been mined, it is standard practice to restore the groundwater quality to pre-mining levels. Restoration is required by state regulations. There are several approaches to restoration, as seen in Table 1.

Table 1: Methods for restoring aquifers after ISL operations

| Restoration Technique | Process | Impacts |
|---|---|---|
| Groundwater Sweep | Extraction of water from production wells to induce a flow of uncontaminated groundwater through the mined zone. Extracted water is treated the same as normal mining operations. Contaminated water is sent to evaporation ponds or is treated and discharged. | Requires substantial use of ground water. Is effective when the confining substrate allows leakage, potentially drawing down useable water supplies. |
| Forward Recirculation | Water is withdrawn via production wells, treated so that it meets required water quality and is reinjected via the injection wells. | Does not allow for removal of lixiviant or mobilized minerals that have escaped the mined aquifer (i.e. will not clean up an excusion). |
| Reverse Circulation | Treated water is injected via the production wells and extracted via the injection wells. | Similar effects to the forward circulation method. |
| Directional Groundwater Sweep | Contaminated water is pumped from a specific set of wells while treated water is injected into the aquifer outside of the boundaries of the mined area. Clean water is thus drawn into the contaminated portions of the aquifer. | While not requiring as much groundwater as the groundwater sweep method, additional groundwater is required for this technique. |

The net effect is stabilization of minerals back into the geology and restoration or improvement in the post –mining water quality of the aquifer. Baseline groundwater quality data that were collected prior to initiation of the ISL mining are used to determine restoration standards. After an ISL mining project has been completed, the site is rehabilitated and returned to the former land use. All infrastructures are removed, such as

buildings, roads, pipes, processing equipment etc. The remaining solid and liquid wastes are disposed of in radioactive waste facilities, and these sites are managed according to regulatory requirements.

## Open Pit Mining

Open pit mining, also known as opencast or open-cut mining, is a type of surface mining that involves excavating earth, rock, and other material to uncover an orebody that lies close to the surface (typically such mines excavate to a depth of no more than 550 feet). The topsoil is removed and then the material between the topsoil and the orebody, the overburden, is removed. The overburden is generally low in radioactive elements, but is considered waste. The ratio of overburden to ore for uranium open-pit mines is 30:1 on average. The excavation of the overburden is completed in rectangular blocks in plain view called pits or strips. The pits are parallel and adjacent to each other with each strip of overburden and the mineral beneath extracted sequentially. The mining process moves the overburden laterally to the adjacent empty pit where the mineral has been extracted. This lateral movement is called casting or open-casting. The overburden is moved by heavy equipment, with the use of explosives to sometimes loosen the overburden. The uncovered mineral is excavated and hauled out of the pit to processing operations. Filling the adjacent empty pits with the overburden is systemic to the process and therefore is the foundation of land reclamation. The processed ore is known as tailings. Uranium strip-mine operations create large areas that require remediation. Large tailings ponds are created to contain the radioactive materials. Federal law requires the tailing ponds to be covered so that rainwater does not mix with the radioactive waste. These pond coverings may be eroded over time by water and wind, which could allow mobilization of radionuclides.

*Reclamation / Restoration*

Open pit mine reclamation and restoration begins prior to mining operations. Careful characterization of the surface slope, composition of the flora at the site and hydrological structure of the region is needed before operations begin. Often open pit waste rock and overburden is put back into the cut after mineral extraction. The decision to place overburden back into the mine is based on the presence of water and whether leaching will cause migration of radionuclides and heavy metals.

Generally, not all overburden can be returned to the pit. The standard technique to address the issue of exposed overburden and waste rock is to dry-cover the overburden and recontour the material.

The last steps for reclamation involve revegitation. The reseeding or replanting of the site helps control erosion and controls dust. Revegitation limits infiltration of precipitation into the disturbed rock and soil.

## Risks

The question regarding environmental impacts largely hinges on the risks associated with the potential impacts and the probability of the impacts occurring. Some of the risks

associated with these types of operations have been characterized and are discussed below. Some risks likely remain unknown. To determine the scale of potential impacts, a survey of the EPA list of superfund sites indicates that no ISL operations have yet generated problems that would require inclusion. A number of uranium milling operations, as a result of open-pit and hard rock mining, in New Mexico, Colorado and Utah have been declared superfund sites. ISL operations and milling share similarities in the drying process but differ substantially in the processing of the orebody to generate the yellowcake. Clean up at the mill sites has involved soils, surface water and ground water. The EPA lists one open pit uranium mine as a superfund site with surface and ground water contamination. Thus, in a worst case scenario, the risks to the environment of northern Colorado are serious. The board was not able to quantify the likelihood of such risks, but merely identify them. Any risk assessment should be based on sound science.

Waste production is directly linked to the risk of adverse environmental impacts in relation to both open pit and ISL uranium mining operations. Mining waste is regulated and management must comply with environmental laws. ISL mining has demonstrated to have far less waste production and risk than open pit operations. ISL mining is the operation of choice where feasible for extracting uranium. Human risks are greatest to miners in cave and open pit operations. Public risks are usually limited to affects of waste through contaminated water and/or soil and their propensity toward mobility and resulting exposure and uptake. Wastes associated with ISL operations include: drilling wastes, wastewater, wastewater sludge, lab wastes, produced water, leachate, liquids from the aquifer restoration, evaporates and refuse if radioactive. Radon levels increase where levels of radium 226 have become concentrated in solid wastes. Management strategies most frequently include solar evaporation or deep well injection for liquid wastes while solid materials may be buried onsite or transported to approved disposal sites/facilities. ISL operations minimize the production of all types of waste compared to open pit operations.

Of concern is the risk of water contamination. It should be noted that the aquifers used for ISL mining are not suitable for drinking water. The location of mineralized soil will by its very nature be contaminated with heavy metals and uranium, and unfit for use regardless of if any mining takes place. Thus the concern is that the aquifers used to for domestic, industrial and agricultural will become contaminated during the mining operations.

There are several ways that water can be contaminated. The first is when water migrates between aquifers. Communication and contamination can occur between aquifers above (shallow) or below (deep) the aquifer or site of interest and operation. Water (and contaminants) may migrate from one aquifer to another by damaged or disturbed geologic features, altered pressure gradients, advection, percolation, or intentional injection. Two of the most important variables to limit the risk of contamination between aquifers are ensuring that an adequate low-permeability zone separates the drinking water aquifer from the production aquifer, and that the injection and production wells are property sealed to prevent leakage between aquifers.

Groundwater is a major source of water for human consumption in many rural locations. Groundwater chemical characteristics are established as baseline reference prior to ISL operations and become reclamation standards for post operations restoration.

The law requires that mining companies cleanup groundwater to the same or similar quality established by the baseline contaminant levels so that the groundwater may be used as it was prior to operations. There exists no obligation to improve the quality beyond prior levels. Use practices vary from site to site. ISL aquifer sites commonly do not have quality drinking water prior to or following mining operations and are not used for primary human needs. Chemical characteristics of groundwater are commonly altered by ISL mining activities due to uranium and other elements becoming mobilized for extraction or waste production and contamination during or after the operations. Some elements have appeared in greater concentration following stabilization of aquifers while others have been reduced as a result of the reclamation process. Analysis of groundwater for quality assessment after stabilization from the Crow Butte, Wyoming ISL revealed minor to moderate increases in concentrations of 13 of 33 contaminants and parameters evaluated including: alkalinity, arsenic, bicarbonate, calcium, iron, magnesium, molybdenum, nitrate and nitrite, potassium, radium 226, uranium, and vanadium. However, the concentration of 16 of the 33 contaminants were reduced including those for ammonium, barium, boron, cadmium, carbonate, chloride, copper, fluoride, lead, manganese, nickel, selenium, silica, sodium, sulfate, total dissolved solids, and zinc. The remaining two contaminants evaluated, chromium and mercury, were essentially at the same concentration. The pH was slightly lower but essentially the same (8.5 prior to 8.18 post - slightly basic) (NRC, 2007, Table 5). The same NRC report provides additional data from the Ruth, Wyoming Pilot R & D Study indicating similar effects to the groundwater quality when assessing 20 different contaminant levels and/or characteristics.

Surface spills from mining operations may also be a source of contamination of groundwater. For example, in the period from December 1999 to August 2007, the Smith Ranch ISL in Wyoming reported 37 spills or leaks with an average spill volume of 6,040 gallons. It may be possible that contaminated water is percolates downward and may contaminate groundwater in non-site shallow aquifers used for human consumption or food production. Percolation depth is a function of soil type and viscosity. For example clay soils are essentially impenetrable whereas, sandy-loamy soils percolate water downward very rapidly. Each site must be assessed for safety precautions to avoid and manage spills particularly if none minded aquifers are close to the surface.

*Consequences*

ISL operations can impact water, air and land resources. Research into the potential effects of excursions, surface spills, fugitive dust and other risks is not complete. Without scientific studies characterizing the scope of the impacts, a complete risk assessment is not available. The following sections discuss potential consequences of contamination from ISL operations.

Water

Potable water supplies derived from contaminated sources (aquifers or surface) pose threats to human and ecosystem health. The Safe Drinking Water Act establishes the Maximum Contaminate Levels (MCLs) for approximately 84 primary and 20 secondary contaminants. Sources used for municipal drinking water are monitored, evaluated,

treated and quality is assured/required. Private wells that become contaminated may not be detected. Private citizens do not monitor and evaluate all water quality parameters, as do municipalities. Raw water commonly used in farming and agricultural production is not subject to the same evaluation, monitoring or standards as drinking water. Contaminants pose threats to health through increased concentration to dangerous levels. Exposure is through primary consumption of the contaminated water as well as secondary consumption through eating food stuffs / products exposed to contaminated water. The Agency for Toxic Substances and Disease Control (ATSDR), reported that toxicological assessment has determined contaminant levels associated with ISL operations may pose health threats. For example, the ISL Crow Butte water quality assessment revealed arsenic levels ranging from 0.002 mg/L prior to mining increased to 0.017 mg/L following stabilization. Research suggests risks from arsenic levels 0.01 to 0.1mg/L are associated with possible hepatic (liver) injury whereas concentrations as low as 0.0037 mg/L were associated with skin lesions. Pre and post selenium levels reduced from 0.003 mg/L to 0.002 mg/L however, levels greater than 0.002 mg/L have been associated with liver damage. Background levels of uranium ranged from 0.092 mg/L prior to operations increased to 1.73 mg/L post mining; levels as low as 0.05 mg/L are associated with kidney damage.

The ISL site evaluation must consider flora and fauna of the area and region, and both resident and migratory plant and animal species. Major impacts to ecosystems from ISL operations come from site disturbance via large ponds and/or pits onsite used to manage wastes as well as the solids produced from drilling and disturbing the geology related to operations. Management strategies inevitably concentrate contaminants that may become mobilized and adversely impact the ecosystems of the area.

Crops can be impacted by the drying up of these ponds which can result in particulate contamination that can result in dispersion of radionuclides. These radioactive particles can be deposit on crops, and can be consumed by animals.

Plants are impacted generally by the disturbance of operations such as in drilling aquifer access holes (hundreds or thousands), setting pipe, building structures, roadways, etc. ISL operations require large scale holding ponds for water that impact surface habitat. Flooding crop areas will destroy production and increase salinity of soils from solar evaporation of water. This will impact plant growth and limit use in future times. Limiting plant growth has the potential to increase air contamination in the future. Plant contact with contaminated water may transfer contaminants to the plant by adsorption or absorption. Contaminant may either “stick” to the surface of plants or be taken-up into the plant.

Domestic animals are impacted by operations as described above. Consumption of contaminated water can produce adverse health affects similar to those seen in other species including humans and are agent specific. Bioaccumulation or concentration of contaminants can also occur in disparate members of the local food web and this can affect species that are commonly consumed by humans thus imparting higher exposures of agents as in radionuclides concentrated by cattle and sheep.

The ecosystem in and around the ISL operations can be influenced by contamination from the operations. As with the agricultural processes, bioaccumulation of contaminants can increase as the minerals and radionuclides move through the food web. The local

ecosystem will experience such bioaccumulation, but the region is also in a flyway for many bird species so the potential to affect other ecosystems linked by the migration and dispersal of animals is also an issue.

Air

Dust is inevitable in mining operations due to disturbance of the geology. Fugitive dust emissions are considerably less in ISL operations when compared to open pit mining. Disturbance of the site results from the operations described above. Mobilization of solids is dependant on wind patterns, barriers and methods used to suppress dust.

Radon levels have been increased where levels of radium 226 has become concentrated in solid wastes. This is a much greater problem in cave and tunnel mining where air circulation is minimized. ISL pit bottoms are common places for sediment/precipitate to concentrate. As solar evaporation of water concentrates solid materials, radionuclides decay and produce higher levels of radon. This is released to the atmosphere. Radon is dispersed easily in the atmosphere (which is why home basement mitigation systems vent directly to the outside) and the risks for radon exposure are limited to the immediate area around the operation.

Mining operations require the use of vehicles and other equipment that operates with fossil fuels. Increased traffic on rural roads could lead to congestion and further air pollution. Open-pit mining would require the use of heavy equipment, further increasing the local air pollution. This increase in air pollutants is not likely to be significant, although it should be noted that the proposed mining sites are within the EPA non-attainment area for the Denver Metro area.

Land / Soil

Land disturbance is significant but far less in ISL operations compared to open pit mining. Disturbances are described above and usually affect a large surface area at the mine site. For example, thousands of holes may be drilled and hundreds of acres may be used for wastewater ponds and pits. Most ISL sites create buffer zones by acquiring thousands of acres around the site of interest. Excursions of lixiviant, pregnant lixiviant, or wastewater all pose a risk to the soil of the mining site. The use of the soil near the operations for agricultural purposes either during operations or after the operations are complete could be impacted by such excursions.

Wildlife is impacted by site operations and disturbance of the ecosystem. The site evaluation must consider species that are both resident in the area and those that are migratory. It is suggested that most impacts are temporary and restoration permits a return and reestablishment of wildlife in time. Habitat fragmentation can occur with the construction of wellfields, roads constructed to support the mining and any fencing done during mining or during reclamation. This fragmentation affects the migration and dispersal of species. Of concern would be the impact on any endangered species (both plant and animal) that utilize the area affected by the mining.

Open-pit mining

ISL mining is considered to reduce environmental risks compared with open-pit mining. The wastes generated in open pit mining include protore, overburden, waste rock,

drill cuttings and wastes, wastewater, treatment sludge, lab wastes, and pit water. Open pit mines may create increased runoff, wind and water erosion. Dewatering of the mine area can create groundwater depressions.

Ground and surface water can be pumped out of the region of the open-pit mine to facilitate access to the ore. After the mining is complete, the pumping is stopped and the pit can refill with ground and surface water. The mine water can be contaminated with metals, radioactive elements and dissolved solids. In some instances, the ground water takes on the chemical characteristics of the mine dewatering effluent. Mine water pumped out of the mine can be high in radionuclides and other metals.

The overburden and waste rock can become a source for acid runoff. This runoff can negatively impact surface and ground water downstream from the mine.

Greater volumes of airborne contaminants can occur with open pit mines with respect to ISL operations. The excavation processes, movement of heavy equipment, wind dispersion of overburden can create fugitive dust. This dust can contain heavy metals and other toxics. Generally, during mine operations water is sprayed on waste and overburden piles to reduce dust. Overburden and waste rock can release higher amounts of radon gas. Although it disperses quickly, radon can be a health risk to workers.

Clearly open-pit mining disturbs soils to a large extent. This type of mining operation can increase the radioactivity of the soil. Both radium and thorium concentrations have been shown to increase in some open-pit mines.

**Baseline Data**

It is important that any risk assessment be based on solid science, which in turn, must be grounded in data that describes the region. This information is also needed if ISl operations are conducted to determine the effectiveness of restoration and any remediation that would be necessary.

Baseline assessments of the geology of the aquifer must be carried out prior to operations to establish baseline restoration goals. The ISL process is intended to mobilize minerals. Pre-mining mineral level concentrations in the water must be determined prior to disturbing the hydrogeology of the site. Assessment and validation is incumbent on the individuals/company seeking access for mining operations and the agencies providing permits.

Likewise, water quality parameters must be established prior to disturbance of any aquifers to establish current quality and restoration goals.

Soil analysis must be performed to establish constituent make-up for the detection of change and/or concentration of contaminants posing health risks to the ecosystem and necessary clean-up strategies, technologies, and goals.

Evaluation of air quality and wind patterns must be performed to establish current quality and restoration goals and probabilities for offsite migration through fugitive dust emissions.

## Conclusions

Mining operations carry with them the potential for significant environmental impacts. Water, soil and air contamination are all possible with the operations that may be conducted in Weld County. The probabilities associated with these impacts are not presently known. In the absence of sound scientific data, an acceptable risk assessment is not currently possible. Without a risk assessment, detailed project descriptions, or access to baseline data the EAB is unable to make recommendations regarding the Centennial Project at this time.

The effects of the Centennial Project extend beyond environmental impacts. There are potential public health and economic impacts as well. The economic impacts of the project may not be tied to actual risks but perceptions. In this case, regardless of the risks, the project may have a negative impact to the region. Other economic impacts may include additional jobs and tax revenue for the duration of the mining operations.

It is often the standard that entities other than the principle operators must show that harm will result in order for permitting to be halted. This approach, however, presupposes that the action is "innocent of harm until proven guilty" and places the burden of proof on those who usually have fewer resources to make their case. Given the seriousness of the potential risks (many of which appear to have low probabilities of occurring), the board would expect that those proposing the mining operation will provide the public with all of the data which they possess that could have any relevancy to the matter at hand and then use these data to propose a reasoned and scientifically based risk assessment of the operations. Without meeting this standard, it is impossible for the Board or the public to provide their informed consent or for the outcome to represent a just resolution. The risks (environmental, economic, health, and social) and the ability of the mine operator and local governments to avoid or mitigate these risks should be weighed against the benefits that may be derived from such an operation when determining whether the mine is acceptable for the region.

## Regulatory requirements

Powertech is required to acquire federal, state and county permits on the Centennial Project in order to commence uranium mining activities. The Colorado Department of Public Health and Environment (CDPHE) has identified the following State and Federal Permits, Authorizations and Requirements that may be required for an in-situ uranium mining and milling operation. The list may change depending on the specific proposal for operation.

**Colorado Department of Public Health and Environment**:
Radiation Control:

1) Radioactive materials/uranium mill license. C.R.S. §25-11-101 et seq., 6 CCR 1007-1, Parts 1, 3, 4, 10, 17, 18. *Colorado's radiation control regulations are authorized through agreement with the U.S. Nuclear Regulatory Commission. In-situ mining of uranium ore is subject to licensing requirements due to the byproduct materials produced. The requirements include provisions regarding*

*environmental assessment, financial assurance, operations, residuals management, worker and public safety and decommissioning.*

Water Quality:

1) Surface water discharge permit (if there will be a discharge to surface water). C.R.S. §25-8-501; 5 CCR 1002-61.
2) Storm water permit. 5 CCR 1002-61.
3) Ground water discharge permit (if the Division of Reclamation and Mining Services {DRMS} fails to provide adequate ground water quality protection). C.R.S. § 25-8-202(7); 5 CCR 1002-61.14. *Any radioactive materials license issued by DRMS would require containment of contaminated solutions within a defined aquifer area. If releases occur, a license requires corrective actions to be evaluated and implemented. Decommissioning requirements include decontamination of the mined zone and return to conditions consistent with groundwater standards, or pre-mining conditions.*

Air Quality:

1) Air quality permit if there will be air emissions. C.R.S. §25-7-101 et seq. *The requirements for air emissions permits are evaluated when an applicant submits an Air Pollution Emission Notice (APEN) the Air Quality Control Division for review.*

Hazardous Materials and Waste Management:

1) Hazardous waste permit, if applicable. C.R.S. §25-15-101 et seq. *Permits are required if specified amounts of hazardous waste are generated or stored on the property.*
2) Solid waste certificate of designation, if applicable. C.R.S. §25-15-101 et seq. *A certificate of designation is required for onsite solid waste disposal activities.*

**Department of Natural Resources**

Division of Reclamation and Mining Services:

1) Reclamation permit. C.R.S. § 34-32-109. *The Rules and Regulations adopted by the Mined Land Reclamation Board contain performance standards for groundwater quality, drainage, post-mining use, wildlife and materials handling during the reclamation phase.*
2) Notice of Intent to Prospect. C.R.S. § 34-32-113. *A notice is required for exploration to define ore bodies, characterize groundwater and determine possible mining and refining methods.*

State Engineer's Office

1) Ground water permit. C.R.S. Title 37, Article 90.

**US Environmental Protection Agency**

1) Class I or Class III Underground Injection Control Permit. 42 U.S.C. §300h; 40 CFR §144.6, 147.301. *This program regulates waste disposal and injection wells used for in-situ uranium mining. Standards for wells pertain to construction methods, operating parameters such as injection volume and pressure, monitoring and reporting, well closure and abandonment procedures, and financial responsibility. Before injection can occur, an applicant must obtain an*

*"aquifer exemption" from the EPA. An exemption can be issued only if the aquifer under consideration does not serve as a source of drinking water and cannot become one in the future due to its mineral, hydrocarbon or geothermal energy content.*

**Weld County**

1) Use by Special Review. Weld County Code, Chapter 23 (Zoning), Article II, Division 4. *The standards for use by special review require County review and approval to address issues related to compatibility with existing and planned uses in the neighborhood. The standards for approval include a requirement that adequate provisions for the protection of the health, safety and welfare of the neighborhood and County be made. Public hearings before the Planning Commission and County Commissioners must be held in order to consider a special review application. Note that Weld County has indicated that they want all of the state and federal permitting requirements to be completed prior to application at the County level for public hearing to consider in-situ uranium mining.*

**Future Statutory Requirements**

1) Bills Submitted for Consideration. *In January of 2008, a group of Northern Colorado lawmakers introduced two bills designed to protect public health and property values from uranium and other mining activities. House Bill 1161 would require mining companies to show they will restore groundwater aquifers to their pre-mining levels. House Bill 1165 would require mining companies to inform residents of mining activity taking place near them, and require local governments to protect local water sources from mining activities.*

## Glossary of Terms

**Aquifer** – An aquifer is a geologic formation or a group of formations that contain sufficient water to permit extraction by wells or release through springs. Aquifer hydrogeology characteristics greatly affect water contaminant levels.

**Arsenic** – Arsenic is a metalloid exhibiting properties of both metals and non-metals. It may be present in combination with other compounds. Arsenic is present in nature and varies in concentration within the geology of soils. It is a known carcinogen and toxic agent. The primary target organs with chronic exposure include the skin, nervous system, liver and vascular system. High level ingestion (70 – 180 milligrams can be fatal to humans. Arsenic is found in our drinking water and food. It is estimated that the average daily intake (ADI) from food is 0.04 milligrams. For those with high seafood diets, the ADI may be as high as 0.02 milligrams. Current drinking water standards limit concentrations to 10 micrograms (.01 milligrams) per liter while most water sources are less than 5 micrograms (0.005 milligrams per liter in the US.

**Extraction Well –** A bore hole or well in an in situ well field through which pregnant lixiviant and ground water are drawn to the surface. Also known as a production well. Typically, an extraction well is surrounded by a number of injection wells.

**Fold** – Bending of rock layers due to slow sustained forces.

**Food web** – An ecological concept that relates species by which species consume others. Plants, which make their own food do not consume other organisms. Often, food webs are represented as simple food chains with a hierarchy, plants consumed by herbivores, which are consumed by predators and so on. Actual food webs are highly reticulated with various loops. Food webs are important for understanding the movement of elements (nutrients or toxic substances) from one part of an ecosystem to another.

**Hard rock mining** – Technique in which tunnels are dug and the ore is extracted from veins found underground. This technique generates less waste material but exposes miners to much higher radiation from the associated radon gas. The waste rock carries with it the possibility of subsequent leaching of toxic elements such as uranium, radium, selenium, or molybdenum into the groundwater.

**In situ mining leaching** – Mining technique, also known as in situ recovery or solution mining, in which holes are bored into the rock containing the mineral. Treated water is forced into a set of holes in order to dissolve the mineral. The water is treated either with sulfuric acid or sodium bicarbonate (sodium bicarbonate is currently used in the United States). The solution containing the mineral is brought to the surface via pumping from another set of holes. The dissolved mineral is then recovered from solution. The mineral-depleted water is then re-injected into the boreholes. This technique generates the least amount of rock waste but raises issues of contamination of useful aquifers by migration of water between aquifers from older drill holes. The region in Weld County where current mining interests are involved was explored in the 1970s with thousands of drill holes bored. Currently in situ mining is the main method used in the United States to extract uranium.

**Injection Well –** A bore hold or well in an in situ well field through which lixiviant enters the aquifer containing the orebody.

**Isotope** – An element can occur as different isotopes. The nucleus of an atom of a particular element contains the same number of protons but can contain different numbers of neutrons. These variants based on the number of neutrons are the isotopes of the element. The fewer the number of neutrons means the isotope is subject to more radioactive decay.

**Open pit mining** – Technique involves the removal of the rock and soil overburden to allow for the extraction of the mineral ore. Generally, this process involves a large amount of dust and extensive use of water is used to mitigate the dust. After the mineral is extracted, generally the area undergoes reclamation. This method also carries with it the possibility of subsequent leaching of toxic elements such as uranium, radium, selenium, or molybdenum into the groundwater.

**Pregnant Solution** - A solution containing lixiviant and the mineral targeted for extraction. Other minerals are often found in the solution having been mobilized by the lixiviant as well.

**Protore** – A mineral deposit that could become economically viable if prices change or technology for extraction improves.

**Radiation** – Energy in the form of waves or particles. It can be either ionizing or non-ionizing (heat, light, microwaves, radio waves). Three forms of ionizing radiation are alpha, beta and gamma. Alpha radiation is easily blocked and only when the source is internal can cellular damage occur (such as when Radon is inhaled, or when ingested, such as Polonium-210 poisoning). Beta radiation can penetrate tissue farther and can cause skin lesions at high exposures, or increased risk of cancers at lower exposures. Gamma radiation has the highest energy and can penetrate tissue readily and can increase the risk of certain cancers. Gamma radiation can cause DNA damage resulting in hereditary changes (in mammals, but such changes have not been documented in humans). As a radioactive element decays it changes to isotopes of different elements each releasing radiation until a final resting state is achieved (non-radioactive isotope). This sequence is the decay chain and the uranium decay chain releases alpha, beta and gamma radiation at various steps. Uranium decay occurs regardless of its location or any physical properties. Radon is an important decay product in the uranium decay chain. Uranium is naturally present in soil and water.

**Radium** – Radium is a naturally occurring radioactive element that assumes 16 different isotopes. The most common isotopes are radium 226, 224 and 228 used widely in medicine and industry. Radium forms when isotopes of uranium or thorium decay in the environment. Most radium (226) originates from the decay of the plentiful uranium (238). Radium 224 and 228 form when Thorium decays. Radium like uranium are naturally occuring and in the soil. Radium is a toxic element that targets the skeletal system causing bone cancer (osteogenic sarcoma).

**Radon** – A radioactive noble gas. The EPA lists radon as the second leading cause of lung cancer. Radon is a daughter element of uranium, that is, when uranium decays one of the elements it becomes is radon. Radon occurs naturally as a gas and as such is generally quickly dispersed in open air. Radon poses a serious health risk when it is allowed to concentrate. Radon can collect in subterranean areas without proper ventilation (mine shafts, basements, etc).

**Reclamation** – Reclamation standards and practices address environmental protection and stability post-mining operations including topsoil salvage and storage, surface and groundwater protection, stability of acreage exposed to wind and water erosion. These standards are established by the permitting agency and are meant to ensure recovery of the site. Standards are focused at surface mining impacts such as in open pit coal mining. The Surface Mining Control and Reclamation Act of 1977 created the Office of Surface Mining Reclamation and Enforcement within the Department of the Interior administered by the State of Colorado.

**Remediation** – Remediation is the cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site, or uranium mine or extraction facility, including those included under the Uranium Mill Tailings Radiation Control Act (UMTRCA).

**Selenium** – Selenium is metal and an essential nutrient. It may be present in combination with other compounds. Selenium is present in nature and varies in concentration within the geology of soils. Deficiency causes cardiomyopathy (heart abnormality). The ADI is estimated at 0.02 milligram through food consumed. Selenium has low toxicity but may also be toxic at very high levels 100 – 100,000 times normal intake. Target organs include skin, hair, nails, and nervous system.

**Tailings** – Tailing are the solid material wastes (waste rock) from mining operations. Tailings are formed when the ore is extracted from the substrate. Uranium mining tailings, while generally low in radioactive elements can contain higher concentrations of contaminants including heavy metals. Open pit and tunnel mining produce large amount of tailings. Tailings reclamation are usually required by the permit process.

**Uranium** – Uranium is the heaviest naturally occurring element. It is found in low concentrations in water, rock and soil. Uranium is weakly radioactive, emitting alpha particles. Uranium occurs as several isotopes. The three most common are U-238 (99.28% of all naturally occurring Uranium), U-235 (0.71%) and U-234 (0.0054%).

Uranium is a heavy metal and as such is toxic to humans. The LD50 dosage for uranium is 29 grams in an average adult. Uranium, in large quantities, damages the kidneys. The CDC reports no radiological effects from naturally occurring uranium.

**Yellowcake** - a processed oxide of uranium, $U_3O_8$, extracted and concentrated from uranium ore: used as the raw material for commercial nuclear materials, esp. fuel elements in nuclear reactors.

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