STATE OF COLORADO

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Colorado Department
of Public Health
and Environment

March 30, 2006

Ms. Janet Schlueter
United States Nuclear Regulatory Commission
State and Tribal Programs
One White Flint North
11555 Rockville Pike
Room 3C-10
Rockville, Maryland 20852

Re: Colorado Radioactive Materials License # 660-01, Intent to submit a draft Completion Review Report for the Maybell Heap Leach Title II Site located in Moffat County, Colorado.

Dear Ms. Schlueter:

Enclosed are two copies of the draft Completion Review Report (CRR) for the Maybell Title II heap leach site located in Moffat County, Colorado for your staff to review. Staff followed NRC's SA-900 in preparing the report. We would appreciate information on your schedule for review. We would like to resolve any issues that might occur early in the review, as our goal and the licensee's objective is to terminate the license as quickly as possible. Thank you for your review and consideration of our concerns.

If you have any questions about the report, please call Mr. Phil Stoffey at 303-692-3452 or e-mail at philip.stoffey@state.co.us.

Sincerely,

Joseph Vranka
Manager, Radiation Control Program
Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment

Enclosure: 2 CRR's

Cc: Mark Plessinger, DOE w/ enclosure
File 660-01 File 3.2 w/ enclosure

Colorado Department
of Public Health
and Environment

March 30, 2006

Draft

Completion Review Report
For the Maybell Site Located in Moffat County, Colorado

Colorado RML # 660-01

Prepared by Philip S. Stoffey
Project Manager
Remediation Program
Colorado Department of Public Health and Environment

For the State and Tribal Programs
United States Nuclear Regulatory Commission

March 2006

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Completion Review Report

Umetco Minerals Corporation

Maybell Colorado Title II Site

Date: March 2006

Licensee: Umetco Minerals Corporation (Umetco)

License Number: 660-01

Facility Name: Umetco Maybell Facility

Location: Maybell, Colorado

Licensed Area To Be Terminated: 180 acres

Project Manager: Phil Stoffey, Remediation Program

Technical Reviewers: Jeff Deckler-Remediation Program Manager (geotechnical); Larry Bruskin P.E.- Solid Waste and Hazardous Materials Program (engineering design and surface water) Edgar Ethington RPG –Radiation Management Control Program (geophsics/geohydrology); Ken Weaver M.S. – Radiation Management Program (health physics) Art Burnham P.H. D. –former project manager, retired (chemistry/health physics)

I. SUMMARY

Umetco Minerals Corporation's (Umetco) site is a former heap leach facility that has been decommissioned and reclaimed under Colorado Department of Public Health and Environment (CDPHE) Agreement State authority by agreement since 1968, amended in 1982, derived from Title II of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). The Maybell Title II site was operated by Umetco Minerals Corporation under Colorado Radioactive Materials License Number 660-01. Under the agreement state program, the State of Colorado is responsible for approval of the remediation plans for Umetco's Maybell Title II facility and for inspections to ensure that the actual remedial actions have been completed pursuant to the requirements contained in the radioactive materials license and approved plans.

The Completion Review Report (CRR) presents the summary data, information and analyses that support the conclusion that the cleanup and construction activities at the Maybell Title II site have been conducted in accordance with the regulations and support the termination of Radioactive Materials License 660-01. This document has been prepared using Nuclear Regulatory Commission guidance documents. These include the *Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Under Title II of the Uranium Mill Tailings Radiation Control Act* and Procedure SA-900 titled *Termination of Uranium Milling Licenses in Agreement States.*

The purpose of this report is to provide the site background, design criteria and as-built information to allow NRC to assess the CDPHE evaluation of the completed remedial actions at the Maybell Title II site for compliance with the regulations. The applicable

standard for reclamation at the Maybell Title II site is Part 18 of the Colorado's *Rules and Regulations Pertaining to Radiation Control* (6 CCR 1007-1-18), titled *Licensing Requirements for Uranium and Thorium Processing.* The State regulation is consistent and compatible with NRC regulations, as required by the State's Agreement with the NRC.

This report also describes reclamation activities that are similar or identical to work completed by the DOE at the Maybell Title I site. The DOE used many of the same materials, designs and design input parameters for the Title I reclamation as Umetco did for the Title II reclamation. The DOE Title I site is located approximately 1 mile to the east of the Maybell Title II site and was reclaimed using the same regulatory standards.

The regulatory process followed during reclamation of the Maybell Title II site included the preparation of reclamation documents in 1994, 1995 and 2004 with subsequent approval of the various documents by CDPHE. These documents form the foundation for reclamation activities conducted at the Maybell Title II site and included:

- *Final Plans and Specifications for Closure Activities* (Umetco, 1995a);
- *Quality Plans and Construction Verification Program* (Umetco, 1995b);
- *Soils Cleanup Plan* (Umetco, 1995c);
- *Liquid Waste Management Plan* (Umetco, 1994);
- *Maybell Heap Leach Facility Final Grading and Drainage Plan, Design Summary* (Umetco 2004a); and
- *Construction Plans and Specifications for Maybell Heap Leach Facility, Final Reclamation* (Umetco, 2004b).

These documents were prepared using regulatory guidance from the Nuclear Regulatory Commission (NRC) (NRC, 1986a, 1986b, 1989, 1990, and 1999; Rogers and others 1984); from published sources (Chenoweth, 1986; Kirkham and others 1981; Gilbert 1987; and from the Department of Energy (DOE) Maybell Title I site (DOE 1989, 1996a, 1996b). DOE activities at the Title I site mirror reclamation activities at the Maybell Title II site. Results of DOE monitoring activities have been used in the assessment of groundwater beneath the Maybell Title II site.

Site control documents that set forth health and safety programs and general environmental monitoring programs were reviewed and approved by CDPHE. These documents are:

- *Maybell Site Health and Safety Plan for Remedial Action* (Umetco, 1995d) and
- *Maybell Policy and Procedures Manual* (Umetco, 1995e).

Combined, all of the above documents established specific-site reclamation activities that were developed and implemented so that CDPHE regulatory requirements could be fully met and so that the work could be conducted in a safe and environmentally sound manner.

The *Quality Plan and Construction Verification Program* (Umetco 1995b) required that certain Compliance Reports be submitted to the Colorado Department of Public Health

and Environment. Each Compliance Report demonstrates how a construction segment or task was performed to meet the requirements contained in the final plans and specifications for the closure activities (Umetco 1995a, 1995c, 2004a, 2004b). CDPHE performed complete and comprehensive reviews of reclamation activities at the Maybell Title II site as reclamation activities were being conducted. Each Compliance Report was reviewed by CDPHE and approved after any requested additions or revisions were completed. These approved reports describe specific construction tasks and present detailed as-built drawings for the reclamation activities described in this report. Compliance Reports are summarized as follows:

Table I-1

Summary of Maybell Compliance Reports

Project Description	Compliance Report	Approval Date
Liquid Waste Management		
Drainage Collection Modifications & New Evaporation Pond Construction	CR-MAY-2.1	9-14-99
This report describes the modification of the drainage collection system and the construction of the new evaporation pond, including clayey liner, leak detection system and synthetic liners.		
Plant Site Decommissioning		
Demolition of Remaining Equipment	CR-MAY-3.1	2-21-01
This report describes the demolition and removal of the remaining processing equipment and support facilities, and the placement of the debris in the Heap Leach Repository.		
Site Restoration & Revegetation	CR-MAY-3.2	12-9-05
This report describes the site restoration and revegetation activities performed on the disturbed former plant site areas.		
Soil Cleanup		
Soil Removal	CR-MAY-4.1	3-21-01
This report describes the excavation of contaminated soil and its placement in the Heap Leach Repository. A total of 65,994 yd^3 was excavated from the offsite soils cleanup area.		
Soil Reclamation	CR-MAY-4.2	5-24-01
This report describes the stripping and stockpiling of existing vegetation from the offsite soils area for use as a soil amendment during final reclamation and the disking of the top eight inches of soil in the delineated mixing areas.		

Table I-1 (Cont.)

Summary of Maybell Compliance Reports

Project Description	Compliance Report	Approval Date
Verification Survey	CR-MAY-4.3	3-1-02
This report describes the verification survey for the cleanup of soils at the site.		
Reclamation & Revegetation	CR-MAY-4.4	12-9-05
This report describes the site restoration and revegetation activities performed on the disturbed offsite areas.		
Heap Configuration		
Contaminated Material Placement and Compaction	CR-MAY-5.1	5-24-01
This report describes the placement and compaction of contaminated scrap and soil in the Heap Leach Repository between 1989 and 1990 and between 1995 and 1997		
Heap Grading	CR-MAY-5.2	3-21-01
This report describes the reconfiguration and grading of soils from the off-site soils cleanup, construction of Channel No. 1 and the shaping of the heaps to construct the final Heap Leach Repository and control storm water runoff.		
Reclamation Cover		
Radon Barrier	CR-MAY-6.1	3-21-01
This report describes the placement, compaction and testing of the eighteen inch thick radon barrier layer on the Heap Leach Repository. A total of 179,182 yd^3 of clayey soil was placed over the compacted contaminated material and compacted to 95% of the Standard Proctor maximum density between 1995 and 1997.		
Random Fill Soils	CR-MAY-6.2	3-21-01
This report describes the placement, compaction and testing of the four-foot thick frost barrier lay on the Heap Leach Repository. A total of 420,800 yd^3 of random fill was placed over the radon barrier and compacted to 95% of the Standard Proctor maximum density between 1995 and 1997.		
Rock Protection Layer	CR-MAY-6.3	5-24-01
This report describes the placement and testing of the rock erosion protection layer on the Heap Leach Repository. A total of 145,306 yd^3 of Type A, B, C and D limestone riprap was placed over the frost protection layer between 1996 and 1998.		

Table I-1 (Cont.)

Summary of Maybell Compliance Reports

Project Description	Compliance Report	Approval Date
Diversion Channels		
Drainage Diversion Channels	CR-MAY-7.0	5-24-01
This report describes the construction of Channel No. 1. The channel was constructed across the top of the Heap Leach Repository in 1995 and down the sideslope in 1997.		
Monitoring Devices		
Monitoring Device Installation	CR-MAY-8.0	10-24-05
This report describes the installation of five surface movement monuments on the top of the Heap Leach Repository in April 2005.		
Heap Drainage & Ancillary Cell Closure		
Cessation of Heap Drainage	CR-MAY-9.1	7-12-00
This report describes the determination that the drainage collection system in the Heap Leach Repository could be abandoned.		
Sealing of Drainage Discharge Pipes	CR-MAY-9.2	3-21-01
This report describes the grouting of the drainage discharge lines from the Heap Leach Repository in August and September 2000.		
Contaminated Material Neutralization & Placement	CR-MAY-9.3	12-9-05
This report describes the placement of contaminated material in the Ancillary Cell constructed in the former Winter Storage Pond. Limestone crusher fines were used to neutralize and stabilize the pond residues from both the Winter Storage Pond and the New Evaporation Pond between June and August 2005.		
Ancillary Cell Radon Barrier	CR-MAY-9.4	12-9-05
This report describes the placement, compaction and testing of the twelve inch thick radon barrier layer on the Ancillary cell. A total of 1,879 yd^3 of clayey soil was placed over the stabilized contaminated material and compacted to a minimum of 95% of the Standard Proctor maximum density during September 2005.		
Ancillary Cell Random Fill Soils	CR-MAY-9.5	12-9-05
This report describes the placement, compaction and testing of the four-foot thick frost barrier layer on the Ancillary cell. A total of 10,600 yd^3 of random fill was placed over the radon barrier and compacted to a minimum of 95% of the Standard Proctor maximum density during September 2005.		

Table I-1 (Cont.)

Summary of Maybell Compliance Reports

Project Description	Compliance Report	Approval Date
Ancillary Cell Rock Protection Layer	CR-MAY-9.6	12-9-05
This report describes the placement of the six-inch thick rock erosion protection layer on the Ancillary Cell. A total of 2,523 yd^3 of Type A limestone rock was placed over the frost protection during September and October 2005.		

The summary data and information presented in this CRR is supported by the twenty Compliance Reports described above as well as as-built drawings of Umetco's reclamation work (Umetco, 2005) and associated backup information contained in the project files.

The CRR summarizes technical information documenting that the completed surface remedial actions were performed in accordance with applicable standards and requirements. Section 2 discusses the geotechnical stability, surface water hydrology, and erosion control features of the disposal repository and cell. Radioactivity cleanup and verification control is presented in Section 3 and documentation of groundwater monitoring activities is set forth in Section 4. Compliance with license conditions and CDPHE rules and regulations is described in Section 5. Included with this Completion Review Report are six figures, the location of the site and the area to be transferred to the DOE (Figure 1), the site configuration and conditions prior to reclamation (Figures 2, 3, and 6) and the site configuration and aerial photographs after completion of all reclamation activities (Figures 4, 5, and 6). The spatial relationship to the DOE Title I facility is shown in Figures 1 and 6, that includes a 1969 and 2005 aerial photo of the two sites.

CDPHE conducted numerous field inspections as the reclamation work proceeded and conducted comprehensive annual reviews of the environmental monitoring and radiological safety programs. CDPHE concludes that the reclamation activities were conducted properly and are protective of human health and the environment. The construction work and underlying design have been evaluated against the requirements of Appendix A, Part 18, of the State of Colorado *Rules and Regulations Pertaining to Radiation Control,* 6 CCR 1007-1. This evaluation is presented after Table I-2. This evaluation concludes that the reclamation activities were conducted in accordance with the approved final reclamation plans and meet the requirements set forth in Colorado's rules and regulations.

Table I-2 correlates sections of this CRR to the appropriate regulatory standards as set forth in the regulations. The table cross references requirements contained in Appendix A of Part 18 with the section in the Completion Review Report where compliance with the requirements are discussed.

Table I-2

Applicable Standards and Requirements Related to Topic Discussed in the CRR

Applicable Requirements		CRR Sections
Appendix A Part 18 of Colorado Rules and Regulations Pertaining to Radiation Control	Criterion 1 1A. Tailings Siting 1B. Site Features 1C. Tailings Isolation 1D. No Active Maintenance	Section 1, 2.1
	Criterion 2 Non-Proliferation	Section 1
	Criterion 3 Above or Below Grade	Section 2.1
	Criterion 4 4A. Erosion Potential 4B. Wind protection 4C. Flatness of Slopes 4D. Rock and vegetative Cover 4E. Seismic Design 4F. Sediment Deposition	 Section 2.2.3 Section 2.2.1 Section 2.2.3 Section 2.2.4 Sections 2.1.8,9,10,11 Sections 2.2
	Criterion 5 Groundwater Protection	 Section 4.1
	Criterion 6 Radon Cover Longevity Radon Flux Phased Flux Flux Reports Cover Materials Activity Soil Cleanup Criteria Non-radiological Hazards Criterion 6A Timeliness of Cover Placement	 Section 2.1.12 Section 3.2 Section 1 Section 3.2 Section 2.1.5,6 Section 3.1 Section 3.1.1 Section 1
	Criterion 7 Groundwater Detection Monitoring	 Section 4.1
	Criterion 8 Process Operations	 Section 1
	Criterion 9 Ownership and Long Term Surveillance	 Section 1
	Criterion 10 Groundwater Hazardous Constituents	 Section 4.1

CDPHE concludes that the specific criteria of Colorado's *Rules and Regulations Pertaining to Radiation Control, Part 18, Appendix A* are met as follows:

CRITERION 1 – SITING:

The Maybell Title II site provides reasonable assurance that the Criterion 1 objective of permanent isolation of the waste materials can be accomplished without ongoing maintenance. Natural conditions that support long-term isolation of the waste materials include remoteness from populated areas, geomorphically stable site, significant depth to groundwater, small upstream catchment area, and absence of nearby rivers or streams.

Consistent with these criteria, the nearest large city is Craig, over 30 miles to the east, with a population of 8,000. The town of Maybell, four miles to the southwest, consists of less than 100 residents. A significant increase in population in the area is not anticipated.

The hydrogeologic and environmental conditions at the site are conducive to containment, immobilization and isolation of contaminants from humans and the environment. The site is in an area that has not been subject to significant erosion or down cutting for over 10,000 years and groundwater is from 200 to 220 feet deep with intervening silty sandstone that geochemically separates the waste materials from the local water table. The upgradient catchment area is less than 40 acres and no major surface water drainages are adjacent to the waste materials. Although there is potential for wind erosion, the cover design has specifically addressed this geomorphic process in order to provide long-term containment of the waste materials. As discussed in Criterion 4, the waste repository and ancillary cell are designed and constructed to withstand erosive forces from extreme precipitation and flooding events and can withstand maximum anticipated vibratory ground motions from an earthquake event.

CDPHE concludes that the disposal site is situated and designed such that the waste materials can be contained for 1,000 years and that no active maintenance is required to maintain repository stability for this period.

CRITERION 2 – WASTE CONSOLIDATION:

Criterion 2 is met because an additional offsite disposal site was not developed for the disposal of Maybell Title II waste materials. The waste materials are being disposed in the same area in which they were originally mined, an area with numerous open pit mines and radioactive overburden piles. In addition, no other disposal facilities are present in the region that could dispose of the waste materials from the Maybell Title II site.

CDPHE concludes that waste disposal at the Maybell Title II will not proliferate the development of small waste disposal sites.

CRITERION 3 – BELOW-GRADE OPTION:

The nature of the site as a heap leach operation made below-grade placement of the leach cells impossible during the processing period. The reclamation design meets the 1,000-year-stability criteria and reduces infiltration through the waste materials. Residual materials from the evaporation ponds were disposed of below grade in an ancillary cell adjacent to the Heap Leach Repository.

CDPHE concludes that below-grade disposal of the entire heap leach repository is not practical and that residual contaminants from the site have been disposed of below grade in the ancillary cell where possible.

CRITERION 4 – DESIGN CRITERIA:

Design criteria used in the preparation of final reclamation plans assure that the design elements set forth in Criterion 4 will be met. The contaminant waste materials will be protected from flooding and erosion by an engineered riprap layer on the repository and ancillary cell covers and appropriately designed drainage channels. The riprap has been designed in accordance with the applicable regulations and with full use of the appropriate guidance documents. Adequate protection is provided by:

1. Selection of proper rainfall and flooding events,
2. Selection of appropriate parameters for determining flood discharges,
3. Computation of flood discharges using appropriate and conservative methods,
4. Computation of appropriate flood levels and flood forces associated with the design event,
5. Use of appropriate methods for determining erosion protection needed to resist the forces produced by the design event,
6. Selection of a rock type for the riprap that is durable and capable of providing erosion protection for the design life, and
7. Placement of a riprap in accordance with accepted engineering practice and in accordance with the quality control procedures.

CDPHE concludes that the cover and drainage channels will not require active maintenance over the 1000-year design life because:

1. The riprap has been designed to protect the waste repository and ancillary cell from rainfall and flooding events which have very low probabilities of occurrence over the design life, resulting in no damage to the layers from those rare events,
2. Rock for the riprap layers is durable and is not expected to deteriorate significantly over the 1000-year design life, and
3. Rock was placed in accordance with accepted engineering practice, meeting the specifications and quality control requirements that minimize the potential for damage, dispersion, and segregation of the rock.

Specific design elements required by Criterion 4 that have been incorporated into the final reclamation plans are as follows:

1. Upstream rainfall catchment areas are minimal, providing a low potential for significant flooding and gully erosion.

2. The site's susceptibility to the forces of the wind was recognized and the cover designed to compensate. Wind protection at the site is effectively mitigated by the rock layer on the six-foot repository cover.

3. Embankment and cover slopes were designed to provide an optimal balance between slope stability and erosion protection. Repository slopes were regraded such that no slopes greater that 5:1 are present on the site.

4. A vegetative cover was not incorporated into the final reclamation plans. As discussed above, a durable rock cover and appropriated drainage channels were incorporated into the final reclamation design. These elements will effectively control long-term erosion at the site.

5. The waste repository has been designed to withstand the maximum vibratory ground monition from a maximum credible earthquake.

6. The top cover contour will enhance deposition to a very limited extent by trapping wind blown materials in the interstices of the rock.

CDPHE concludes that the design elements and constructed covers and drainage channels for the disposal repository and ancillary cell provide appropriate protection against erosion and dispersion by natural forces over the design life such that long-term maintenance is not required.

CRITERION 5 – GROUNDWATER PROTECTION:

Elements discussed in Criterion 5, 7 and 10 have been addressed in the implementation and evaluation of the detection monitoring program conducted at the Maybell Title II site. Detection monitoring for groundwater at the site has been conducted on a continual basis since the construction of the initial wells in 1975. Operational monitoring continued through uranium processing activities (1975 – 1981) and site closure activities (1989 – 1998). Operational monitoring activities ceased in 1998 with the completion of the cover of the Heap Leach Repository. Post-operational monitoring of the groundwater at the site occurred from 1998 through 2005.

Data collected during detection monitoring have been used to satisfactorily characterize geohydrologic conditions at the site and to evaluate potential contaminants in the Browns Park aquifer. During this 30-year monitoring period, there have been no contaminants from the heap leap operations detected in groundwater at the site.

Groundwater at the site was protected by a low-permeability liner beneath the heap leach cells, collection of the leachate liquids by a drain system on top of the liner, and subsequent evaporation of the contaminated liquids. These operational elements assured that no corrective action program was needed at the site.

CDPHE concludes based on the absence of groundwater contamination that groundwater resources at the site have been protected and that Criterion 5 has been met.

CRITERION 6 – EARTHEN COVER:

Requirements set forth in Criterion 6 have been met through appropriate design and construction activities conducted at the site. The repository and ancillary cell covers are designed to limit the release of radon to less than 20 $pCi/m^2/sec$. Thickness of the radon barrier and inclusion of a thick frost protection layer over the low permeability layer effectively control radon emanations for the long-term design life. Quality control sampling and analysis of cover material according to procedures approved by CDPHE assures that the in place materials meet the design specifications.

Measurements after construction of the repository and ancillary cell covers indicates a mean radon flux rate of 0.4 and 0.6 $pCi/m^2/sec$, respectively. Evaluation of long-term erosion rates, summarized in the above assessment of Criterion 4, shows that the covers will be stable for 1,000 years.

Final status surveys show that the Maybell Title II site has met cleanup standards set forth in Criterion 6. These materials were placed in the final repository so that long-term containment of the materials without active maintenance would be assured.

CHPHE concludes that, because radon emanations are controlled for the long term and that site cleanup has been conducted according to the appropriate standards, Criterion 6 has been met.

CRITERION 7 – DETECTION MONITORING PROGRAM:

Detection monitoring at the site has followed the requirements contained in Criterion 7 As described in Criterion 5, groundwater wells were monitored at the site for 30 years. Evaluation of the groundwater data indicates that contaminants from the heap leach facility have not impacted water resources at the site and that a compliance monitoring was not needed.

CDPHE concludes that the detection-monitoring program conducted at the Maybell Title II site meets the requirements contained in Criterion 7.

CRITERION 8 – MILLING OPERATIONS:

Criterion 8 elements were met during operation of the Maybell Heap Leach Facility by the strict adherence to the requirements contained in the site-specific health and safety plan and site procedures, by yearly independent ALARA audits, and by annual

inspections by CDPHE. The health and safety procedures, as formally contained in license conditions and independently audited, provide reasonable assurance those radiation protection standards, including the requirement that exposures to ionizing radiation be kept as low as reasonably achievable, were met during reclamation activities.

CDPHE concludes that the requirements set forth in Criterion 8 were met during site operation and reclamation activities.

CRITERION 9 –TITLE AND CUSTODY:

The Department of Energy (DOE) is preparing title transfer and long-term care documents. Upon termination of the radioactive materials license, the site will be transferred to the U. S. Department of Energy in accordance with the provisions of Title II of the Uranium Mill Tailings Radiation Control Act (UMTRCA) for long-term surveillance.

CDPHE concludes that site closure activities are compatible with the material and site transfer requirements set forth in Criterion 9.

CRITERION 10 – LIST OF HAZARDOUS CONSTITUENTS:

Constituents considered to be reasonably derived from the heap leach materials were identified for the Maybell Title II site. These constituents were monitored for and fully evaluated in the detection-monitoring program established for groundwater at the site.

CDPHE concludes that activities at the Maybell Title II site have not contributed to groundwater contamination and thus meet the requirements of Criterion 10.

CDPHE concludes from its site inspections and document evaluations that Umetco's former Maybell Heap Leach Title II site meets all applicable regulatory standards and requirements. With a determination by NRC, as required in Section 274c(4) of the UMTRCA act that all applicable standards and requirements have been met, CDPHE concurs that Radioactive Materials License 660-01 can be terminated.

II. DOCUMENTATION OF BASES FOR CONCLUSION

1. Description of decommissioning and reclamation activities

The reclaimed Maybell Title II Heap Leach Facility is located in northwestern Colorado approximately 4 miles northeast of the town of Maybell in the W½, Section 24, T7N, R95W, 6th PM, Moffat County, Colorado (Figure 1). The site is located in an historic uranium mining district characterized by large open pit mines and associated overburden piles. Site topography is gently rolling at an elevation of about 6,200 feet above mean sea level.

After the initial discovery, open-pit mining, milling and recovery operations occurred in the Maybell Title II mining district as a part of the federal program for the procurement of uranium from 1957 through 1964. The Maybell Title I facility was operated until 1964 and was subsequently closed in 1996 by the Department of Energy as a part of the UMTRA program.

No significant mining or processing activity occurred in the mining district from 1964 to 1975. Construction of the Maybell Heap Leach Facility was initiated by Union Carbide in 1975. The heap leach facility operated between 1975 and 1982. Heap leach cells were constructed in 1975, 1976, 1977, 1978, 1979, and 1980 on a mine overburden pile built during the excavation of the Rob Pit (Figures 2 and 3).

Approximately 2,000,000 dry tons of subgrade ore (less than 0.05% uranium) were placed on a compacted clay liner in the leach cells with an attendant overdrain system. This subgrade ore was wetted with sulfuric acid to dissolve the uranium minerals. Pregnant leachate was transferred to the processing area where the leachate was either recycled to the heaps for upgrading or processed by ion exchange within the plant. Additional processing resulted in a uranium oxide precipitate that was sent offsite for final purification.

Although the majority of operations ceased in 1982, management of the liquid waste continued by collecting liquids from the cell liners and then evaporating liquids in the ponds on the surface of the heap leach cells. A spray evaporation system was installed in 1988 to enhance the evaporation efficiency. This system operated until 1994, at which time a new lined evaporation pond was constructed to collect and contain the liquid waste.

Major reclamation activities began in 1989 by reshaping the 1975-1976 heaps and the north side of the 1977 heap to a 5H: 1V slope. This work continued through 1990 until all heaps were reshaped and the final configuration of the Heap Leach Repository was completed. In 1991, the sides and a portion of the top of the pile were covered with an interim (6-inch nominal) soil cover except for a 7-acre area on top of the 1977 heap, which was reserved for the spray evaporation system.

Reclamation activities in 1994 included the construction of a New Evaporation Pond and the heap toe drain system as well as an extension of the original underdrain system and discharge piping into the New Evaporation Pond.

The area surrounding the Maybell Title II Heap Leach Facility was characterized using a combination of scans for gamma radiation and analysis of surficial (0-15 cm) and

subsurface (>15 cm) soils (Umetco 1990, 1991, and 1995f). Cleanup activities followed the requirements set forth in the *Soils Cleanup Plan, Maybell Heap Leach Facility*, approved by CDPHE in 1994. Soil clean up took place in 1995 when approximately 70,000 yd^3 were excavated and placed in the heap leach cells. Debris and scrap from the process plant were placed, sized and disposed in the Heap Leach Repository. The radon barrier cover material was completed on the top repository and an interim frost protection (Random Fill) layer was placed over it to protect the material in 1995. In 1996, the radon barrier was completed on the repository sideslopes. After completion of the radon barrier, a random fill layer was placed during the 1996 and 1997 construction seasons. In 1997, placement of Type A, B, C, and D erosion protection materials was initiated. The placement of erosion protection materials was completed during 1998 on the cover and on drainage Channel No. 1 (Figures 4 and 5).

All construction activities were conducted in accordance with a State-approved quality assurance and quality control plan for construction activities. Post-closure groundwater monitoring of the Maybell Title II Heap Leach Facility was initiated in 1998, after completion of construction activities, and formally approved by CDPHE in 2001.

The NRC inspected the completed reclamation activities in May 2001 during a field review of the Maybell Title II site. The NRC found that reclamation work had been performed properly and recommended that an energy dissipating structure (launch rock) be constructed at the outfall of Channel No. 1. This launch pad was constructed during the 2005 construction season. The NRC made no other recommendations.

No reclamation construction activities took place from 1998 until 2000 when the heap leach drains were sealed with approval and oversight of CDPHE after cessation of heap drainage. The ponded liquids from the heap leach were evaporated in the New Evaporation Pond until the 2005 construction season.

The New Evaporation Pond and the Winter Storage Pond were reclaimed in 2005. Liners in both ponds were shredded and remaining debris was sized and placed in the Winter Storage Pond that was covered in accordance with the Maybell quality plan QP-MAY-1.

A monitoring and inspection procedure was developed and implemented for the Maybell Title II site after repository closure in 1998. This procedure included the routine assessment of repository integrity, evaporation pond capacity, and general site conditions. Umetco and independent CDPHE inspections confirm the stability of the Heap Leach Repository and associated drainage channels. Recent measurements of the settlement monuments on the heap repository confirm that steady state conditions have been reached and that measurable settlement of the repository is not occurring.

When all regulatory requirements are completed, the Maybell Title II site will be transferred to the U. S. Department of Energy (DOE) for long-term surveillance. The site reclamation fund and long-term care fund will be terminated at the time of license termination, with the long-term-care fund being transferred to the federal government.

Three design change orders were initiated by Umetco that were not included in the reclamation plan documents which involved the following design items:

On May 13, 1996, approval was obtained to dispose of a concrete slab contaminated with Title I material to an excavation in the Northeast corner of the heap. The slab was

reduced to rubble having a maximum volume of one cubic foot. The rubble was placed in such a manner to minimize voids and prevent stacking. Heap material was placed over and in the voids in lifts not exceeding 2 feet in thickness and compacted to 90% of the Standard Proctor maximum dry density (ASTM D698).

On May 15, 1996, approval was obtained to relocate soils believed contaminated with hydrocarbons to the Heap Leach Repository. The soils were relocated and compacted to 90% of the Standard Proctor maximum dry density (ASTM D698).

On August 30, 2004, approval was obtained to provide final design modifications for the in-place reclamation of the evaporation ponds and stabilization of the Rob Pit ramp with launch rock. A grading and drainage plan design summary was included to support the design modifications.

2. Documentation that the completed surface remedial actions was performed in accordance with applicable standards and requirements.

2.1. Geotechnical Stability

2.1.1. Introduction

This section presents the results of geotechnical engineering tests and studies related to the closure of Umetco's Title II Maybell site. The geotechnical engineering aspects include: (1) information related to the disposal and borrow sites; (2) construction and heap leach materials; and (3) design and construction details related to the disposal site, disposal repository and cell.

The closure actions consisted of the consolidation of contaminated materials and equipment from the site to the Heap Leach Repository from 1991 to 1996 and the consolidation of the ponded evaporates and residual contaminated debris to the Ancillary Cell in 2005.

The Heap Leach Repository is an above-grade, stabilized-in-place embankment extending to a maximum height of 75 feet above the prevailing surface grade. The Heap Leach Repository is composed of the heap leach material, which was placed on top of a 12-inch clay liner that was constructed on top of mine spoils. The repository was recontoured to a maximum 5:1 slope and covered with a minimum of 6.5 feet of cover including radon barrier clay, random fill and rip rap materials.

The Ancillary Cell was an existing heap drainage storage pond that was constructed below grade and adjacent to the Heap Leach Repository. Synthetic pond liner and contaminated debris remaining on the site was compacted in this cell. The Ancillary Cell was covered with a minimum of 5.5 feet of cover, including radon barrier clay, random fill and erosion protection material.

The information for this section of the report was obtained from the following documents with supporting information from other sources noted in the text: *Site Characterization Report* (Chen, 1988), *Conceptual Design Report* (Chen, 1987), *Final Plans and Specifications for Closure Activities* (Umetco, 1995a), *Quality Plan and Construction Verification Program for Reclamation Activities* (Umetco, 1995b), *Soil Cleanup Plan* (Umetco, 1995c) and the *Maybell Heap Leach Facility Final Grading and Drainage Plan* (Umetco, 2004).

2.1.2. Site Description

The 180-acre site at an elevation of about 6200 feet is approximately 2 miles north of the Yampa River and 4 miles northeast of the town of Maybell, Colorado (Figure 1). The site is located on the Browns Park Formation that directly overlies the Mancos Shale. The uranium heap leach piles, which were from 35 to 50 feet in height, were reshaped into a 60-acre repository containing approximately 2 million tons of low-grade ore. The total Radium-226 activity of the heap is approximately 96 curies.

An 8-acre former processing site was directly adjacent to the leach cells and consisted of a process plant and evaporation ponds. Contaminated soils and demolition debris from the process plant were buried within the Heap Leach Repository between two of the former heap leach cells. Contaminated evaporates from the evaporation ponds and all remaining debris were isolated into the Ancillary Cell adjacent to the repository.

The piles were covered with engineered earthen radon barriers to reduce the radon flux to less than 20 pCi/m^2s and to decrease the infiltration of precipitation into the interior of the piles. Frost protection materials and erosion protection materials were in turn placed atop the radon barrier material.

2.1.3. Repository Area

Several subsurface investigations have been completed at the Maybell Title II site to characterize the site, heap materials and borrow materials. Results of these investigations are discussed in section 2.1.6.

Dames and Moore in 1975 reported details of the field and laboratory analyses of six test pits and one well completed and logged in the vicinity of the heap area. Two test pits and the well were completed in the material that the mine spoils lie upon. The remaining test pits were completed in the spoil material that would become the pad for the heap leach cells. The laboratory program consisted of permeability, compaction, grain size, direct shear test, and petrographic and mineralogical identification. The Dames and Moore (1975) report includes logs of the test pits and well and the laboratory results.

In October of 1993, Umetco conducted a geotechnical investigation on the reshaped heaps to acquire accurate geotechnical data for the heap material. The investigation consisted of drilling four boreholes with a hollow stem auger to a point of refusal at the compacted clay liner. Drawing M-001-94 of the May 1994 *Liquid Waste Management Plan* Report contains the locations of the boreholes. The *Liquid Waste Management Plan* contains the borehole logs and the geotechnical results from this investigation.

2.1.4. Borrow Areas

Geotechnical investigations for the borrow areas included the collection of representative samples and conducting appropriate field and laboratory analyses. The investigations evaluated the Rob Pit over burden stockpile, the banks of the Yampa River and the Yampa River Alluvial Fan south of U.S. Highway 40. Results of these investigations are discussed in section 2.1.6.

The Dames and Moore (May, 1975) report details the findings from ten test pits excavated in the alluvial clay borrow area. The locations of the test pits are detailed on Plate 3 of that report.

Chen and Associates (1987) collected five samples of borrow materials for laboratory analysis. They included samples of the Yampa Alluvium clay, Rob Pit overburden, and 1978 and 1980 heap materials.

Additional clay borrow investigations were conducted by Umetco in the Alluvial Fan (Umetco, 1989) south of Highway 40 in a bend on the Yampa river and at the borrow area south of the river on the Steele property near the town of Maybell (Umetco, 1995a).

2.1.5. Geotechnical Investigation Program

The geotechnical evaluations discussed above indicate that investigations conducted at the Maybell Title II site and borrow areas adequately define geotechnical conditions in the area and support the assessment of geotechnical stability of the heap leach materials and disposal repository. Results of these discussions are discussed in section 2.1.6.

2.1.6. Testing Program

The geotechnical engineering characteristics and strength parameters for the heap leach cells, contaminated soils and natural soils have been determined by Umetco through field and laboratory analysis of samples and from field investigations. Table 2.1.5-1 and 2.1.5-2 provide specific material properties from these investigations. These investigations were conducted to determine suitability of the materials for use in heap leach reclamation activities. This section also addresses where these materials were used and construction quality control to verify proper placement of the materials. Table 2.1.5-3 and 2.1.5-4 provide the quality control test results for construction of the repository and cell covers. The geotechnical engineering characteristics and quality specifications for these materials met guidance criteria.

Borrow Materials

The Dames and Moore (1975) sampling plan included a laboratory program for analysis of permeability, compaction, grain size, direct shear and petrographic and mineralogical identification. Ten test pits were investigated in the Yampa Alluvial clay which was used to construct the liner on top of the mine spoils pad for the heap leach.

The August, 1987, Chen and Associates analysis of borrow materials included gradation characteristics, moisture-density relationships, specific gravity, Atterberg Limits, triaxial cohesion, direct shear cohesion, hydraulic conductivity, radium, radon emanation coefficient and radon diffusion. Some of the Yampa Alluvial clay identified in this report was placed as the final cover in the 1995 construction year. This report also evaluated the Rob Pit Overburden, which was used to construct the frost protection layer of the cover on the Heap Leach Repository and Ancillary Cell.

Chen and Associates analyzed samples from five test pits at this location in 1989 for the same parameters as the 1987 samples. This material was used to complete the clay radon barrier on the Heap Leach Repository and Ancillary Cell. Atterberg Limits, Standard Proctors, gradations and field density tests were conducted during placement of these materials.

In 1995 Umetco collected samples from the Rob Pit Overburden and Clay borrow areas for analysis. These samples were analyzed for radium, radon emanation coefficient and radon diffusion by Rogers and Associates

Cover materials were evaluated for durability testing, including LA abrasion, specific gravity, absorption, tensile strength, Schmidt hammer and sulfate soundness. Results of these tests are shown on Table 2.2-4.

All materials were compacted to 90 percent of the Standard Proctor maximum dry density as determined by ASTM D-698 except for the Radon Barrier materials that were compacted to 95 percent. The clay liner for the heap leach constructed in 1975 was compacted to 90 percent of the Standard Proctor maximum dry density as determined by AASHTO T-180.

Radiological tests were also conducted on the borrow materials. Testing results included determining radon emanation coefficients, radium concentrations and radon diffusion coefficients. These parameters are shown on Table 2.1.5-2 for the random fill, radon barrier clay and heap materials.

Heap Leach Cells

Dames and Moore (1975) analyzed two test pits in the underlying soils beside the spoils pad and four in the spoils themselves for the same parameters as the borrow materials.

The Umetco (1993) geotechnical investigation of the reshaped heaps consisted of drilling four boreholes with a hollow stem auger. The boreholes were advanced using continuous split spoon samplers to obtain samples for determination of existing moisture content, gradations, unit weight and capillary moisture content.

Contaminated Materials

In 1987 Umetco collected samples from the 1977 and 1979 heaps for analysis. Rogers and Associates analyzed these samples for radium and radon emanation coefficient.

From 1995 through 1997, Umetco placed and compacted the off site and process area contaminated materials into the heap. All material was placed in lifts not exceeding 2 feet and compacted to 90 percent of the Standard Proctor maximum dry density as determined by ASTM D698.

In 1995 Umetco collected samples from each of the heaps for analysis. These samples were analyzed for radium, radon emanation coefficient and radon diffusion by Rogers and Associates.

On the basis of the field exploration and laboratory testing programs, the borrow sites contained suitable quantities of materials of sufficient quality for use in construction of the radon barrier, random fill and erosion protection layers for the covers. In addition, the riprap material meets durability requirements for frequently wetted areas (drainage channels).

Based on the review, CDPHE concludes that the number and type of tests conducted in the testing program were appropriate for the support of the engineering analyses performed and that the scope of the testing program and the utilization of the test results to define the material properties are in general agreement with applicable regulatory guidance.

Table 2.1.5-1
Maybell Soil Properties for Soil Cover Design

Material and Source	Source of Data	Standard Proctor ASTM D698		Specific Gravity	Atterberg Limits ASTM D4318		Gradation ASTM D421 & D2217			Hydraulic Conductivity ASTM D5084	
		Optimum Moisture %	Max. Dry Density		LL	PI	% Gravel	% Sand	% Silt/Clay	Coefficient k, (cm/sec)	Molded Density %
Radon Barrier Clay	1, 3, 4	14.3	113.8	2.70	31.8	14.2	0	28.5	71.5	7.25×10^{-8}	93.5
Maybell Clay	1	14.6	112.9	2.72			0	33	67	6.9×10^{-7}	92
Heap Material	2			2.66			0	81.5	18.5		

Sources of data:
1 Chen, Conceptual Design Report of Uranium Ore Heap Leach Facility, 1987.
2 Chen, Site Characterization Report for Uranium Ore Heap Leach Facility, 1988.
3 Chen, Laboratory Testing on Submitted Soil and Rock Samples from Maybell, Colorado and White Mesa Mill, Utah, (Letter) 1987.
4 Western Engineers, Maybell Reclamation Project; Clayey Material Borrow Area, (Letter) 1989.

Table 2.1.5-2
Measured Radiological Soil Properties

Material	Radon Emanation Coefficient	Radium (pCi/g)	Radon Diffusion Coefficient (cm^2/s)
Random Fill	0.11 ± 0.01	3.06 ± 0.37	2.13E-02
Radon Barrier Clay	0.19 ± 0.02	2.32 ± 0.3	1.37E-02
Heap Material	0.27 ± 0.01	53 ± 0.4	1.72E-02
Winter Storage Pond Material	0.27	27.13	1.72E-02

Sources of data:
1: Umetco, 1995a, Final Plans and Specifications
2: Umetco, 2004c, Design Change Order, Final Reclamation Plan for the Maybell Heap Leach Facility.

Table 2.1.5-3
Results of Quality Control Tests for Heap Leach Repository Cover Construction

Material	Standard Proctor ASTM D698			Nuclear Density Gauge Test ASTM D2922 & D3017			Atterberg Limits ASTM D4318	
	Number of Tests	Average Max. Dry Density	Average Optimum Moisture	Number of Tests	Average Reported Dry Density	Average Reported Percent Moisture	Number of Tests	Average PI
Radon Barrier Clay	45	113.7	14.7	602	109.6	16.4	198	13.4
Random Fill	97	115.4	13.8	1349	111.6	13.7	234	NP
Contaminated Material	75	112.5	14.5	539	105.3	12.2	NA	NA

Sources of data: 1 F-13 and F14 Forms; Proctors
2 F-15 Forms; Nuclear Compaction Test Data
3 F-7, F-8 and F-9 Forms; Atterberg Limits

Notes: NP (Non Plastic)
NA (Not Analyzed)
Failed field tests resulted in recompaction of the area and retesting.

Table 2.1.5-4
Results of Quality Control Tests for Ancillary Cell Cover Construction

Material	Standard Proctor ASTM D698			Nuclear Density Gauge Test ASTM D2922 & D3017			Atterberg Limits ASTM D4318	
	Number of Tests	Average Max. Dry Density	Average Optimum Moisture	Number of Tests	Average Reported Dry Density	Average Reported Percent Moisture	Number of Tests	Average PI
Clay Radon Barrier	5	118	13	10	115.2	13.1	6	13
Frost Protection	6	113	13	29	109.1	12.1	6	2
Contaminated Material*	NT	NT	NT	NT	NT	NT	NT	NT

Sources: 1 F-13 and F14 Forms; Proctors
2 F-15 Forms; Nuclear Compaction Test Data
3 F-7, F-8 and F-9 Forms; Atterberg Limits
Failed field tests resulted in recompaction of the area and retesting

Notes: NT Not Testable
* Pond residues were solidified with a 1.25:1 to 1.5:1 stabilization mixture of limestone crusher fines to soil residue, to form a cemented solidified mass.

2.1.7. Slope Stability

Slope stability of the reclaimed heap was analyzed using the UTEXAS2 (University of Texas Analysis of Slopes – Version 2) computer program. This program allows the use of several methods of analysis including input of seismic coefficients for use in pseudo-static slope stability computations. Spencer's procedure of slices for computing factor of safety was selected for this analysis.

Geotechnical stability of the slopes of the Heap Leach Repository is presented in this section. The exploration data, test results, slope characteristics, and methods of analyses pertinent to the slope stability aspects of the reclamation plan are appropriate for the analysis of the slope stability. The analyzed cross-section and the characteristics of the slopes have been satisfactorily represented and that the most critical slope section has been considered for stability analyses.

Soil parameters for the various materials used in the slope stability analysis have been established by appropriate testing of representative materials (Table 2.1.7-1). Soil parameter values have been assigned to layers on the basis of data obtained from geotechnical explorations at the site. Determination of these parameters for slope stability evaluation follows conventional geotechnical engineering practice. An appropriate method of stability analysis (Spenser's method) has been employed to address the likely extreme adverse conditions to which the slope might be subjected for the static case.

The slope stability analysis was performed for the maximum slope elevation located on the southern side of the reshaped heap. Input parameters for the analysis were developed for laboratory testing as reported in Appendix A of the Site Characterization Report (Chen, 1988), and the CDPHE approved Liquid Waste Management Plan (Umetco, 1994). Table 2.1.7-1 summarizes material types and strength parameters input for stability analyses. To provide a conservative analysis, the cohesive strengths of random fill soils were neglected and a phreatic surface was assumed to exist above the clay liner. This conservative phreatic surface disappeared as the heap leach materials were dewatered after cover construction.

The seismicity evaluation is presented in section 2.1.9. The maximum peak horizontal ground acceleration is estimated at 0.3 g with a corresponding pseudo-static coefficient of 0.20. The stability analysis performed for the reclaimed heap utilizes a conservative seismic coefficient of 0.25 for the analysis under pseudo-static conditions. This value is approximately the same as the peak horizontal acceleration of 0.27 used at the adjacent DOE Title I facility (DOE, 1994).

The unsaturated sand and sandstone of the heaps and foundation of the heaps are not susceptible to liquefaction under earthquake conditions and do not require dynamic analysis in regard to this structure.

NRC 3.11 Regulatory Guide, Table 3.2, establishes NRC requirements for minimum factor of safety. The resulting factors of safety of the slope stability analysis are shown in Table 2.1.7-2. The minimum factors of safety resulting from this slope stability analysis exceed established NRC minimum requirements.

Table 2.1.7-1

Slope Stability Input parameters

Material	Unit Weight (PCF)	Cohesion (PSF)	Internal Angle of Friction (Degrees)
Foundation	118.0	230	33.8
Mine Spoil	115.5	0	33.8
Clay Liner	118.0	[3]1100	0
Heap Material	[4]115.5	0	33.8
Clay Soil Layer (Cover)	[2]118.0	[3]1100	0
Random Fill (Cover)	[1]118.0	0	33.8

Note: Cohesive Strength of random fill, heap materials and mine spoil were neglected. Actual cohesive strength for these materials is 230 psf.

(1) Unit weight computation based on 95% maximum density (D698) at 6% moisture.
(2) Unit weight computation based on 95% maximum density (D698) at 9% moisture.
(3) Undrained triaxial cohesion.
(4) Measured in-place unit weight at long-term moisture content of 10%.

Table 2.1.7-2

Stability Analysis

Condition	Calculated Factor of Safety	NRC Minimum Factor of Safety
Static	3.41	1.5
Pseudostatic (seismic) Coeff. = 0.25)	1.48	1.0

Based on review of these analyses and the results, CDPHE concludes that the slopes of the Heap Leach Repository are designed to endure the effects of the geologic processes and events, including earthquake and settlement, to which they may reasonably be subjected during the design life and that the analyses have been made in a manner consistent with the regulations.

2.1.8. Credible Faults

The Maybell Title II site lies within the Uinta-Elkhead Seismotectonic Province. Several faults within the region have been identified as potentially active by the Colorado Geological Survey (Kirkham and Rogers, 1981), the U. S. Geological Survey (Witkind, 1975, 1976) and Fugro (Anderson, 1979). Most show no evidence of Quaternary movement.

The DOE (1996) in their assessment of the Title I site collected geomorphic evidence to determine the age of the last fault movement in the Maybell site region and to estimate the minimum time since displacement. They found that the last movements occurred prior to the Late Pleistocene and that all known fault groups within 40 miles of the site are noncapable. However, Fault 3 (Kirkham and Rodgers, 1981) located 10 km (6.3 miles) from the site was assumed to be active and was used in the conservative analysis of earthquake motion at the Maybell Title II site.

2.1.9. Seismic Evaluation

According to Appendix A, the disposal repository may not be located near a capable fault that could cause a maximum credible earthquake (MCE) larger than that which the repository could reasonable be expected to withstand. The term "maximum credible earthquake" means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering regional and local geology, seismology and specific subsurface characteristics. Evaluation of the MCE considered the historical earthquake record, the regional tectonic setting and the presence of potentially active faults in the vicinity.

In addition to the historical review, the MCE for the Uinta-Elkhead Seismotectonic Province is a Richter magnitude of 6.5 event estimated by Kirkham and Rogers (1981). This event at its closest approach to the site on Fault 3 described by Kirkham and Rogers (1981) was attenuated to the Maybell Heap Leach site according to the relationships established by Campbell (1981). Maximum peak horizontal ground acceleration is estimated to be 0.30 g from the MCE at a distance of 8 miles. The NRC in the *Final Standard Review Plan* dated October 1992, indicated that two-thirds of the peak acceleration should be used to define the seismic coefficient used in the pseudostatic analysis. The calculated seismic coefficient is 0.20; however, a 0.25 pseudostatic coefficient has been conservatively used in the analysis of the heap leach pile stability.

CDPHE concludes that the design event used to evaluate repository stability is conservative and can be used to assess potential ground motion effects on repository stability.

2.1.10. Settlement and Cover Cracking

The waste material consists of cohesionless to low-cohesion, silty sand. The materials were placed by dumping and spreading at relatively low moisture contents as opposed to being placed as very high moisture slurry such as tailings. Other than transportation, placement and extraction, a physical process did not treat the ore. Hauling and spreading equipment applied some degree of compaction during the initial placement. Consolidation of the waste material has occurred from self-weight loading over a 14-year period. Flooding of the heaps during the leaching process as well as annual infiltration of

snowmelt has contributed to the settlement of the heaps. Additional consolidation of the heaps resulted through surcharge loading of the heaps during the reshaping operation. The reshaping involved reduction of the original slopes to a 5:1 (H: V) gradient. Excavated material from the reshaping was placed and compacted on top of the heap.

Cover materials were placed and compacted to assure that settlement of the cover materials was negligible. Post-construction settlement of the heap materials and cover will not cause significant deformation of the top surface, perimeter slopes, or channels because of the preconsolidation of the heap materials, the natural properties of these materials and the construction methods used during regrading and cover placement. Recent measurements of the settlement monuments confirm that steady state conditions have been reached and that measurable settlement of the Heap Leach Repository is not observable as measurements are within the variability of the survey instrumentation (≈ 3 mm).

Observations on the placement and compaction of the approximately 10 feet of limestone neutralized materials in the Ancillary Cell indicate that future differential settlement that could adversely affect the integrity of the cover will not occur. The neutralized waste materials were placed and solidified in nominal one-foot lifts to form a concrete like structural mass. Differential settlement of the cell cannot occur because of the homogenous compact nature of the solidified waste.

CDPHE concludes that the settlement-monitoring program is sufficient to satisfy applicable portions of Appendix A regarding reclamation design to control radiological hazards for the design life without active maintenance after reclamation is complete.

2.1.11. Liquefaction Potential

The liquefaction potential was evaluated with respect to the foundation and heap materials. The foundation varies from silty sands to weakly cemented sandstone. Heap materials are also composed of silty sands. At the time of construction these materials were in a partially saturated condition with low to moderate amounts of moisture that decreased over time.

For liquefaction to occur, several site and soil conditions must be satisfied, such as the presence of loose cohesionless soils in a saturated condition, presence of groundwater and level of seismic event. These conditions do not exist at the Maybell site.

As described in section 2.2.10, consolidation of the granular waste material has occurred from self-weight loading over the 14-year period before cover placement and for an additional 10 years since. In October of 1993, a geotechnical investigation was conducted on the reshaped heap to identify the quantity of free liquids stored in the heap and to acquire accurate geotechnical data to establish input parameters for modeling of liquid movement in the heap. The geotechnical investigation, described in the *Liquid Waste Management Plan* (1994), indicates no significant volume of saturated material existing within the heap. Furthermore, the saturated hydraulic conductivity of the radon barrier will be in the range of 10^{-7} cm/sec satisfying the NRC criteria for groundwater compliance. With the radon barrier in place there is no influx from precipitation and the heap material will remain unsaturated for the design life of the embankment. Therefore

the unsaturated sand and sandstone of the heaps and foundation of the heaps are not susceptible to liquefaction.

Based on a review of documents, CDPHE concludes that there is adequate assurance that liquefaction will not adversely affect pile stability or long-term containment of the waste.

2.1.12. Cover Design

The Heap Leach Repository cover provides a minimum of 6 feet of protection on the top and sides of the repository. The cover has been designed to limit the infiltration of precipitation, protect the pile from erosion and the control the release of radon to the atmosphere.

Umetco used five different embankment cover sections dependant upon location on the repository. Separation of fine and coarse-grained materials did not occur during processing activities and no separate cover profiles were developed or used at the site.

(1) The typical cover section for the top consists of:

18 inches of compacted clayey soil (radon barrier layer)

48 inches of random fill (frost protection layer)

6 inches minimum of Type A Rock (erosion protection layer)

(2) The typical cover section for the embankment consists of:

18 inches of compacted clayey soil (radon barrier layer)

48 inches of random fill (frost protection layer)

6 inches minimum of Type A Rock (erosion protection layer)

12 inches minimum of Type B riprap (erosion protection layer)

(3) The cover section for areas where the clay liner was exposed to regraded slope of heap consisted of:

18 inches of compacted clayey soil (radon barrier layer)

42 inches of random fill (frost protection layer)

6 inches minimum of Type A Rock (erosion protection layer)

12 inches minimum of Type B riprap (erosion protection layer)

(4) The cover section for areas where the clay liner terminated below the graded surface consisted of:

18 inches of compacted clayey soil (radon barrier layer)

42 inches of random fill (frost protection layer)

6 inches minimum of Type A Rock (erosion protection layer)

12 inches minimum of Type B riprap (erosion protection layer)

(5) The cover section for the below-grade Ancillary Cell consisted of:

12 inches of compacted clayey soil (radon barrier layer)

48 inches of random fill (frost protection layer)

6 inches minimum of Type A Rock (erosion protection layer)

Laboratory tests show that the average hydraulic conductivity of the radon barrier materials was 7.25×10^{-8}. However the hydraulic conductivity used for the radon barrier calculations was 1.2×10^{-7} cm/sec from the 1987 Chen report and is conservative. The design of the reclaimed heaps incorporates features that effectively remove surface water resulting from precipitation, which combined, with regionally low annual precipitation and the low hydraulic conductivity of the cover clay prevents significant infiltration into the heap materials. Cessation of flow in the heap drainage system confirms that the radon barrier is effective in minimizing deep infiltration into the repository.

This cover design is comparable to the DOE's cover design for the Maybell Title I facility. There the DOE used 6 feet of cover materials that consisted of 1.5 feet of Radon barrier that exhibited an infiltration rate of 1.0×10^{-7}, 4 feet of frost protection, and 6 inches of bedding material and 8 inches of rock for erosion protection. The DOE used the same materials as Umetco with the exception of the radon barrier material. Umetco utilized the Yampa river alluvial clay that exhibited an average infiltration rate superior to the DOE's amended overburden radon barrier material.

An analysis of frost penetration into the reclamation cover was performed using the *Digital Solution of Modified Buggren Equation to Calculate Depths of Freeze Thaw in Multi-layered Systems* computer program developed by the U. S. Army Cold Regions Research and Engineering Laboratory. Values for heat capacity, thermal conductivity and latent heat of fusion were generated by the program based upon density and moisture content input values.

Soil density values used in the model are minimum specified values based on laboratory testing of the borrow area material (Chen, 1987). To be conservative in the analysis, a water content of six percent was assumed for the random fill layer of the reclamation cover. An n-factor of 0.7 was input as recommended by the United States Department of Energy (DOE) for graded top slopes and cobble and gravel side slopes (DOE, 1989).

The resulting total frost penetration determined is 51.7 inches. Since the cover provides a minimum of 54 inches over the top of the radon barrier, frost penetration will cause no adverse effect to the radon barrier.

CDPHE has evaluated the cover design with regard to geotechnical stability and long-term control of the waste materials and concludes that the design is acceptable.

2.1.13. Subsidence

The Maybell Heap Leach Repository and associated Ancillary Cell are located on about 1000 feet of silty sands of the Tertiary Browns Park Formation. This formation is fully consolidated, shows no signs of recent subsidence, and has not been subject to underground mining or appreciable amounts of groundwater withdrawal. The Maybell

Title II site has not been subject to significant subsidence effects for over 10,000 years and it is likely that it will not be subject to subsidence in the next 1,000 years.

CDPHE concludes that ground subsidence will not adversely impact the repository during the design life.

2.1.14. Construction Methods and Features

CDPHE reviewed the detailed final reclamation plan and associated specifications, including text, tables, and design drawings submitted by Umetco for the Maybell Title II site. The reclamation plan presents the investigations and testing which formed the basis of the reclamation design and associated specifications. Additionally, the plan describes the design concept in detail. The text is supported by tables that summarize design parameters and figures that clearly show plans, profiles, and details of the proposed remedial action.

In summary, the side slopes were re-contoured to a maximum slope of 5:1. Mill debris has been buried systematically in the repository. A permanent layered cover provides protection from excessive radon emanation, and permits rainfall to drain away satisfactorily.

CDPHE reviewed and evaluated the geotechnical construction criteria provided in the reclamation plan. Based on this review, CDPHE concludes that the plans and drawings clearly convey the proposed closure action design features. In addition, the excavation and placement methods and specifications are consistent with standard engineering practice and appropriate guidance documents.

2.1.15. Testing and Inspection

CDPHE reviewed drawings and technical specifications submitted by Umetco regarding final reclamation of the Heap Leach Repository and Ancillary Cell. The technical specifications discuss testing methods and quality control procedures applicable to the remedial work. Appropriate reference is made to standard methods that governed the placement and testing of soil and rock materials.

CDPHE's review of the plan has found that the quality control program for testing and inspection demonstrates that the requirements of Umetco's Radioactive Materials License 660-01 and Colorado's *Rules and Regulations Pertaining to Radiation Control* have been met.

2.1.16. Conclusion

Based on the evaluation of the geotechnical engineering aspects of the design of the closure action as presented in the final reclamation plan and review of compliance reports CR-MAY-3.1, CR-MAY-4.1, CR-MAY-4.2, CR-MAY-4.3, CR-MAY-5.1, CR-MAY-6.1, CR-MAY-6.2, CR-MAY-8.0, CR-MAY-9.3, CR-MAY-9.4, and CR-MAY-9.5 generated from the work performed during construction in accordance with the Maybell Quality Plan, CDPHE concludes that the embankment and borrow soils have been adequately characterized. Furthermore, the cover system is adequately designed to resist the effects of freezing conditions that can reasonably be expected. In addition, the slopes of the Heap Leach Repository are designed to endure the effects of the geologic processes and events, including resistance to earthquake and settlement, to which they may

reasonably be subjected during the design life and that the analyses have been made in a manner consistent with the guidance documents. CDPHE concludes that there is adequate assurance of safety with respect to liquefaction potential. In conclusion, the CDPHE review of geotechnical stability has found the Maybell Title II site to be in conformance with regulatory requirements of criterion 1-4, and 6 of Part 18, Appendix A, of Colorado's Regulations Pertaining to Radiation and Control.

2.2. Surface Water Hydrology and Erosion Protection

The regional area is drained by the Yampa River located 2 miles to the south of the Maybell Title II site. Lay Creek, a tributary to the Yampa River, parallels US Highway 40 about 2 miles to the southeast of the Maybell Heap Leach Repository (Figure 1). Several unnamed intermittent and ephemeral tributaries to the Yampa originate in the proximity of the repositories. The drainage patterns in the region are rectangular to dendritic and flow in a general southwesterly direction (Chen and Associates, 1987).

The Heap Leach Repository is situated in a relatively small watershed, about 40 acres. The catchment area from the top of the Heap Leach Repository towards Channel No. 1, the central channel located across the top and down the east slope of the repository, is approximately 40 acres (Figure 4). The remainder of the watershed including the slopes of the main pile sheet flow to natural drainage paths. The Ancillary Cell is protected from erosion by channel No.2 which drains approximately 30 acres.

Slopes of the repository top (1%), repository sides (20%), the Ancillary Cell (1.5%), and diversion channels (0.5% to 20%) are within limits discussed in NRC regulatory guidance documents. Erosion protection studies were performed on these features and adequately sized riprap was used to ensure stabilization for up to one thousand years to the extent reasonably achievable and for at least two hundred years. The remaining portions of the site were graded to gentle slopes and re-vegetated. Although considered, sediment deposition to increase cover thickness was evaluated and found to be not feasible given the geologic setting of the heap leach cells.

The information for this section of the report was obtained from the following documents with supporting information from other sources noted in the text: the Site Characterization Report (Chen, 1988), *Final Plans and Specifications for Closure Activities* (Umetco, 1995a), *Quality Plan and Construction Verification Program for Reclamation Activities* (Umetco, 1995b), *Maybell Heap Leach Facility Final Grading and Drainage Plan* (Umetco, 2004), the DOE's *Final Completion Report from the Maybell Title I facility* (DOE, 1998), NRC's *Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites* (NRC,1990), NUREG/CR-4620 *Methodologies for Evaluating Long-Term Stabilization of Uranium Mill Tailings Impoundments* (NRC,1986), NUREG/CR-1623 *Design of Erosion Protection for Long-Term Stabilization* (NRC,1999) and NUREG/CR-4480 *Erosion Protection of Uranium Tailing Impoundments* (NRC,1986).

2.2.1. Flood Flow and Surface Water Diversion

Erosion control features and repository stability were designed to withstand the effects of a probable maximum precipitation (PMP) event, which is the major long-term risk to the stability of the site. The PMP event was used to design the erosion protection layer of the

multi-layer cover and to design the permanent, long-term diversion channels. A Probable Maximum Flood (PMF) generated from the occurrence of a PMP was the critical case used in designing the reclamation cover.

The PMP event was determined using local-storm PMP calculation procedures for the Colorado River, Great Basin and California Drainages and general-storm PMP calculation procedures for the Colorado River and Great Basin contained in the Hydrometeorological Report No. 49 (NOAA, 1977). The PMP was found to be a one-hour localized event (thunderstorm) that produces 7.05 inches. The high rainfall intensity associated with the local storm results in a much higher peak flow than the general PMP storm which results in higher total runoff volume but much lower peak flows.

The PMP and PMF calculations are presented in the *Reclamation Plan, Final Design, Plans and Specification, the Maybell Heap Leach Facility,* (Umetco, 1995a). The PMF calculations for Channel No. 2 and Ancillary Cell are prescribed in *Maybell Heap Leach Facility, Final Grading and Drainage Plan,* (Umetco, 2004a).

The Peak Flow Rate was conservatively determined using the Rational Method where the runoff coefficient used in the formula was assumed to be 1, which assumes that no infiltration will occur as recommended in NUREG/CR-4620 (NRC, 1986a). The time of concentration was calculated using either the Soil Conservation Service Triangular Hydrograph Theory for the Heap Leach Repository and the Kirpich Method for the Ancillary Cell. The flow concentration factor was assumed to be 3 (conservative) for the Heap Leach Repository and Channel No. 1 and for the Ancillary Cell and Channel No. 2 as recommended in NUREG/CR-4620. The Peak Flow Rates are summarized in Table 2.2-1.

Table 2.2-1

Peak Flow Rates

Drainage Area	**Peak Flow Rates, cubic feet per second (cfs)**
Main Repository Top	1.30 cfs/ft
Main Repository 5H: 1V Side Slopes	2.19 cfs/ft (maximum)
Channel No. 1	625.61
Ancillary Cell Top	0.38 cfs/ft
Channel No. 2	578.60

In order to reduce the quantity of overland flow along the perimeter slopes and attendant erosion potential, the repository configuration was designed to convey surface sheet flow from the top of the repository toward Channel No. 1. Channel flows drain directly into the Rob Pit.

The NRC recommended that a launch pad be constructed in the outfall area of Channel No. 1. This launch pad was constructed in 2005.

The channel was sized using the guidance and equations presented in NUREG/CR-4620, specifically the Haestad computer model and Manning's Equation. The input parameters and computed results for Channel No. 1 are presented in the 1995 reclamation plan (Umetco, 1995a) and calculations for Channel No. 2 are given in the 2004 design summary (Umetco, 2004a).

The design of the repository toe protection was based on the methodologies established in NUREG/CR-4480 (NRC, 1986a). The design of the channel outlets was based on the recommendations contained in Appendix D of the *Final Staff Technical Position (STP), Design of Erosion Protection Cover for Stabilization of Uranium Mill Tailings Sties,* (NRC, 1990). The design procedures for both applications are dependent on an estimation of the depth of scour at the toe of the slope or channel outlet. The maximum scour depth at the toe of the Heap Leach Repository was estimated to be 1.2 feet. From this estimated value, the width and depth of the horizontal toe protection was determined to be 24 inches wide and 24 inches deep. The maximum scour depth was calculated for each channel outlet. The results were compared and the maximum value of 6.5 feet selected to design the Channel No. 1 outlet.

The maximum scour depth for the outfall of Channel No. 1 was reevaluated using the as-built channel dimensions, as-built slope, the PMP runoff flow, and an 8-hour PMF flow duration. The reevaluation design utilized recent guidance provided in Appendix D of NUREG-1623 (NRC, 1999) and scour equations developed by the US Army Corps of Engineers. The maximum scour depth was estimated to be 11.3 feet deep with a volume of 4,007 cubic yards. Based on the results of the scour potential evaluation a circular launch rock basin was designed with adequate dimensions and volume to bypass the maximum channel discharge, infill the potential scour hole, and retard head cutting. A stacked rock basin design was adopted instead of a buried apron to reduce the amount of disturbance to the existing invert of the Channel No. 1 toe and to avoid the formation of a sump. The launch rock basin incorporated an overflow weir calculated using the broad crested weir formula. The calculations are given in the 2004 design summary (Umetco, 2004a).

CDPHE reviewed and evaluated the sites surface water hydrology and erosion protection parameters and concludes that the reclamation designs will meet the regulatory requirements set forth in Appendix A.

2.2.2. Rock Durability and Gradation

Erosion protection for the Heap Leach Repository top and 5:1 side slopes, the Ancillary Cell, and the channels was determined using the methodologies established in Appendix D of the STP (NRC, 1990).

The Safety Factors Method was used for the design of the erosion protection on the repository tops and channels, which have slopes of less than two percent. The Stephenson Method was used for the side slopes, which have slopes of twenty percent. To maintain a minimum number of riprap types for processing, four separate riprap gradations were selected. The selection of riprap types was based on the volume required and filter bed compatibilities. The selection of riprap type was based on the riprap type that had a D_{50} (particle size for which 50 percent of the material is finer) greater than the D_{50} calculated for each application.

Table 2.2-2 provides a summary of the designed median (D_{50}) particle size, specified erosion protection type, and specified erosion protection thicknesses. Table 2.2-3 lists the four types of erosion protection and grain size distribution for the specified type.

In accordance with the recommendations in NUREG/CR-1623, the rock layer thicknesses were a minimum of 1.5 times the design D_{50} filter sizing was performed using the methods recommended in NUREG/CR-4620.

Gradations were performed during the construction of the Heap Leach Repository and Channel No. 1 during material delivery to the site or placement between 1995 and 1997. No gradations were performed during the 2005 construction of the Ancillary Cell and Channel No. 2 because of previous tests conducted during material stockpiling for the Heap Leach Repository construction. Each gradation test was performed on a composite of at least three random sample locations from the completed placement area or on-site stockpile and collected approximately every 7,000 cubic yards. The tests were reviewed by the Umetco Quality Control Officer, the Umetco Design Engineer and approved by CDPHE. Results are documented in Compliance Report CR-MAY-6.3 (Umetco 2001).

Table 2.2-2

Erosion Protection Design

Drainage Area	Design D50, inches	Erosion Type	Rock Layer Thickness
Heap Leach Repository top	0.6	Type A	6 inches
Heap Leach Repository 5H: 1V side slopes	6.55	Type B Type A as bedding	12 inches 6 inches
Channel No. 1 Sta. 0+00 (start) to 14+61.1	2.5	Type C Type A as bedding	12 inches 6 inches
Channel No. 1 Sta. 14+61.1 to 18+00 (end)	22.5	Type D Type A as bedding	30 inches 6 inches
Ancillary Cell	0.52	Type A	6 inches
Channel No. 2	17.4	Type D Type A as bedding	36 inches 6 inches

Table 2.2-3

Erosion Protection Type Particle Size Distribution

		Particle Size Distribution		
Riprap Type	Design D_{50}	Maximum Size	D_{50}	D_{15}
Type A	0.6 inches	3 inches	3/8 to 1-1/2 inches	#4 to 3/4 inch
Type B	6.5 inches	9 inches	5 to 8 inches	3 to 6 inches
Type C	2.5 inches	6 inches	2 to 5 inches	3/4 to 3 inches
Type D	22.5 inches	30 inches	18 to 24 inches	5 to 10 inches

Rock selection and production followed the procedures suggested in the NRC Staff Technical Position, *Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites*, dated 1990. Limestone rock from the Steele Quarry met the criteria for long-term erosion protection. An initial petrographic examination was performed in May 1989 by Western Engineers, Inc. and is described in *Summary of Methods and Findings, Petrographic and Laboratory Analysis – Limestone Rock Sample, Umetco Minerals Corporation Maybell Heap Reclamation Project.* A second petrographic analysis was performed for the quarry owner on June 12, 1995 and is described in *Petrographic Analysis, ASTM Method C-295*, by DCM Science Laboratory, Inc. Durability tests (Sodium Sulfate Soundness, Los Angeles Abrasion, Specific Gravity, Absorption, Indirect Tensile Strength, and Schmidt Rebound) were performed in 1987, 1989 and 1994. The rock quality score, using the scoring method from Table D-1 – Scoring Criteria for Determining Rock Quality in NUREG-1623 Appendix D, was over 80 and would not require oversizing for use in either critical or non-critical areas.

Rock durability testing was performed during placement to ensure the quality of the limestone riprap met the approved construction design plans and specifications. Rock samples were tested approximately every 18,000 cubic yards of production. Rock durability scores, based on specific gravity, absorption, Los Angeles Abrasion and Sodium Sulfate Soundness, averaged 91.5, with the lowest at 84.9 and the highest at 95.2, indicating the limestone used in construction was of good quality for use as erosion protection and did not require oversizing. The same limestone quarry was used to provide riprap for the Department of Energy's Maybell Title I site. Twenty-eight durability tests were completed by the Department of Energy (DOE, 1996). The average rock score was 88.8. This score is based on using specific gravity, absorption, Sodium Sulfate Soundness, Los Angeles Abrasion, Indirect Tensile Strength and Schmidt Hammer. The rock score using only specific gravity, absorption, Sodium Sulfate Soundness and Los Angeles Abrasion of these tests averaged 91.2.

The results of the durability testing are given in Table 2.2-4 and were reviewed by the Umetco Quality Control Officer and the Design Engineer. Test results were approved by CDPHE as documented in Compliance Report CR-MAY-6.3 (Umetco 2001).

CDPHE reviewed the data regarding rock durability testing and gradation and concluded that the limestone used for armoring the disposal repository, ancillary cell and channels will be stable for the design life of the facility.

2.2.3. Vegetative Cover

Vegetative cover was not used in the design or construction of the Heap Leach Repository or Ancillary Cell.

2.2.4. Sedimentation

Sedimentation of Channel No. 1 was not evaluated because the drainage area to the channel is covered with rock erosion protection and no sediment will accumulate reducing diversion channel flow capacity. The depth of flow in Channel No. 2 was calculated to be 2.43 feet; the channel was constructed 10 feet deep, which provides over 7 feet of freeboard. In addition to the channel oversizing, the designed D_{50} was 17.5 inches whereas the D_{50} of the Type D riprap used in construction was 22.5 inches, which provides larger voids to accommodate a larger volume of sediment. The calculations are discussed in the 2004 design summary (Umetco, 2004a).

2.2.5. Conclusion

The surface hydrology and erosion protection were designed and constructed in accordance with the NRC guidance documents to meet the regulatory requirements of criteria 4 and 6 in the State of Colorado *Rules and Regulations Pertaining to Radiation Control* Part 18, Appendix A. Compliance reports CR-MAY-5.2, CR-MAY-6.3, CR-MAY-7.0 and CR-MAY-9.6 were generated from the work performed during construction in accordance with the Maybell Quality Plan (Umetco, 1995b). Testing results and construction verification required by the Quality Plan (Umetco, 1995b) were reviewed by CDPHE. CDPHE's review of the design documents and inspections of the construction activities and geotechnical test results indicate that the decommissioning actions were performed in accordance with all applicable standards and requirements.

Table 2.2-4

Limestone Riprap Durability Results

Sample Number	Soundness, percent loss	LA Abrasion, revolutions as indicated, percent loss	Specific Gravity	Absorption, percent	Indirect Tensile Strength, lbs/sq. in.	Schmidt Rebound	Rock Score [a]
1987 [b,c]	0.8	14.1 (100)	2.67	0.4			**84.9**
1989 [d]		4.8 (200)					
Steele 1989 [e]	3.7	32.7 (200)	2.70				
5-12-94 [f]	0.65 0.41 0.03	7.6 (100)	2.68 2.71	0.28 0.31	1186.3	65.2	**88.7**
Steele 6-29-95 #1 [g] (Sample 1 Bedding)	3.5	6.2 (100)	2.722	0.04	880	33.8	**95.2**
Steele 6-29-95 #2 [g] (Sample 2 Type A)	2.8	5.8 (100)	2.713	0.04	1180	37.8	**95.0**
Steele 6-29-95 #3 [g] (Sample 3 Type B)	4.1	5.7 (100)	2.712	0.05	1010	49.3	**94.1**
DUR-A-4 [h] (A-4 Type A)	0.0	7.7 (100)	2.69	0.19			**92.0**
DUR-A-5 [h] (A-5 Bedding)	0.0	7.8 (100)	2.70	0.25			**91.5**
DUR-A-9 [h] (A-9 Bedding)	0.1	8.3	2.70	0.26			**91.2**
DUR-B-1 [h] (B-1 Type B)	0.0	7.7	2.69	0.23			**91.2**
DUR-C-1 [h] (C-1 Type C)	0.37	7.6	2.70	0.18			**93.1**
WEI Type D[i]	≤ 1.0	7.59	2.68	0.28			**89.3**

a. Durability scores are calculated using Table D-1, Appendix D of the STP for Sodium Sulfate Soundness, Los Angeles Abrasion (100 revolutions), Specific Gravity and Absorption test results only.
b. From letter dated October 19, 1987 to Umetco from Chen and Associates.
c. From letter dated December 23, 1987 to Umetco from Western Engineers, Inc.
d. From letter dated August 7, 1989 to Umetco from Western Engineers, Inc.
e. From letter dated November 21, 1989 to Maybell Enterprises from Ground Engineering Consultants, Inc.
f. From letter dated May 12, 1994 to Umetco from Western Engineers, Inc.
g. From letter dated June 29, 1995 to Maybell Enterprises from Ground Engineering Consultants, Inc.
h. From laboratory testing performed in February and March 2001 by Red Mesa Consulting, Inc.
i. From Compliance Report CR-MAY-6.3 dated February 23, 2001

3. Documentation that the completed site decommissioning actions was performed in accordance with applicable standards and requirements.

3.1. Radiation Cleanup and Control

3.1.1. Introduction

Cleanup of the heap leach site was based on the CDPHE approved *Final Plans and Specifications for Closure Activities (*1995), and the *Soil Cleanup Plan* (1995c). These plans were prepared in accordance with the Maybell Radioactive Materials License 660-01, and Colorado's *Rules and Regulations Pertaining to Radiation Control* Part 18, Appendix A. The ALARA (as low as reasonable achievable) principle was followed in the conduct of soil cleanup activities.

Characterization studies were conducted at the Maybell Facility and surrounding area in 1989 and 1991 (Umetco 1990, 1991and 1995f). These characterization studies assessed radiological and potentially hazardous constituents including radium, thorium, uranium, arsenic, selenium, cadmium, lead, vanadium, nickel, zinc, and molybdenum. CDPHE, the Colorado Geological Survey and Little Snake Resource Area of the Bureau of Land Management thoroughly reviewed and commented on the *Soil Cleanup Plan* and approved its implementation.

3.1.2. Process Site Decommissioning

Remediation of the process area took place over a period of several years from the end of the heap leach activities until the completion of the soil clean up activities. The majority of the remaining equipment, support facilities, instrumentation, piping, electric controls and switchgears were dismantled, sized and placed in trenches excavated in the top and northwest corner of the heap during the 1995 and 1996 construction seasons in accordance with the CDPHE approved Quality Plan (Umetco, 1995b). The trenches were excavated to depths that insured the top of the debris and scrap materials were a minimum of 500 cm below the final graded heap surface prior to placement of the reclamation cover.

The soil cleanup phase of the process area decommissioning was completed during the 1995 construction season. All contaminated materials were excavated and relocated to the heap in accordance with the *Soil Cleanup Plan* (Umetco, 1995c). Approximately 26,000 yd^3 of contaminated materials were removed from the process area. An additional 40,000 yd^3 of contaminated soils adjacent to the Heap Leach Repository were excavated and placed in the repository. Appropriate environmental controls for air water and soils were in effect while conducting all remedial activities at the site in accordance with the *Health and Safety Plan* (Umetco, 1995d) and *Policy and Procedure Manual* (Umetco, 1995e).

3.1.3. Final Status Survey

Post-remedial action-conditions at the Maybell Title II site were assessed by conducting penetrating radiation surveys and by soil sample collection and analyses. These soil verification survey data were collected between June 1995 and October 1999 in the mined, unmined, and process areas and in 2004 for the new evaporation pond area.

Direct field measurements included both scintillation and pressurized ionization chamber (PIC) penetrating radiation measurements.

The Final Status Survey methodology was previously detailed in the CDPHE approved *Soil Cleanup Plan* (Umetco, 1995c) and developed to determine compliance with U. S. Environmental Protection Agency (EPA) 40 CFR 192 soil cleanup standards for radium and Appendix A, Part 18 of Colorado's *Rules and Regulations Pertaining to Radiation Control.* The survey was developed in accordance with EPA's *Methodology for Evaluating Cleanup Standards*, (EPA, 1989); *Statistical Methods for Environmental Pollution Monitoring* by R. O. Gilbert (1987); and *Manual for Conducting Radiological Surveys in Support of License Termination* (NRC, 1992).

All data collected between June 1995 and October 1996 were from collimated scintillation measurements taken at ground surface at the intersections of the 10m x 10m verification grid. These areas included the mined area and the northern and easternmost unmined areas.

All data collected in October 1999 were from collimated scintillation measurements taken at one foot above the ground surface using the global positioning system (GPS) based scintillometer. The GPS survey region includes the remaining unmined cleanup areas and the process area. Measurement coverage and density in these areas was extensive. A summary of survey areas, scan and sample results is presented in Tables 3.1.3-1 to 3.1.3-3. Details regarding the soil removal activities and verification survey are presented in Compliance Reports CR-May-4.1, CR-May-4.2 and CR-May4.3 (Umetco, 2005).

Table 3.1.3-1
Survey Unit Summary

Survey Unit	Scintillometer Readings per Survey Unit	Area of Survey Unit, m^2
Mined Area	582	57,062
Unmined Area	4112	97,942
Process Area	901	55,207

Table 3.1.3-2
Summary of In-Situ Ra-226

Analytical Categories		In-Situ Ra-226 (pCi/g) Corrected*
Mined Area	Average of Readings	4.2
	Minimum Reading	0.2
	Maximum Reading	10.2
Unmined Area	Average of Readings	3.4
	Minimum Reading	0.2
	Maximum Reading	7.2
Process Area	Average of Readings	4.1
	Minimum Reading	1
	Maximum Reading	8.2

Notes: The cleanup criteria of Ra-226 is 27.3 pCi/g in the mined area, 6.7 pCi/g in the unmined area, and 6.7 pCi/g in the process area.

Maximum and minimum values represent single measurements and do not represent average readings with a 10m by 10m area.

Table 3.1.3-3
Summary of soil sample laboratory analyses

	Unmined Area	Mined Area	Process Area
Number of soil samples	20	25	19
Minimum Ra-226 Concentration (pCi/g)	1.7	1.9	2.3
Maximum Ra-226 Concentration (pCi/g)	4.5	29	11
Mean Ra-226 Concentration (pCi/g)	2.9	5.7	4.7

Notes:

The cleanup criteria of Ra-226 is 27.3 pCi/g in the mined area, 6.7 pCi/g in the unmined area, and 6.7 pCi/g in the process area.

Maximum and minimum values represent single measurements and do not represent average readings with a 10m by 10m area.

Verification and validation of the survey results combined with an assessment of the quantity and quality of the data were conducted. The data were validated to ensure that the results supported the objectives of the survey. The Final Status Survey was found acceptable by CDPHE.

3.1.4. CDPHE Verification

An independent verification survey was conducted by CDPHE. The units surveyed included the mined, un-mined and processing areas. Walking surveys were compared to the results of the soil cleanup verification activities. These surveys were in agreement with the results contained in the verification report and confirmed that soil cleanup activities were conducted in conformance with the regulations.

3.1.5. State Oversight

In addition to the independent verification CDPHE conducted numerous site visits, and inspections during site reclamation activities including detailed site inspections and walking gamma surveys on all areas as they were cleaned up. Results of the CDPHE surveys were compared to Umetco's results and were found to be in agreement.

3.1.6. Conclusion

Results of the soil cleanup verification survey conducted for the Maybell Title II Heap Leach Facility demonstrate that the site-specific soil cleanup criteria have been attained. This conclusion is based on an extensive gamma survey and laboratory results reported for the 64 soil samples. The results of the soil cleanup verification survey shown in Tables 3.1.3-1 through 3.1.3-3 demonstrate the effectiveness of remedial actions, that the ALARA principle has been met, and that the soil cleanup standards for radium at the site have been attained.

CDPHE concludes that the criteria set forth in Appendix A of Colorado's *Rules and Regulations Pertaining to Radiation Control* have been met.

3.2. Radon Emanation

The Heap Leach Repository was designed to provide reasonable assurance that releases of radon-222 do not exceed a rate of 20 $pCi/m^2/s$ when averaged over the disposal area in accordance with the applicable EPA regulations in 40 CFR 192.02(b). Radon flux was calculated using the RADON computer model (Rogers and others 1984; NRC 1989).

Radon attenuation input parameters for the Heap Leach Repository were developed from radiological measurements and geotechnical soil tests. Table 3.2-1 summarizes the input data used in the RADON attenuation model for the Heap Leach Repository cover.

Table 3.2-1
Radon Model Input Parameters for the Heap Leach Repository

Parameter	Heap Material	Clay Soil Layer	Random Fill
Layer thickness (cm)	500	45.7	121.9
Layer density (gm/cm^3)	1.68	1.75	1.78
Radium Activity (pCi/g)	53	2.3	3.1
Emanation Coefficient	0.265	0.193	0.106
Moisture Coefficient (%)	9	10	6
Diffusion Coefficient	0.017	0.014	0.022

Results of the RADON model analysis indicate that a closure cover comprised of 18-inches of clayey soil overlain by 4-feet of random fill would exhibit an exit flux of 8.9 $pCi/m^2/s$.

Radon attenuation input parameters for the Ancillary Cell were developed from radiological measurements and geotechnical soil tests. Table 3.2-2 summarizes the input data used in the radon attenuation model for the cover on the cell.

Table 3.2-2
Radon Model Input Parameters for the Ancillary Cell

Parameter	Pond Material	Clay Soil Layer	Random Fill
Layer thickness (cm)	500	30.5	122
Layer density (gm/cm^3)	1.68	1.75	1.78
Radium Activity (pCi/g)	27.1	2.32	3.06
Emanation Coefficient	0.265	0.193	0.106
Moisture Content (%)	9	10	6
Diffusion Coefficient	0.017	0.014	0.022

Results of the RADON model analysis indicate that a closure cover comprised of 12-inches of clayey soil overlain by 4-feet of random fill would exhibit an exit flux of 5.9 $pCi/m^2/s$.

3.2.1. Radon 222 Measurements

Umetco completed separate radon flux measurements for the Heap Leach Repository and Ancillary Cell at the heap leach site in accordance with 40 CFR part 61, Appendix B, Method 115. In both cases, all meteorological requirements were met.

Radon 222 measurements on the Heap Leach Repository were completed in 1997. One hundred Large-Area Activated Charcoal Canisters (LACC) were used for this activity and deployed on an evenly spaced grid as discussed in the Final Radon Flux

Measurements Report (Umetco, 1998). Since the measurements were taken after completion of disposal activities for the heap leach, the entire pile was considered to be one region, which covered 278,000 m^2. The mean radon flux rate for the Heap Leach Repository was 0.4 $pCi/m^2/s$.

In September 2005, 100 LACs were deployed on the Ancillary Cell in a grid pattern on 6.7 m centers. The grid on the cell covered 3,716 m^2. The mean radon flux rate for the Ancillary Cell was 0.6 $pCi/m^2/s$.

These measurements are well below the regulatory standard of 20 $pCi/m^2/s$ in Criterion 6 of Appendix A to Part 18 of the Colorado *'s Rules and Regulation Pertaining to Radiation Control* and are consistent with the designs based on analytical evaluations.

3.2.2. Conclusion

CPDHE's review of radon emanation data and reports has found the Maybell Heap Repository and Ancillary Cell to be in conformance with regulatory requirements of Colorado's *Rules and Regulations Pertaining to Radiation Control* Part 18, Appendix A.

4. Documentation that the completed groundwater monitoring program was performed in accordance with applicable standards and requirements.

4.1. Groundwater Monitoring Program

Monitoring of groundwater at the Maybell Title II site has been conducted in accordance with criteria set forth in Appendix A, of Part 18 in Colorado's *Rules of Regulations Pertaining to Radiation Control*. Results from the monitoring programs demonstrate no impacts from previous uranium processing and disposal activities to groundwater at the Maybell site. The Maybell Title II Heap Leach Facility was designed and operated to zero discharge of the leachate solution. Clay-lined cells were used for heap leach activities and liquids generated from theses activities were collected in lined storage ponds. These actions effectively mitigated the seepage of liquids into the subsurface material or into groundwater below the site.

The hydrogeology of the site was evaluated prior to construction of the Heap Leach Facility in 1975, as part of the design phase of the reclamation cover and during post-operational monitoring of the site. Hydrologic evaluations performed by Umetco to characterize physical parameters, which control groundwater occurrence, flow, and potential transport of contaminants were reviewed by CDPHE. The detection monitoring program for the site was established with CDPHE's approval of a monitoring program that met criteria of Part 18, Appendix A. This program included the routine monitoring evaluation of groundwater quality in upgradient background wells and wells located down gradient from the heap leach and storage pond area.

Detection groundwater monitoring at the Maybell Title II site has been conducted on a regular basis since the construction of the initial wells in 1975. Operational monitoring continued through uranium processing activities (1975 – 1981) and site closure activities (1989 – 1998). Operational monitoring activities ceased in 1998 with the completion of the cover of the Heap Leach Repository. Post-operational monitoring of the groundwater at the site occurred from 1998 through 2005. During this 30-year period, there has been no contaminants input to groundwater from the processing liquids.

Results of the detection-monitoring program have been reported to CDPHE on an annual basis. This detection-monitoring program has been reviewed by CDPHE from 1993 through 2004. In addition, a final groundwater report was submitted to CDPHE in 2000 for their review (Umetco, 2000). CDPHE reviews included the assessment of site geology, hydrology, geochemistry, and evaluation of water quality monitoring data. These reviews have confirmed the findings presented in the annual reports and confirmed the absence of contaminant inputs to the Browns Park aquifer. Because groundwater contamination from the heap leach site was never detected, a groundwater compliance program was never developed or implemented at the site.

4.1.1. Monitoring Wells

The detection monitoring program included two upgradient or background wells, NE Heap and Rob Ramp, and two downgradient wells, Millsite 1 and Millsite 2.
The Rob Ramp and Millsite 1 wells have been monitored at least semiannually since before processing at the heap leach facility began in 1975 and at NE Heap and Millsite 2 since 1991. The wells at the Maybell facility were monitored to compare groundwater

quality from the downgradient wells to background levels established in wells up gradient of the heap leach site. Indicator analytes proposed by Umetco and approved by CDPHE include uranium, thorium-230, radium-226, calcium, magnesium, potassium, sodium, bicarbonate, carbonate, chloride, sulfate and total dissolved solids. These analytes were monitored at least semi-annually from 1991 to 2005.

In October of 1999 CDPHE requested that Umetco install an additional well to the south of the heap area to show that ponded liquids from the Winter Storage Pond were not affecting groundwater quality. This well was installed in 2000 and subsequently monitored. Results of this sampling showed that there was no degradation of groundwater quality from liquids in the Winter Storage Pond. CDPHE reviewed this monitoring data in 2001 and concluded that the aquifer as sampled by well Millsite #3 shows stable chemistry and has not been impacted by onsite operations. CDPHE authorized the removal of this well based on these findings.

CDPHE reviewed all historical groundwater data in 2005 and determined that water quality in the monitoring wells were stable and showed no increase in key indicator parameters. In addition, CDPHE compared groundwater chemistry with results obtained from the upgradient DOE Title I monitoring wells and concluded that the Maybell wells were within the range of DOE determined background, and that the Browns Park aquifer is unaffected by post-uranium-recovery operations from the heap leach operations. Cessation of post-closure groundwater monitoring was approved by CDPHE in 2005 (CDPHE, 2005). The four remaining wells were sealed in accordance with state regulations in 2005 so that final site grading could be conducted.

The decision to seal the wells is supported by the evaluation of the groundwater regime by the DOE in their Long Term Surveillance Plan for the Maybell Colorado Title I Disposal Site (1999). The DOE concluded that:

- "Ground water in the uppermost aquifer is not a current or potential source of drinking water in the area because it contains widespread ambient contamination caused by naturally occurring uranium mineralization and from the effects of broad-scaled human activity unrelated to uranium-milling activities at the site (uranium exploration and mining activities)."
- "Since ground water remediation is not planned for the Maybell processing site, ground water monitoring will not be required for demonstration of compliance with the ground water protection standards." and
- " Also, there is no risk to human health and the environment because there are no known exposure pathways for ground water from the uppermost aquifer to a receptor."

4.1.2. CDPHE Assessment Activities

CDPHE conducted reviews of Umetco's well completion methods and groundwater sampling protocols (Umetco, 1995e, as amended). These protocols are consistent with the standard industry practices for collection, preservation and shipment to an analytical laboratory. All samples since 1991 were sent to a certified analytical laboratory with a stringent quality assurance/quality control program. Overall the analytical results were

verified by CDPHE to be accurate based upon Umetco's quality control program and consisting of the analytical results for over 30 years.

4.1.3. Geochemistry

Background water quality, as described in the Final Groundwater Report (Umetco, 2000) for the site, was characterized from upgradient groundwater samples collected from Umetco wells. Background water quality data were also available from the DOE hydrogeological data set used to define groundwater quality upgradient and downgradient of the former mill site and tailings pile (upgradient of heap leach site). Background geochemistry is defined as the concentration levels of target constituents under natural site conditions excluding anthropogenic impacts, in this case uranium mining and processing activities.

The occurrence of contaminants in wells at the DOE Title I site indicate water quality impacts on Browns Park groundwater may be influenced by naturally occurring uranium mineralization. *In-situ* ore bodies in the Browns Park Formation could continue to impact groundwater quality along the natural flow system in the region.

Chemical data from up-gradient and down-gradient monitoring wells relative to the heap were used to evaluate geochemical trends. The Umetco well samples are chemically similar and stable over time with calcium-sulfate type waters for all wells except the calcium-sulfate-bicarbonate water type in the Rob Ramp well. These groundwater chemistries are chemically distinct from the magnesium-sulfate type water represented by the processing site leachate. These data are consistent with the groundwater monitoring data obtained by the DOE at the Maybell Title I site located up gradient of the Umetco site. The DOE concluded that no significant impacts have occurred to the Browns Park aquifer from previous milling operations and has ceased monitoring the wells at the Title I site. Likewise, CDPHE concluded that there are no impacts to the aquifer and approved cessation of groundwater monitoring.

4.1.4. Conclusion

CDPHE has made a determination that the closure of Umetco's facility is in compliance with State groundwater regulations associated with uranium mill closure. The closure is specifically in compliance with Criterion 5, Criterion 7, and Criterion 10, which incorporate the basic groundwater protection standards imposed by EPA in 40 CFR Part 192, Subparts D and E; mandated by NRC in 10 CFR Part 40, Appendix A which specifies groundwater monitoring requirements; and implemented by CDPHE in Part 18, Appendix A of the State regulations.

Regulation 18.3.3 of the *State of Colorado Rules and Regulations Pertaining to Radiation Control* states that "Throughout the construction and operating phases of the mill, the applicant/licensee shall conduct an operational monitoring program to measure or evaluate compliance with applicable standards and regulations, to evaluate performance of control systems and procedures, to evaluate environmental impacts of operation, and to detect long-term effects." It should be noted that Umetco monitored ground water at the Maybell site until the heap leach facility ceased operations in 1982. During the operational phase, environmental impacts from operations were evaluated and potential long-term effects to ground water were not detected based on the geohydrology.

Nevertheless, after the operational phase had ceased, Umetco continued to monitor ground water during the reclamation or site closure phase of the work. This phase was completed in 2005. Again, environmental impacts were evaluated and potential long-term effects to ground water were not detected nor are they anticipated based on the geohydrology. As part of the reclamation, the ground water wells were plugged and abandoned after over 30 years of detection monitoring and 23 years after completion of the operational phase. After the reclamation or site closure phase was completed, Umetco has entered into an inspection/surveillance phase while paper work is being completed to transfer the site to DOE. DOE has concurred with the Colorado State Agreement Program that further ground-water monitoring at this site is no longer necessary. It should be noted that ground-water chemistry monitoring was not required at the Maybell Title I site and that the water level wells were plugged and abandoned in 2004, prior to abandonment of the wells at the Umetco Maybell Title II site

5. Compliance with license conditions

Umetco has completed the reclamation of the Maybell facility under license from the State of Colorado. During the reclamation period there have been 10 amendments to the license and 15 annual license inspections of the facility. Of the annual CDPHE license inspections there was only 1 potential violation reported.

A CDPHE inspection on October 28, 1996 identified one item of non-compliance. That item was a failure to maintain a financial assurance instrument in force. Umetco later provided CDPHE with documentation that the financial instrument was self-renewing. CDPHE concluded that an additional response from Umetco was not required.

In addition there were three deviations from license requirements self-reported by Umetco.

On February 21, 2001 Umetco reported to CDPHE that a deviation had occurred in regard to Maybell procedure E-1, Liquid Waste Monitoring. An audit by Umetco revealed that the liquids in the leak detection sumps had not been pumped since March of 2000 as required by Umetco's procedures. Umetco instituted a corrective action program that included increased audits of the Maybell Title II site by Environmental Health and Safety personnel and a formal retraining of inspection personnel.

On March 26, 2002, Umetco reported to CDPHE a deviation from license condition 26.2. The Lower Limits of Detection (LLD) required by LC26.2 were not met by Umetco's vendor laboratory. Umetco verified that the vendor reported concentrations were within the range of historic values. A corrective action included a change in methodology at the vendor laboratory to meet the LLDs required by LC26.2.

On February 26, 2004 Umetco reported to CDPHE a deviation from license condition 18.2.3. Umetco found during annual ALARA audit activities that the interval between ALARA audits (12 Months), as defined by LC18.2.3, had been exceeded by 1 month. Umetco requested that LC18.2.3 be reworded in the license to read "The licensee shall review the radiation protection program annually for content and implementation."

Each of these three self reported deviations from license conditions were subsequently corrected with no finding of violation by CDPHE.

6. Discussion of results of State's site closure inspections

CDPHE has performed site closure inspections over the years as the site remediation moved from one phase to the next. CDPHE has employed inspection staff and provided specialized consultants to review and verify every aspect of site closure.

CDPHE's site inspections were conducted to ensure that the site reclamation activities were performed as required by regulations and license conditions. Umetco submitted detailed plans and specifications for all aspects of the reclamation work. These plans and specifications were reviewed and approved by CDPHE. CDPHE inspectors performed numerous field inspections to verify conformance of site activities to the approved plans. These inspections included construction of the repository cover, including radon barrier,

rock placement as well as construction of the diversion channels. Field inspections also focused on soil cleanup activities and associated verification surveys.

Monitoring during site closure evaluated environmental media and site performance. Periodic inspection and monitoring activities were performed to determine radionuclide concentrations in air, soil and groundwater. Umetco has been required to perform this monitoring and to report results annually. CDPHE has performed split sampling and has evaluated monitoring results in the State's independent laboratory to provide verification of Umetco's results.

7. License Termination Conclusion

CDPHE-HMWMD has determined that Umetco has complied with the State of Colorado *Rules and Regulations Pertaining to Radiation Control* and other State and Federal Regulations with regards to decommissioning. CDPHE-HMWMD staff has determined that by inspections, communications and review of documents and reports that reclamation at the Maybell Site was done to the following:

- Work was performed according to the approved plans, specifications, and practices,
- Any deviations from the approved plans, specifications, and practices were identified and corrected promptly,
- Variances from the approved plans, specifications, and practices were evaluated and justified sufficiently to support acceptance prior to implementation,
- Umetco prepared a long-term monitoring and maintenance report in (March 2006). This report discussed transfer of the Maybell site to the US Department of Energy,
- The Maybell Site in Montrose County, Colorado can be released to DOE, and
- The Colorado Radioactive Materials License RML-660-01can be terminated.

In conclusion, CDPHE-HMWMD believes that Umetco's Maybell site has met all applicable standards and requirements. With a determination by NRC, as required by Section 274c. (4) Of the Act, that all applicable standards and requirements have been met, the Colorado Radioactive Material License 660-01 may be terminated.

In a letter dated April 12, 1996 to DOE, Governor Roy Romer declined the Colorado State's option to be custodian of the Durita site and the Maybell site. Pending acceptance of this CRR and an approved Long-Term Surveillance Plan, it is recommended that the Maybell site be transferred to the DOE for long term custodial care.

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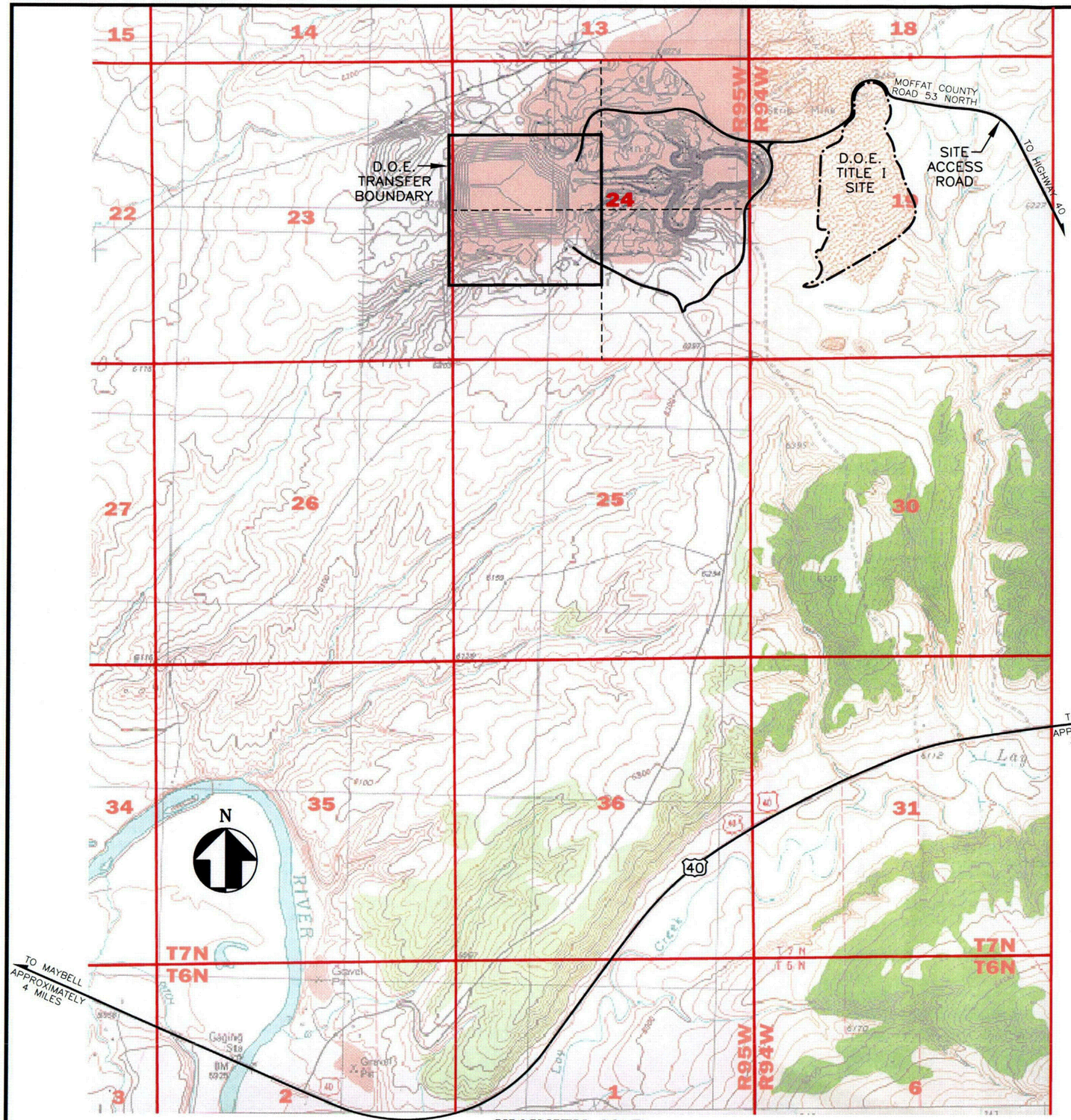
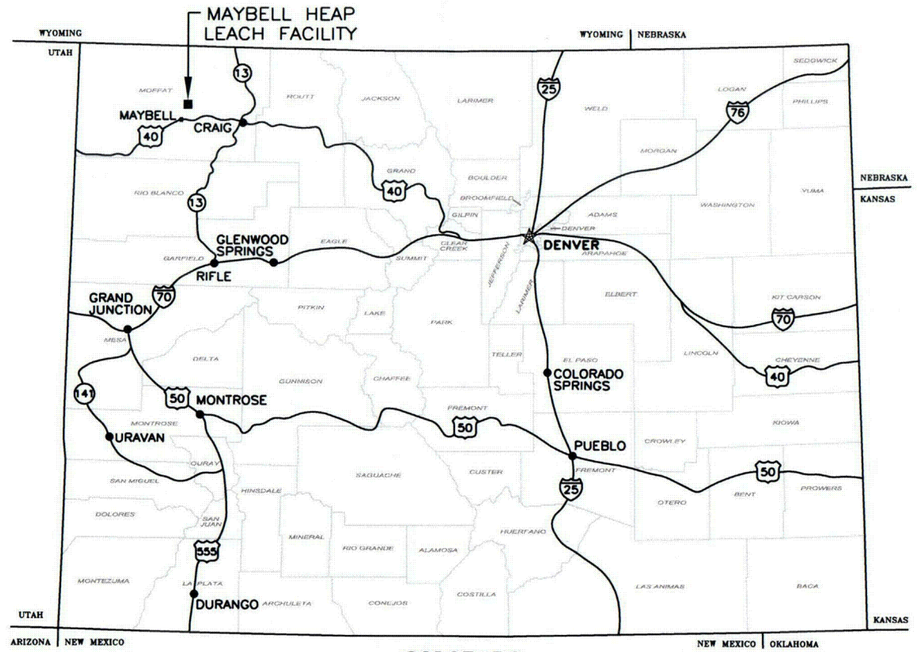


VICINITY MAP

SCALE: 1" = 2000'



COLORADO

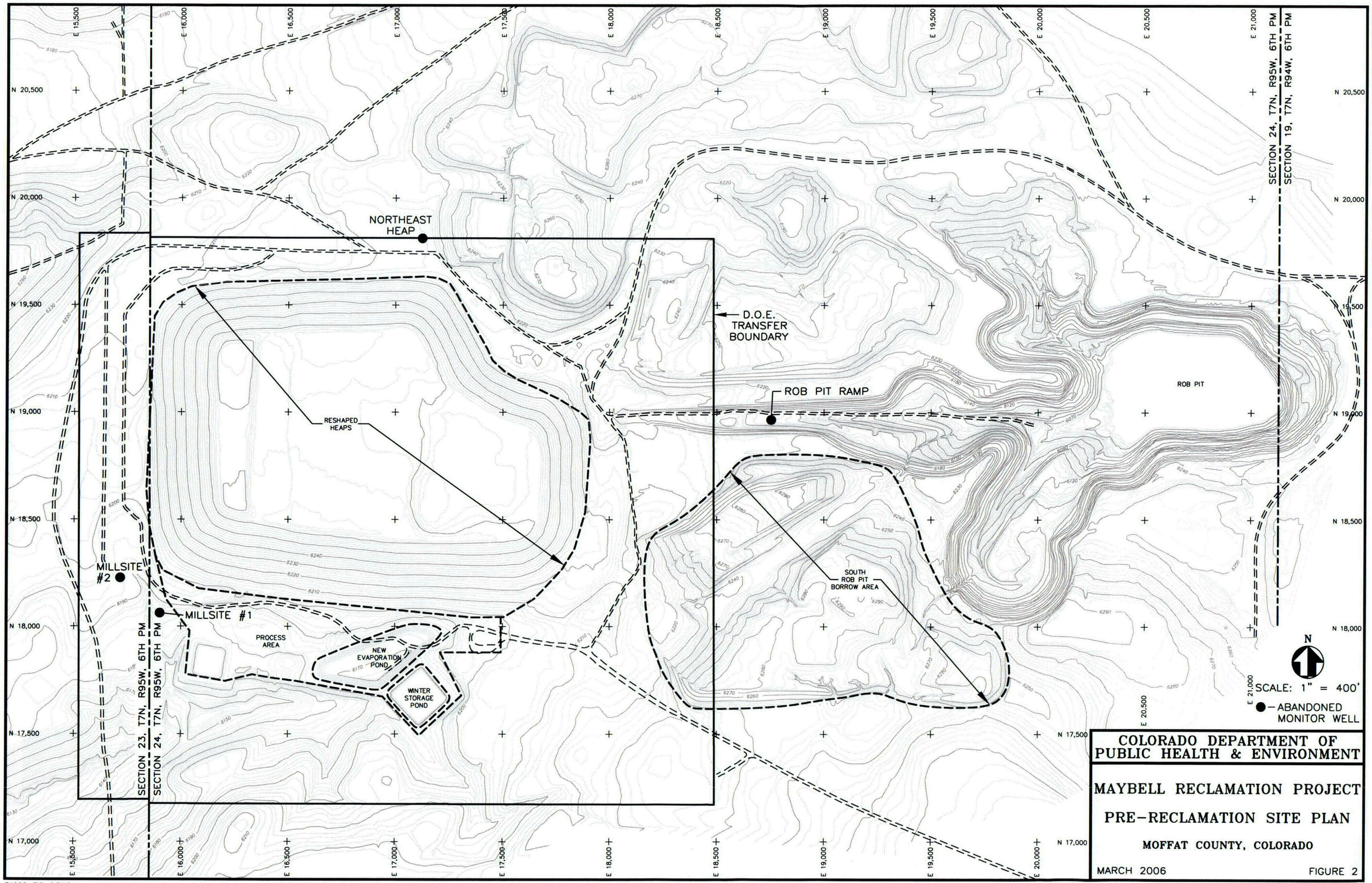
LOCATION MAP

NOT TO SCALE

COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT	
MAYBELL RECLAMATION PROJECT	
LOCATION MAP	
MOFFAT COUNTY, COLORADO	
MARCH 2006	FIGURE 1

SA900-FIG-1CDH.DWG

C01



COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT

MAYBELL RECLAMATION PROJECT

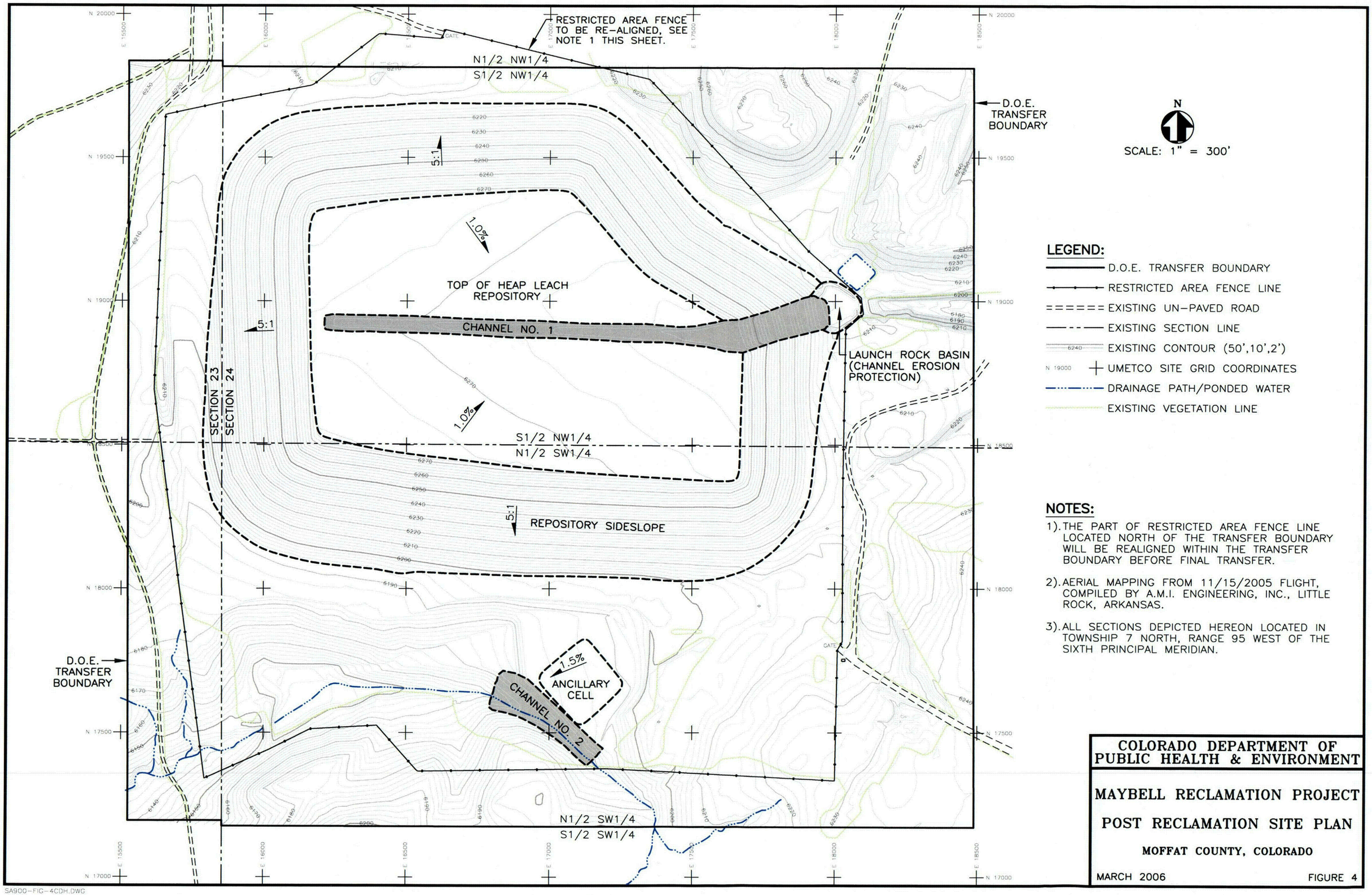
PRE-RECLAMATION SITE PLAN

MOFFAT COUNTY, COLORADO

MARCH 2006 FIGURE 2

SA900-FIG-2.DWG

C02



NOTES:

1). THE PART OF RESTRICTED AREA FENCE LINE LOCATED NORTH OF THE TRANSFER BOUNDARY WILL BE REALIGNED WITHIN THE TRANSFER BOUNDARY BEFORE FINAL TRANSFER.

2). AERIAL MAPPING FROM 11/15/2005 FLIGHT, COMPILED BY A.M.I. ENGINEERING, INC., LITTLE ROCK, ARKANSAS.

3). ALL SECTIONS DEPICTED HEREON LOCATED IN TOWNSHIP 7 NORTH, RANGE 95 WEST OF THE SIXTH PRINCIPAL MERIDIAN.

COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT

MAYBELL RECLAMATION PROJECT

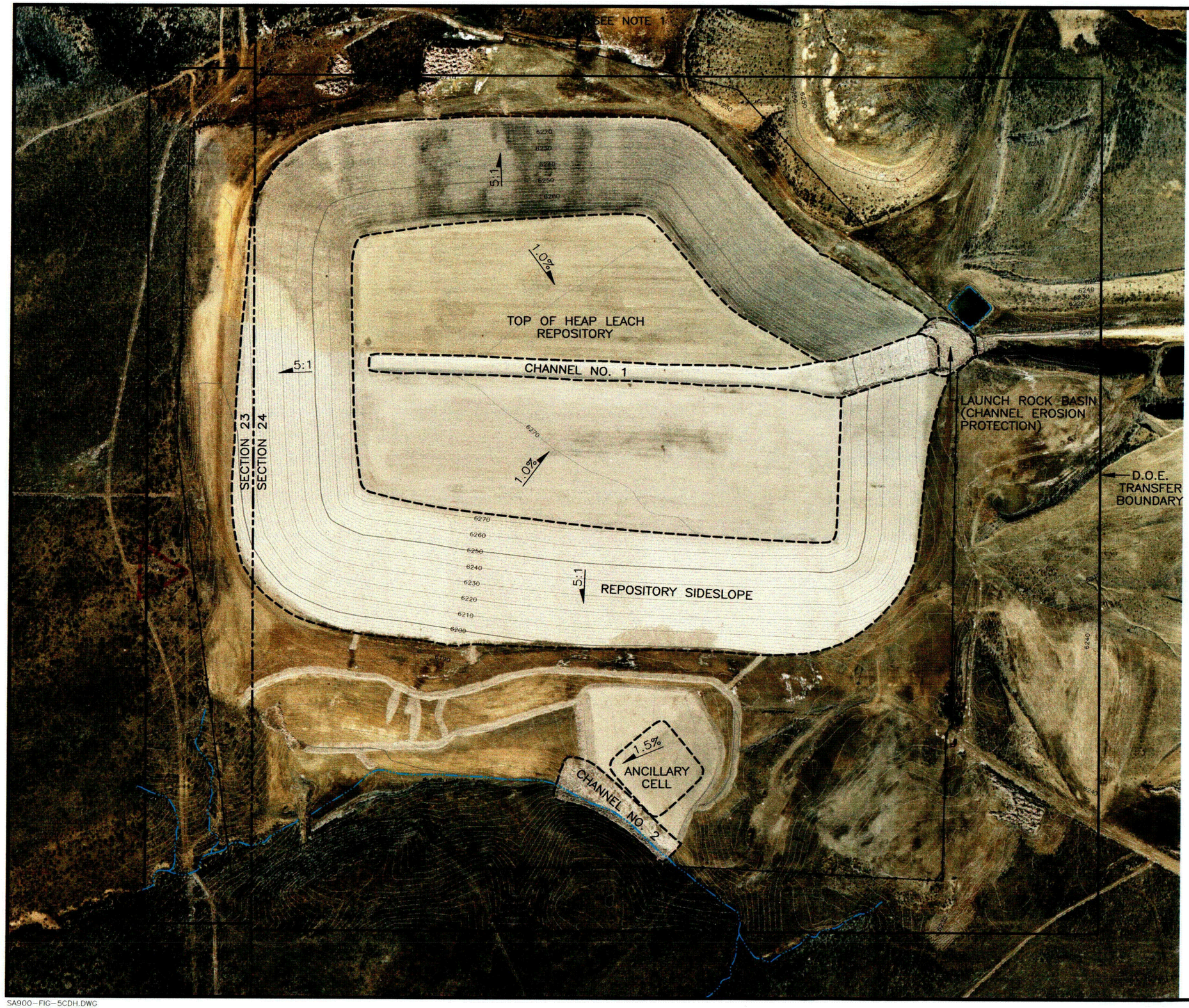
POST RECLAMATION SITE PLAN

MOFFAT COUNTY, COLORADO

MARCH 2006 FIGURE 4

SA900-FIG-4CDH.DWG

C04



N

SCALE: 1" = 300'

LEGEND:

- D.O.E. TRANSFER BOUNDARY
- RESTRICTED AREA FENCE LINE
- EXISTING SECTION LINE
- 6240 EXISTING CONTOUR (50',10',2')
- DRAINAGE PATH/PONDED WATER

NOTES:

1). THE PART OF RESTRICTED AREA FENCE LINE LOCATED NORTH OF THE TRANSFER BOUNDARY WILL BE REALIGNED WITHIN THE TRANSFER BOUNDARY BEFORE FINAL TRANSFER.

2). AERIAL MAPPING FROM 11/15/2005 FLIGHT, COMPILED BY A.M.I. ENGINEERING, INC., LITTLE ROCK, ARKANSAS.

3). ALL SECTIONS DEPICTED HEREON LOCATED IN TOWNSHIP 7 NORTH, RANGE 95 WEST OF THE SIXTH PRINCIPAL MERIDIAN.

COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT

MAYBELL RECLAMATION PROJECT

2005 POST RECLAMATION AERIAL

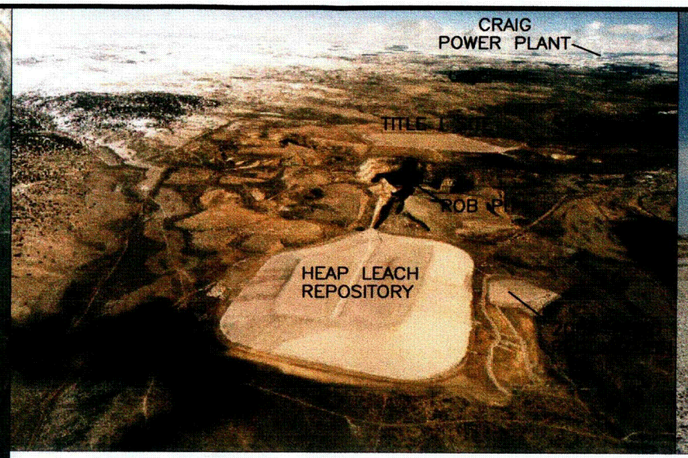
MOFFAT COUNTY, COLORADO

MARCH 2006 FIGURE 5

SA900-FIG-5CDH.DWG

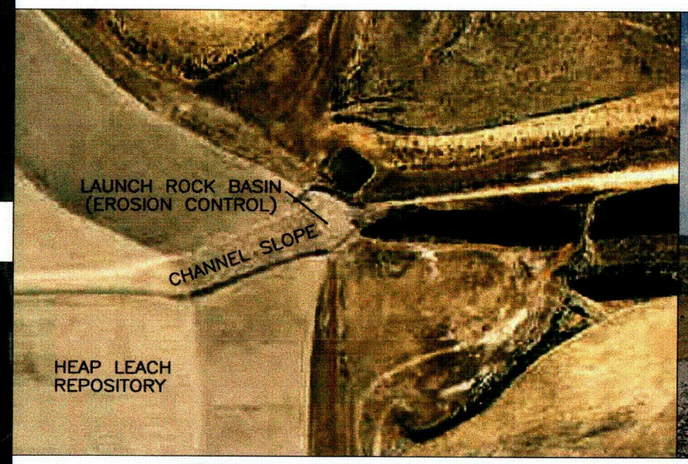
C05

11/15/2005 MAYBELL AERIAL PHOTOGRAPH

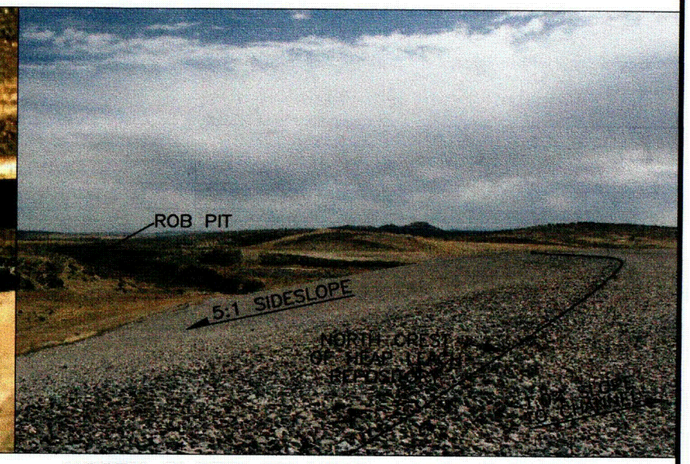


2005 OBLIQUE AERIAL (LOOKING EAST)

CHANNEL ON TOP OF HEAP LEACH REPOSITORY

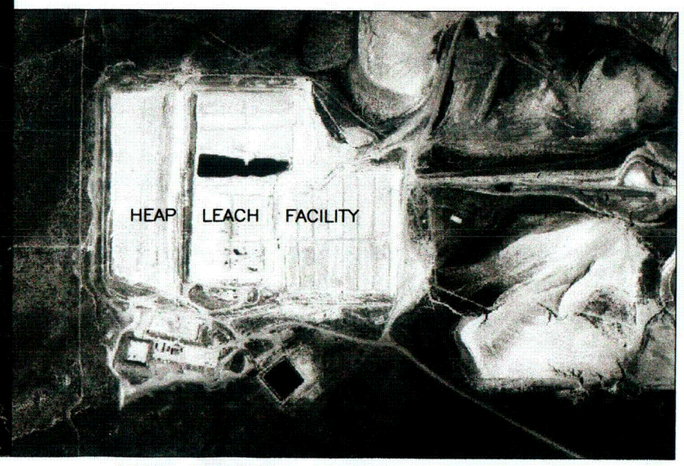


EROSION CONTROL BASIN



NORTH SLOPE OF HEAP LEACH REPOSITORY

11/14/1969 MAYBELL AERIAL PHOTOGRAPH



1980 MAYBELL AERIAL PHOTOGRAPH

COLORADO DEPARTMENT OF PUBLIC HEALTH & ENVIRONMENT

MAYBELL RECLAMATION PROJECT

PRE/POST RECLAMATION PHOTOS

MOFFAT COUNTY, COLORADO

MARCH 2006 FIGURE 6

SA900-FIG-6CDH.DWG

C06