Alton Coal Development, LLC
Florida Extension Office
6602 Ilex Circle
Naples, Florida 34109
Phone (239) 825-2332

Date: March 31, 2017

Daron R. Haddock
Coal Program Manager
Oil, Gas & Mining
1594 West North Temple, Suite 1210
Salt Lake City, UT 84114-5801

Subject: 2016 Coal Mining Annual Report; Alton Coal Development LLC, Coal Hollow Mine, C/025/0005

Dear Mr. Haddock,

Alton Coal Development, LLC is providing the 2016 Coal Mining Annual Report for the Coal Hollow Mine. The completed report and attachments have been electronically submitted by uploading to the Divisions ePermitting site.

Please let me know if you have any questions or concerns.

Sincerely

B. Kirk Nicholes
Resident Agent

# APPLICATION FOR COAL PERMIT PROCESSING

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

**Permittee:** Alton Coal Development, LLC
**Mine:** Coal Hollow Mine **Permit Number:** C/025/0005
**Title:** MRP Annual Report 2016 amendments to permit
**Description,** Include reason for application and timing required to implement:
Addition of new topsoil analysis

**Instructions:** If you answer yes to any of the first eight questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
*Explain*: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☐ Yes ☒ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☐ Yes ☒ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☐ Yes ☒ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?
☐ Yes ☒ No 24. Does the application include confidential information and is it clearly marked and separated in the plan?

**Please attach three (3) review copies of the application. If the mine is on or adjacent to Forest Service land please submit four (4) copies, thank you.** (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

| B. Kirk Nicholes | Resident Agent | 03/31/2017 | B. Kirk Nicholes |
|---|---|---|---|
| Print Name | Position | Date | Signature (Right-click above choose certify then have notary sign below) |

Subscribed and sworn to before me this 31 day of March, 2017

Notary Public: Marty Nicholes, state of Utah.

My commission Expires: 670359
Commission Number: 9-11-2017
Address: 1670 E Millstone Cir
City: Enoch State: UT Zip: 84721

Notary Public
MARTY NICHOLES
Commission #670359
My Commission Expires
Sept 11, 2017
State of Utah

| For Office Use Only: | Assigned Tracking Number: | Received by Oil, Gas & Mining |
|---|---|---|
| | | |

Form DOGM- C1 (Revised December 10, 2007)

# APPLICATION FOR COAL PERMIT PROCESSING
## Detailed Schedule Of Changes to the Mining And Reclamation Plan

**Permittee:** Alton Coal Development, LLC
**Mine:** Coal Hollow Mine
**Permit Number:** C/025/0005
**Title:** MRP Annual Report 2016 amendments to permit

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

| | | | DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED |
|---|---|---|---|
| ☒ Add | ☐ Replace | ☐ Remove | (01)Chapter 2, Appendix 2-2 (Cont.), 2016 Soil Analysis (add to end of appendix 2-2) |
| ☐ Add | ☒ Replace | ☐ Remove | (02)Chapter 5, Drawing 5-38 |
| ☐ Add | ☒ Replace | ☐ Remove | (03)Chapter 5, Drawing 5-76A |
| ☐ Add | ☒ Replace | ☐ Remove | (04)Chapter 5, Drawing 5-76B |
| ☐ Add | ☒ Replace | ☐ Remove | (05)Chapter 3, Appendix 3-6 (replace 2016 report only) |
| ☒ Add | ☐ Replace | ☐ Remove | (06)Volume 9, Chapter 4, Appendix 4-7 (add to end of Appendix) (Confidential) |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |
| ☐ Add | ☐ Replace | ☐ Remove | |

| Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan. | Received by Oil, Gas & Mining |
|---|---|
| | |

# Appendix 2-2 (cont.)

2016 Soil Analysis Results

Inter-Mountain Labs
Your Environmental Monitoring Partner
1673 Terra Avenue, Sheridan, Wyoming 82801 ph: (307) 672-8945

**Date:** 9/29/2016

**CLIENT:** Alton Coal Development, LLC
**Project:** Coal Hollow Reclamation
**Lab Order:** S1608481

# CASE NARRATIVE

**Report ID:** S1608481001

Samples 16TS-1, 16TS-10, 16TS-13, 16TS-2, 16TS-3, 16TS-4, 16TS-5, 16TS-6, and 16TS-9 were received on August 29, 2016.

Samples were analyzed using the methods outlined in the following references:

U.S.E.P.A. 600/2-78-054 "Field and Laboratory Methods Applicable to Overburden and Mining Soils", 1978
American Society of Agronomy, Number 9, Part 2, 1982
USDA Handbook 60 "Diagnosis and Improvement of Saline and Alkali Soils", 1969
Wyoming Department of Environmental Quality, Land Quality Division, Guideline No. 1, 1984
New Mexico Overburden and Soils Inventory and Handling Guideline, March 1987
State of Utah, Division of Oil, Gas, and Mining: Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining, April 1988
Montana Department of State Lands, Reclamation Division: Soil, Overburden, and Regraded Spoil Guidelines, December 1994
State of Nevada Modified Sobek Procedure
Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition

All Quality Control parameters met the acceptance criteria defined by EPA and Inter-Mountain Laboratories except as indicated in this case narrative.

Reviewed by: Karen A Secor
Karen Secor, Soil Lab Supervisor

Inter-Mountain Labs
1673 Terra Avenue, Sheridan, Wyoming 82801 ph: (307) 672-8945

Your Environmental Monitoring Partner

# Soil Analysis Report

**Alton Coal Development, LLC**
463 North 100 West
Suite 1
Cedar City, UT 84721

Report ID: S1608481001

Project: Coal Hollow Reclamation
Date Received: 8/29/2016

Date Reported: 9/29/2016
Work Order: S1608481

| Lab ID | Sample ID | pH s.u. | Potassium ppm | Phosphorus ppm | Nitrate(as N) ppm |
|---|---|---|---|---|---|
| S1608481-001 | 16TS-1 | 8.1 | 266 | 9 | 16.3 |
| S1608481-002 | 16TS-2 | 8.0 | 273 | 9 | 12.6 |
| S1608481-003 | 16TS-3 | 8.0 | 255 | 9 | 13.5 |
| S1608481-004 | 16TS-4 | 7.9 | 218 | 7 | 16.6 |
| S1608481-005 | 16TS-5 | 7.9 | 230 | 6 | 14.5 |
| S1608481-006 | 16TS-6 | 8.0 | 243 | 7 | 13.5 |
| S1608481-007 | 16TS-9 | 7.8 | 310 | 14 | 58.5 |
| S1608481-008 | 16TS-10 | 7.9 | 269 | 9 | 66.5 |
| S1608481-009 | 16TS-13 | 7.7 | 271 | 17 | 29.5 |

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: Karen A Secor
Karen Secor, Soil Lab Supervisor

**Inter-Mountain Labs**
Sheridan, WY and Gillette, WY

# - CHAIN OF CUSTODY RECORD -

*All shaded fields must be completed.*
This is a legal document: any misrepresentation may be construed as fraud.

Page 1 of 1
# 152498

| Client Name | Project Identification | Sampler (Signature/Attestation of Authenticity) | Telephone # |
|---|---|---|---|
| Alton Coal Development, LLC | Coal Hollow Reclamation | B. Kirk Nicholes | 435-691-1551 |

| Report Address | Contact Name | Purchase Order # | Quote # |
|---|---|---|---|
| 463 N 100 W Suite 1<br>Cedar City, Utah 84721 | Kirk Nicholes<br>Email: Knicholes@altoncoal.com<br>Phone: 435-691-1551 | | |

Invoice Address: Same

| ITEM | LAB ID (Lab Use Only) | DATE SAMPLED | TIME SAMPLED | SAMPLE IDENTIFICATION | Matrix | # of Containers | Available Phosphorus | Soluble Potassium | Nitrate-Nitrogen | Paste pH | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 51608481-001 | 8/24/16 | | 16TS-1 | SL | 1 | X | X | X | X | | | | | |
| 2 | -002 | | | 16TS-2 | | 1 | X | X | X | X | | | | | |
| 3 | -003 | | | 16TS-3 | | 1 | X | X | X | X | | | | | |
| 4 | -004 | | | 16TS-4 | | 1 | X | X | X | X | | | | | |
| 5 | -005 | | | 16TS-5 | | 1 | X | X | X | X | | | | | |
| 6 | -006 | | | 16TS-6 | | 1 | X | X | X | X | | | | | |
| 7 | -007 | | | 16TS-9 | | 1 | X | X | X | X | | | | | |
| 8 | -008 | | | 16TS-10 | | 1 | X | X | X | X | | | | | |
| 9 | -009 | | | 16TS-13 | | 1 | X | X | X | X | | | | | |
| 10 | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | |

| LAB COMMENTS | Relinquished By (Signature/Printed) | DATE | TIME | Received By (Signature/Printed) | DATE | TIME |
|---|---|---|---|---|---|---|
| | | | | Karen A Secor | 8/29/16 | 0850 |

**SHIPPING INFO**
- [x] UPS
- [ ] Fed Express
- [ ] US Mail
- [ ] Hand Carried
- [ ] Other _____

**MATRIX CODES**

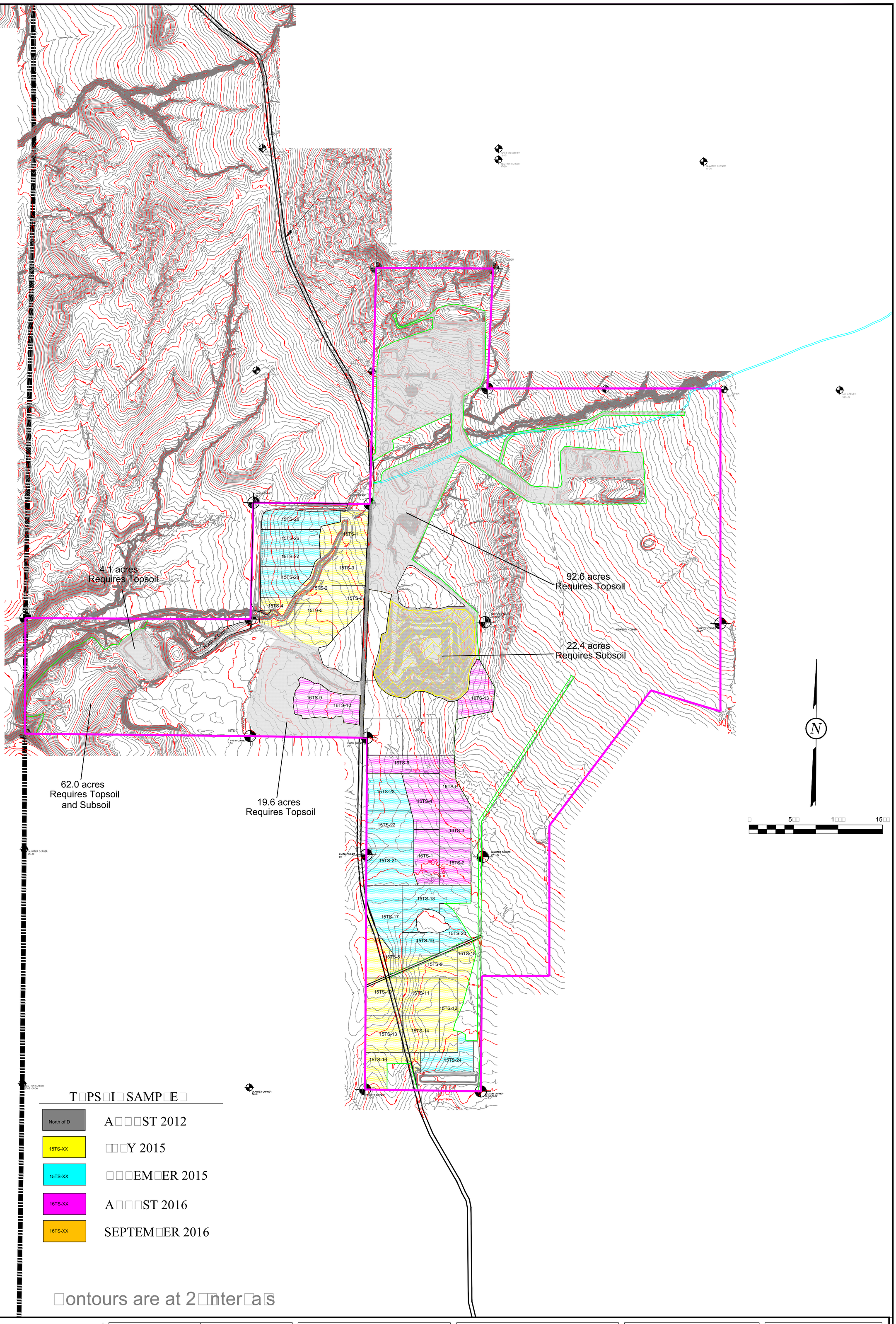
| | |
|---|---|
| Water | WT |
| Soil | SL |
| Solid | SD |
| Filter | FT |
| Other | OT |

**TURNAROUND TIMES**
Check desired service
- [x] Standard turnaround
- [ ] RUSH - 5 Working Days
- [ ] URGENT - < 2 Working Days

*Rush & Urgent Surcharges will be applied*

**COMPLIANCE INFORMATION**
Compliance Monitoring? Y / N
Program (SDWA, NPDES,...)
PWSID / Permit #
Chlorinated? Y / N
Sample Disposal: Lab Client

**ADDITIONAL REMARKS**




T□PS□I□ SAMP□E□

| | |
|---|---|
| North of D | A□□□ST 2012 |
| 15TS-XX | □□□Y 2015 |
| 15TS-XX | □□□EM□ER 2015 |
| 16TS-XX | A□□□ST 2016 |
| 16TS-XX | SEPTEM□ER 2016 |

□ontours are at 2□nter□a□s

LEGEND:

- PERMIT BOUNDARY
- PRIVATE COAL OWNERSHIP
- SECTION LINE
- FOUND SECTION CORNER
- FOUND PROPERTY CORNER
- BONDED AREA

| DRAWN BY: | CHECKED BY: |
|---|---|
| K NICHOLES | LWJ |
| DRAWING: FIGURE 1 | DATE: 10/17/2015 |
| | SCALE: 1" = 500' Printed on 24"x 36" |
| JOB NUMBER: 1400 | SHEET |

REVISIONS

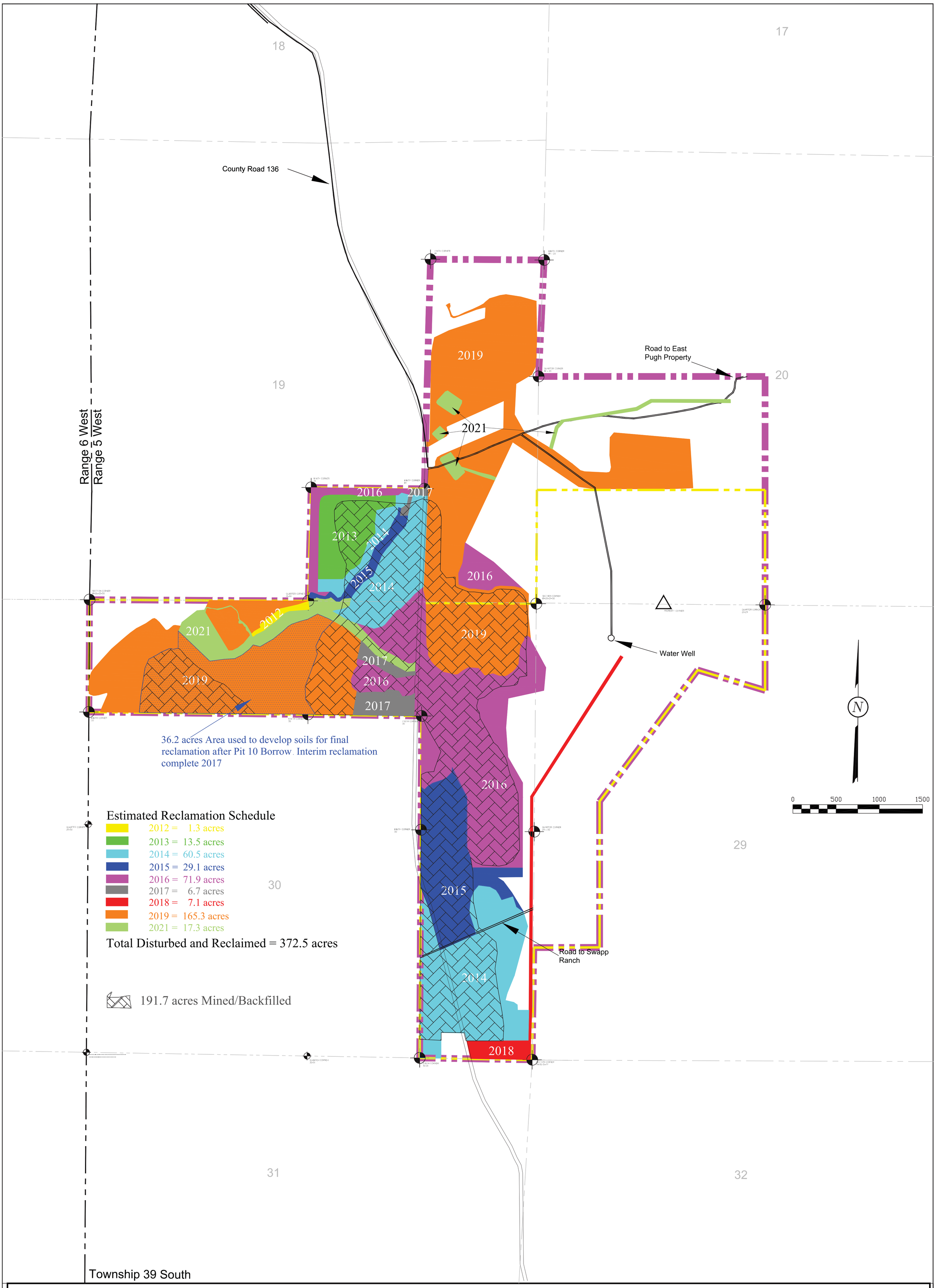
| DATE: | BY: |
|---|---|
| 06/30/16 | □N |
| 03/30/17 | □N |
| | |
| | |
| | |
| | |
| | |

TOPSOIL SAMPLING LOCATIONS

COAL HOLLOW PROJECT
ALTON, UTAH

FIGURE 1

Alton Coal Development
Coal Hollow Project
463 North 100 West, Suite 1
Cedar City, Utah 84721
Phone (435)867-5331
Fax (435)867-1192




LEGEND:

- PERMIT BOUNDARY
- PRIVATE COAL OWNERSHIP
- SECTION LINE
- FOUND SECTION CORNER
- FOUND PROPERTY CORNER
- POSTMINING ROADS

| DRAWN BY: | CHECKED BY: |
|---|---|
| K. NICHOLES | LWJ |
| DRAWING: 5—38 | DATE: 12/18/2014 |
| | SCALE: 1" = 500' |
| JOB NUMBER: 1400 | SHEET |

REVISIONS

| DATE: | BY: |
|---|---|
| 03/05/14 | KN |
| 04/11/16 | KN |
| 07/29/16 | KN |
| 08/01/16 | KN |
| 03/31/17 | KN |
| | |
| | |

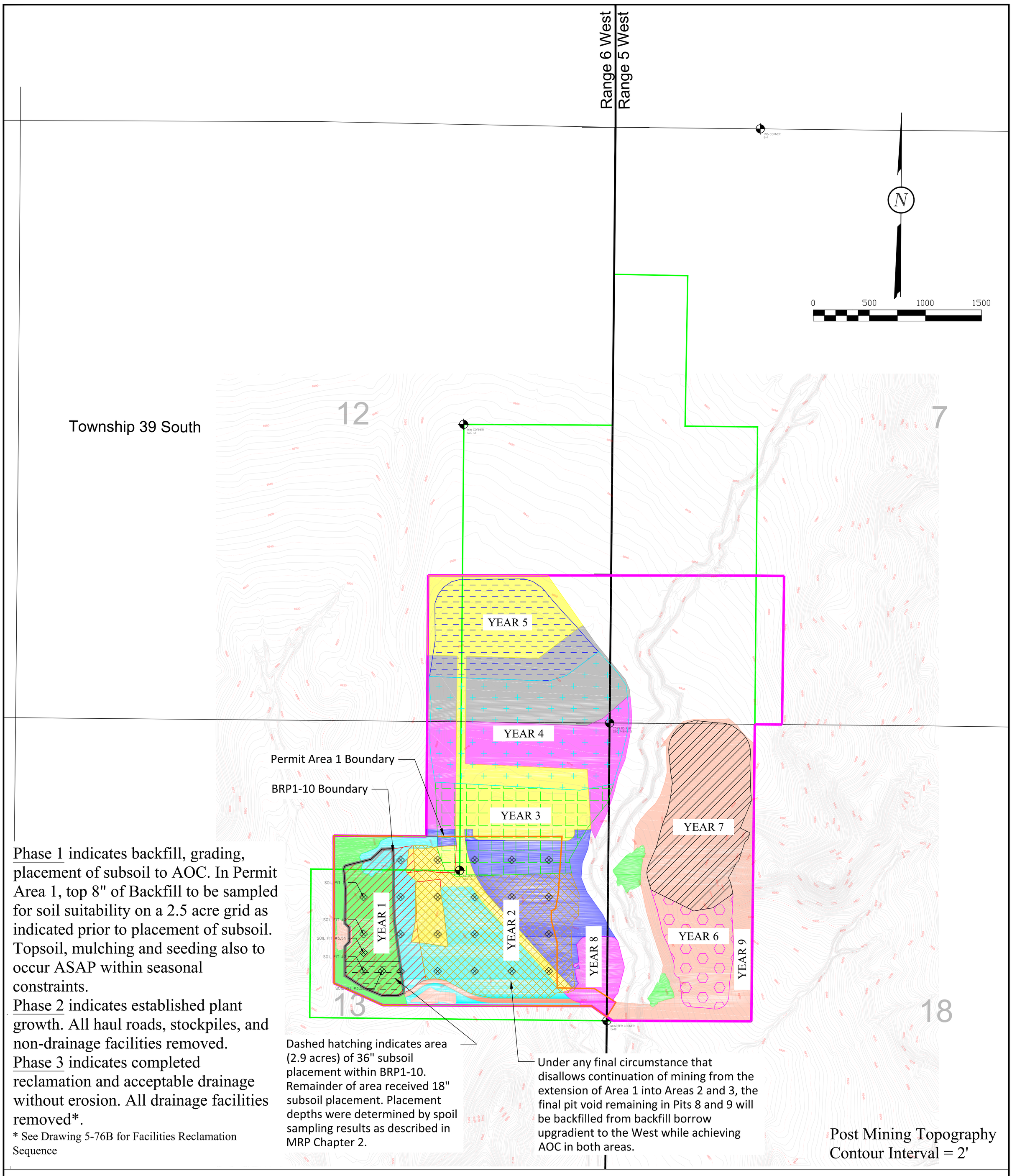
RECLAMATION SEQUENCE

COAL HOLLOW PROJECT
ALTON, UTAH

DRAWING: 5-38

UTAH REGISTERED #154168 DAN W. GUY PROFESSIONAL ENGINEER

Alton Coal Development
Coal Hollow Project




Phase 1 indicates backfill, grading, placement of subsoil to AOC. In Permit Area 1, top 8" of Backfill to be sampled for soil suitability on a 2.5 acre grid as indicated prior to placement of subsoil. Topsoil, mulching and seeding also to occur ASAP within seasonal constraints.

Phase 2 indicates established plant growth. All haul roads, stockpiles, and non-drainage facilities removed.

Phase 3 indicates completed reclamation and acceptable drainage without erosion. All drainage facilities removed*.

* See Drawing 5-76B for Facilities Reclamation Sequence

Phase 1 Reclamation:

- Year 1 Reclaim = 17.9 Acres
- Year 2 Reclaim = 34.7 Acres
- Year 3 Reclaim = 24.1 Acres
- Year 4 Reclaim = 39.3 Acres
- Year 5 Reclaim = 24.3 Acres
- Year 6 Reclaim = 11.6 Acres
- Year 7 Reclaim = 26.4 Acres
- Year 8 Reclaim = 00.0 Acres
- Year 9 Reclaim = 00.0 Acres

Total Ph. 1 Reclamation = 178.4 Acres

Phase 2/Surface Mulch & Seeding:

- Year 1 Seeding = 16.2 Acres
- Year 2 Seeding = 25.0 Acres
- Year 3 Seeding = 22.3 Acres
- Year 4 Seeding = 22.2 Acres
- Year 5 Seeding = 23.8 Acres
- Year 6 Seeding = 49.3 Acres
- Year 7 Seeding = 57.8 Acres
- Year 8 Seeding = 5.8 Acres
- Year 9 Seeding = 2.5 Acres

Total Ph. 2 Reclamation = 224.9 Acres

Phase 3 Reclamation to be completed and released within the 5-10 year timeframe from Phase 1.

LEGEND:

- PERMIT BOUNDARY
- PRIVATE COAL OWNERSHIP
- SECTION LINE
- FOUND SECTION CORNER
- FOUND PROPERTY CORNER
- BACKFILL SAMPLE PIT

| DRAWN BY: | CHECKED BY: |
|---|---|
| A. CHRISTENSEN | DWG |
| DRAWING: 5-76A | DATE: 4/16/15 |
| | SCALE: 1" = 400' |
| JOB NUMBER: 0001 | SHEET |

REVISIONS

| DATE: | BY: |
|---|---|
| 8/15/16 | AC |
| 9/7/16 | AC |
| 10/3/16 | AC |
| 12/14/16 | AC |
| 1/5/17 | AC |
| 2/2/17 | AC |
| 3/31/17 | AC |

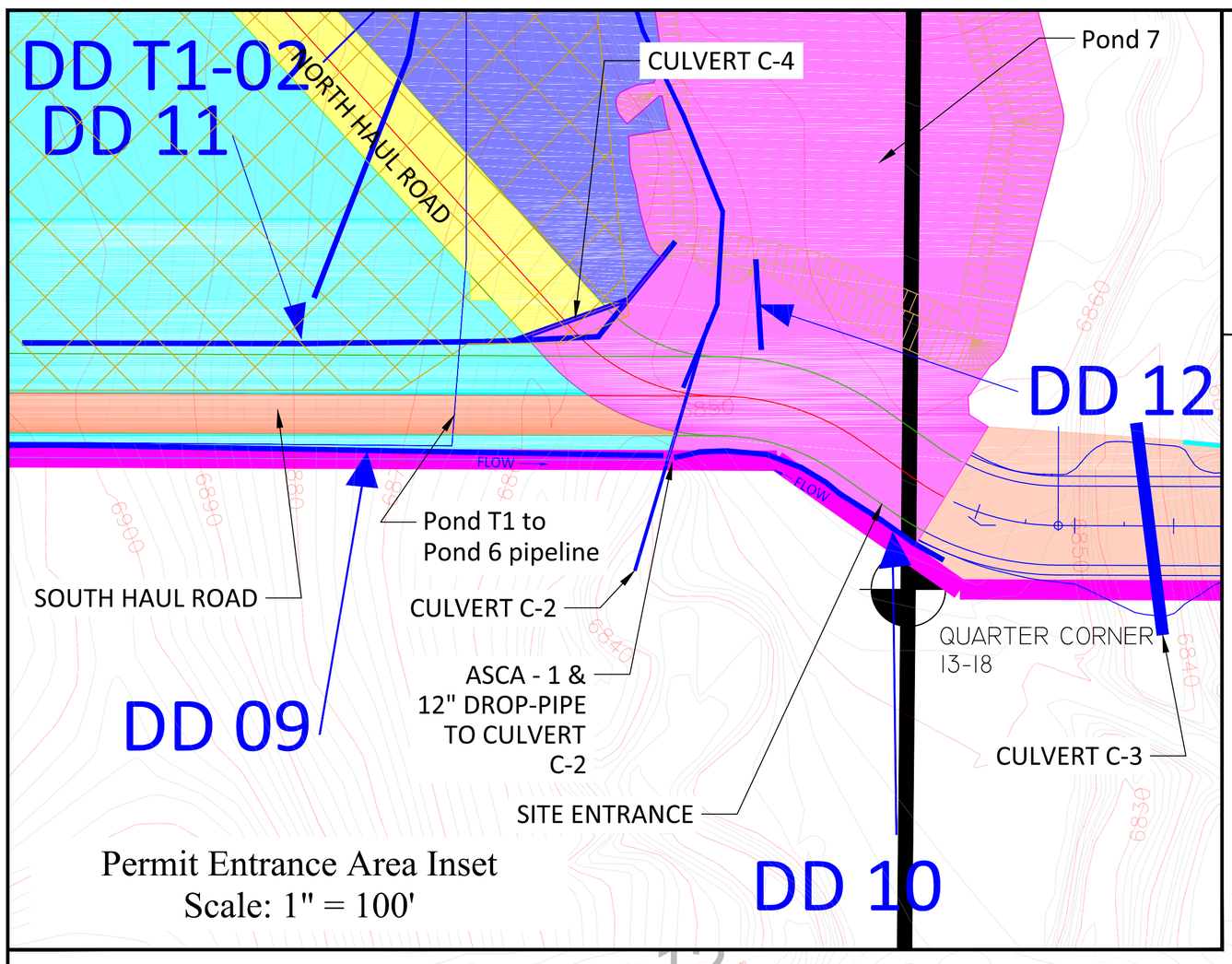
EARTHWORKS RECLAMATION SEQUENCE

NORTH COAL HOLLOW PROJECT
ALTON, UTAH

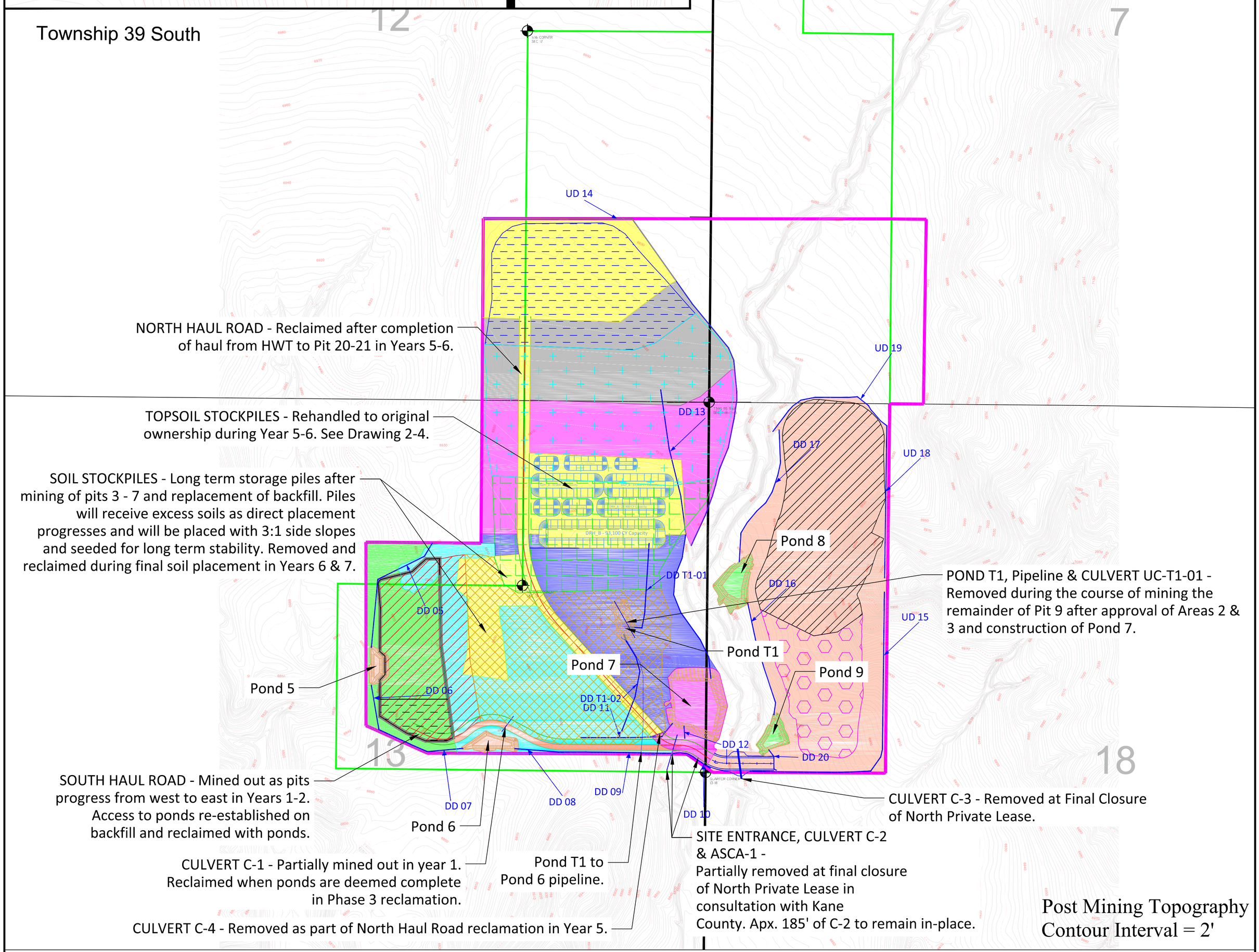
DRAWING: 5-76A

UTAH REGISTERED PROFESSIONAL ENGINEER #154168 DAN W. GUY

Alton Coal Development
Coal Hollow Project
463 North 100 West, Suite 1
Cedar City, Utah 84721
Phone (435)867-5331
Fax (435)867-1192




Permit Entrance Area Inset
Scale: 1" = 100'




Post Mining Topography
Contour Interval = 2'

Phase 1 Reclamation:

- Year 1 Reclaim = 17.9 Acres
- Year 2 Reclaim = 34.7 Acres
- Year 3 Reclaim = 24.1 Acres
- Year 4 Reclaim = 39.3 Acres
- Year 5 Reclaim = 24.3 Acres
- Year 6 Reclaim = 11.6 Acres
- Year 7 Reclaim = 26.4 Acres
- Year 8 Reclaim = 00.0 Acres
- Year 9 Reclaim = 00.0 Acres

Total Ph. 1 Reclamation = 178.4 Acres

Phase 2/Surface Mulch & Seeding:

- Year 1 Seeding = 16.2 Acres
- Year 2 Seeding = 25.0 Acres
- Year 3 Seeding = 22.3 Acres
- Year 4 Seeding = 22.2 Acres
- Year 5 Seeding = 23.8 Acres
- Year 6 Seeding = 49.3 Acres
- Year 7 Seeding = 57.8 Acres
- Year 8 Seeding = 5.8 Acres
- Year 9 Seeding = 2.5 Acres

Total Ph. 2 Reclamation = 224.9 Acres

Phase 3 Reclamation to be completed and released within the 5-10 year timeframe from Phase 1. **Ponds, culverts and ditches (except Area 1 extension)** to be assessed and reclaimed as Phase 3 nears completion. Area 1-A structures will be removed as mining advances.

Contour Interval = 2'

LEGEND:

- PERMIT BOUNDARY
- PRIVATE COAL OWNERSHIP
- SECTION LINE
- FOUND SECTION CORNER
- FOUND PROPERTY CORNER

| DRAWN BY: | CHECKED BY: |
|---|---|
| A. CHRISTENSEN | DWG |
| DRAWING: 5-76B | DATE: 10/12/15 |
| | SCALE: 1" = 400' |
| JOB NUMBER: 0001 | SHEET |

REVISIONS

| DATE: | BY: |
|---|---|
| 12/1/2015 | AC |
| 12/15/2015 | AC |
| 1/8/16 | AC |
| 8/15/16 | AC |
| 9/7/16 | AC |
| 10/3/16 | AC |
| 3/31/16 | AC |

FACILITIES RECLAMATION SEQUENCE

NORTH COAL HOLLOW PROJECT
ALTON, UTAH

DRAWING: 5-76B

UTAH REGISTERED PROFESSIONAL ENGINEER #154168 DAN W. GUY

Alton Coal Development
Coal Hollow Project
463 North 100 West, Suite 1
Cedar City, Utah 84721
Phone (435)867-5331
Fax (435)867-1192

# Greater Sage-grouse Population Monitoring and Habitat Improvement

## Alton - Sink Valley, Utah

# Progress Report

**For**

## Alton Coal Development, LLC

**December 26, 2016**

**Prepared by**
**Steven L. Petersen, Ph.D.**
**Sage-grouse Population and Habitat Consultant**

# Greater Sage-grouse Population Monitoring and Habitat Improvement Alton – Sink Valley, Utah

## Progress Report for Year 2015-2016

**Steven L. Petersen, Ph.D., Consultant**

### Introduction and Background

The Alton/Sink Valley area, located in southcentral Utah, is home to the citizens of a thriving local community and is habitat to a diversity of plant and animal species. One species, the greater sage-grouse (*Centrocercus urophasianus*), has lived in this area for decades, sharing this landscape with ranchers, farmers, and recreationists. In 2010, Alton Coal Development (ACD) initiated mining operations in Sink Valley, extracting and exporting coal for energy production in Delta, Utah.

The conservation of greater sage-grouse in the Alton/Sink Valley area continues to be a high priority for ACD. The local sage-grouse population has remained stable throughout the life of the mine, and extensive work is done to ensure healthy sagebrush habitats. In comparison to challenges managers often face with declining sage-grouse populations speices-wide, the Sink Valley population is one of the few that have been able to demonstrate long-term population stability (Boyd et al. 2010, Petersen et al. 2016). Habitat management goals and improvements have included the reclamation of mine-related disturbances (including the historic lek), removing pinyon-juniper trees to extend sagebrush communities and increase habitat use potential (Baruch-Mordo et al. 2013, Braun et al. 1977, Doherty et al. 2008), and controlling sage-grouse predator species (i.e. ravens and coyotes).

A summary of the specific sage-grouse population monitoring and habitat conservation accomplishments for 2015-2016 include the following.

1. During non-breeding months, birds were consistently observed in the Sink Valley area, primarily in the sagebrush fields and bullhogged area southwest of the mine.
2. In October, 53 birds were observed in the mine area, the highest reported during any monthly survey in 2016.
3. ACD employees made 54 observations of birds within the immediate mining area, including inside mining pits and trenches.
4. DWR reported 15 strutting males in spring 2016. This is the highest reported lek count since 2001.
5. Reclaimed areas following the completion of mining activities in the south valley (historic lek area). Seeded plants included native and introduced grasses and forbs. Shrubs (i.e. big

and black sagebrush) are establishing within these reclaimed sites, resulting in early succession of potential sagebrush dominated communities.

6. Wildlife Services removed approximately 158 ravens and 3 coyotes.

*Report Objectives*

The purpose of this report is to present the accomplishments and sage-grouse conservation efforts that were completed during the 2015-2016 period (described above). This includes results of the sage-grouse monitoring program, data collection and assessment of reclamation efforts, additional habitat improvements, and predator control.

## Table of Contents


Introduction and Background ..... 2

*Report Objectives* ..... 3

Table of Contents ..... 3

1. Sage-grouse Population Monitoring ..... 4

*1.1 Employee Observations and Sage-grouse Population Monitoring* ..... 4

*1.2 Sage-grouse Surveys* ..... 9

*1.3 GPS Collaring and Monitoring* ..... 13

*1.4 Historic and Current Lek use in Alton/Sink Valley* ..... 17

*1.5. Manuscript production and publication* ..... 18

*1.6 Noise Detection and Sound Assessment* ..... 18

2. Habitat Mitigation and Improvements ..... 18

*2.1 Reclamation Response* ..... 18

*2.2 Juniper Mastication* ..... 23

3. Predator Control Activities ..... 24

*3.1 Raven Control* ..... 24

4. Participation and Involvement with Local Working Groups ..... 27

References ..... 27

Acknowledgements ..... 27

## 1. Sage-grouse Population Monitoring

*1.1 Employee Observations and Sage-grouse Population Monitoring*

During the year, ACD employees report any sightings of sage-grouse observed within the mining area. These observations are reported to Kirk Nicholes, ACD Environmental Manager, who keeps a log of all observations. Typical observations include sightings along roadsides, within mine sites and disturbed areas, and near ponds.

All ACD employee observations are casual (employees are not charged to survey for birds). While sighting locations may suggest spatio-temporal seasonal variability in sage-grouse occurrence within the mine footprint, variability in observations may be a result of heightened awareness by employees rather than an increase in bird use activity or density.

Of special note, employees frequently observed males strutting with females present within and surrounding the reclaimed historic Lek. The highest number of birds observed near the reclaimed historic lek was 12 males and 12 females.

ACD mine employee are trained in sage-grouse conservation strategies, and how to identify sage-grouse from other bird species. When reported, Kirk determines the exact location where birds were observed and identifies the coordinate location for that observation. The results of these sightings are used to assess population patterns and trends within the mining area (Table 1, Figure 1). This information is used to assess habitat use patterns.

Table 1. Observations of sage-grouse reported by ACD employees between October 2015 and December 2016 within the Alton/Sink Valley region.

| Obs ID | Date | Time of observation | Number of birds Observed | Location | State Plane Coordinates |
|---|---|---|---|---|---|
| 1 | Oct. 13, 2015 | 8:00 am | 4 | Observed east of the highwall trench backfilling operation (Scott C.) | 351029 E 1768930 N |
| 2 | Oct. 14, 2015 | 11:00 am | 7 | Observed at base of subsoil stockpile from the excess spoils (Scott C.) | 354724 E 1768190 N |
| 3 | Oct. 26, 2015 | 8:00 am | 15 | Crew observed 15 in field south of the excess spoils pile (Riley A.) | 352591 E 1766302 N |
| 4 | Oct. 27, 2015 | 9:25 am | 20 | Observed in field south of the excess spoils pile (Scott C.) | 352585 E 1766233 N |
| 5 | Oct. 28, 2015 | 7:35 am | 17 | Observed at northwest side of the new lek area (Cody M.) | 351500 E 1765033 N |
| 6 | Nov. 3, 2015 | 7:30 am | 4 | Observed on haul road to spoils pile (Cody M.) | 353674 E 1767438 N |
| 7 | Nov. 11, 2015 | 8:45 am | 4 | Observed north of topsoil stockpile #4 (Davey J.) | 354630 E 1768868 N |
| 8 | Nov. 24, 2015 | 10:45 am | 2 | Observed at the wildlife exclosure fence. Birds flew to the west (Larry J.) | 364563 E 1762222 N |
| 9 | Jan. 9, 2016 | 11:30 am | 16 | Observed between pit #10 and Robinson Creek (Riley A.) | 353782 E 1768066 N |
| 10 | Jan 12, 2016 | 8:10 am | 18 | Observed between pit #10 and Robinson Creek (Riley A.) | 353711 E 1768066 N |
| 11 | Jan. 13, 2016 | 7:43 am | 25 | Observed between pit #10 and Robinson Creek, down in snow (Scott C.) | 353809 E 1767725 N |
| 12 | Jan. 18, 2016 | 8:00 am | 16 | Observed at CHM excess spoils pile (Riley A.) | 357879 E 1766283 N |
| 13 | Jan. 19, 2016 | 9:00 am | 20 | Observed in the reclamation area below the haul road (Larry J.) | 354473 E 1767888 N |
| 14 | Jan. 25, 2016 | 5:30 am | 3 | Observed at CHM excess spoils pile by a parked loader (Davey J.) | 352919 E 1765910 N |
| 15 | Feb. 2, 2016 | 3:52 pm | 25 | Flying from subsoil stockpile #2 over the lower portion of Robinson Creek (Rod R.) | 354652 E 1768231 N |
| 16 | Feb. 8, 2016 | 10:00 am | 25 | Observed flying over the excess spoils pile (ACD) | 352975 E 1766077 N |
| 17 | Feb. 9, 2016 | 10:00 am | 25 | Observed flying over the excess spoils pile (ACD) | 352905 E 1766101 N |
| 18 | Feb. 10, 2016 | 10:10 am | 25 | Observed flying over the excess spoils pile (ACD) | 352975 E 1766111 N |
| 19 | Feb. 12, 2016 | 10:00 am | 15 | Observed south of pit #10 (Joe K.) | 353397 E 1765774 N |
| 20 | Feb. 16, 2016 | 5:00 pm | 20 | Observed at Red Dog Hill (Jack K.) | 353397 E 1765774 N |
| 21 | Feb. 17, 2016 | 7:46 am | 4 | Observed at the east entrance of pit #10 (Rod R.) | 354176 E 1768415 N |
| 22 | Feb. 23, 2016 | 7:15 am | 6 | Observed at the southeast side of subsoil pile #2 (Davey J.) | 354582 E 1768256 N |

Table 1 (*continued*).

| Obs ID | Date | Time of observation | # of birds Observed | Location | UTM Coordinates |
|---|---|---|---|---|---|
| 24 | Feb. 29, 2016 | 6:40 am | 8 | Observed between Robinsons Creek and the county road (Riley A.) | 354582 E 1767883 N |
| 25 | Mar. 7, 2016 | 6:40 am | 8 | Observed on the reclaimed area by ditch #4 (where the berm runs east-west) (Riley A.) | 353903 E 1766698 N |
| 26 | Mar. 11, 2016 | 10:44 am | 2 | Observed between the southwest corner of NPL Area 1 (Drew C.) | 362311 E 1762039 N |
| 27 | Mar. 16, 2016 | 6:25 am | 6 | Observed between the subsoil and topsoil stockpile (Riley A.) | 355606 E 1760506 N |
| 28 | Mar. 17, 2016 | 8:30 am | 20 | Observed birds on both sides of Dames Road (Cody M.) | 350135 E 1768675 N |
| 29 | Mar. 17, 2016 | 8:30 am | 10 | Observed where pipe comes from pit #10 (Cody M.). | 353748 E 1768126 N |
| 30 | Mar. 18, 2016 | 8:40 am | 24 | 12 male strutting, 12 females historic lek N. of Dame Road (Joe K.) | 350388 E 1768447 N |
| 31 | Mar. 24, 2016 | 7:49 am | 2 | Males strutting at the reclamation site on pit #10 (Riley A.) | 353672 E 1768119 N |
| 32 | Mar. 24, 2016 | 9:05 am | 12 | Flyover at UG laydown going east into juniper trees (Larry J.) | 355676 E 1768767 N |
| 33 | Mar. 29, 2016 | 7:42 am | 4 | Males on west side of county road, west of pit #10 (Davey J.) | 353643 E 1767868 N |
| 34 | April 1, 2016 | 1:00 pm | 8 | One hen and 7 chicks at the well site (Kirk N.) | 353504 E 1770240 N |
| 35 | April 2, 2016 | 6:56 am | 4 | 3 males and 1 hen observed south of HWT, north of Dame road. Noise from truck, dozer, and loader at HWT backfill (59-61 Htz). Males flush. (Kirk N.) | 350388 E 1768447 N |
| 36 | April 2, 2016 | 7:13 am | 2 | Females, fly over HWT activity (Kirk N.) | 350317 E 1768438 N |
| 37 | April 2, 2016 | 7:29 am | 3 | Hens flushed from reclaim site south of Dames road. Activity at HWT: truck and loader (60-61 Htz), wind 0-3 mph. (Kirk N.) | 350317 E 1768438 N |
| 38 | April 27, 2016 | 7:45 am | 2 | Males at intersection of Dames road and the county road (Kirk N.) | 349918 E 1768307 N |
| 39 | May 11, 2016 | 8:00 am | 13 | Observed on reclaim site and county road near pond #4 (Larry J.) | 349057 E 1768500 N |
| 40 | May 13, 2016 | 8:07 am | 3 | Observed at the intersection of the haul road from the spoil and county road (Kirk N.) | 353301 E 1767852 N |
| 41 | June 7, 2016 | 7:30 am | 30 | 4-5 hens with 6-7 chicks each flew into conservation area (Cody M.) | 353570 E 1770248 N |
| 42 | June 8, 2016 | 7:30 am | 8 | Observed at the well (Cody M.) | 353505 E 1770347 N |
| 43 | June 24, 2016 | 9:04 am | 7 | 7 chicks 50' north of the well, flushed to the east (Joe K.) | 353586 E 1770196 N |
| 44 | June 24, 2016 | 9:04 am | 5 | Chicks walking on road toward the weather station (Joe K.) | 353549 E 1770447 N |

| | | | | | |
|---|---|---|---|---|---|
| 45 | June 24, 2016 | 11:20 am | 5 | Hens (1 collared) in the New Dame lease area (Steve Z. and Kirk N.) | 352454 E 1770106 N |
| 46 | July 8, 2016 | 7:35 am | 4 | 1 hen and 3 chicks at Dame north pond (Steve Z. and Kirk N.) | 351093 E 1769949 N |
| 47 | July 8, 2016 | 8:06 am | 5 | Flushed in front of cows 300' west of well site (Steve Z. and Kirk N.) | 353470 E 1769769 N |
| 48 | July 8, 2016 | 8:08 am | 2 | Flushed from below silver maples located near the orchard (Steve Z. and Kirk N.) | 353290 E 1770465 N |
| 49 | July 9, 2016 | 11:00 am | 4 | 1 hen and 3 chicks at Sorensen's place (Steve Z. and Kirk N.) | 351361 E 1770348 N |
| 50 | July 28, 2016 | 9:00 am | 4 | County road bypass at north cattle guard (Kirk N.) | 351594 E 1764940 N |
| 51 | Aug. 15, 2016 | 11:01 am | 10-12 | Flushed by the well (Riley A.) | 353556 E 1770371 N |
| 52 | Aug. 19, 2016 | 11:36 am | 8 | Hens and chicks south of the well (Riley A.) | 353242 E 1770194 N |
| 53 | Aug. 25, 2016 | 3:37 pm | 8 | Observed by the green gates on the reclaim site (Riley A.) | 352286 E 1768034 N |
| 54 | Sept. 9, 2016 | 12:04 pm | 4 | Observed near the well (Riley A.) | 353406 E 1770231 N |

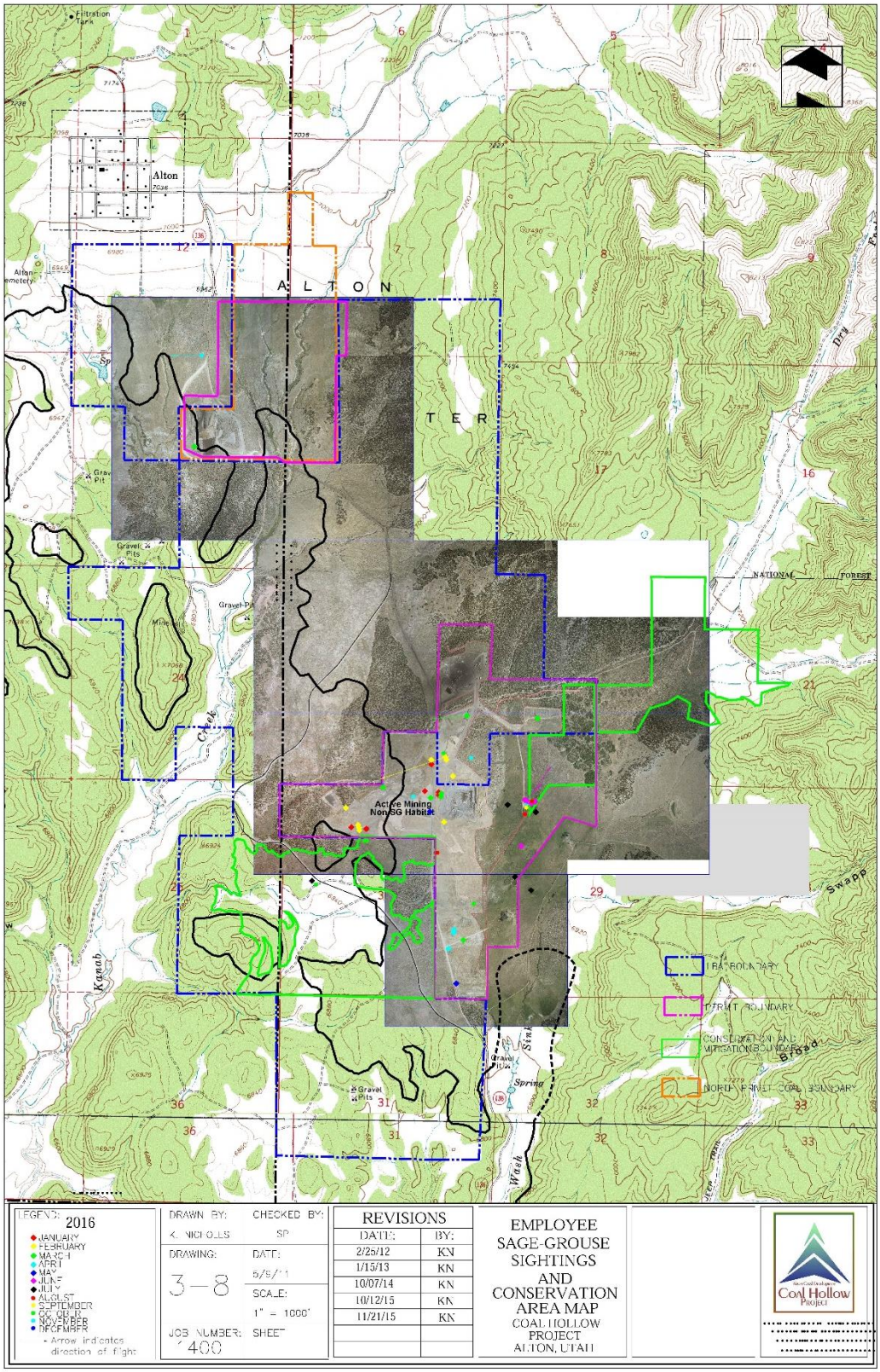



Figure 1. Location of sage-grouse observations made by ACD employees in 2016.

### *1.2 Sage-grouse Surveys*

Surveys were conducted by S. Petersen near the beginning of each month. The purpose of these surveys is to count the total number of sage-grouse observed within the Sink Valley and mining area. During breeding months, surveys are limited to non-nesting habitats and lek counts to prevent hens flushing from nests or disturbing hens with chicks during the early brood-rearing period. Habitats surveys are those dominated by sagebrush, primarily black and mountain big sagebrush.

Surveys are conducted by walking through each habitat along a pre-determined transects. Each time an individual bird or group of birds were observed, the coordinate position for that location was recorded (using GPS). The time of day and a decibel level (recorded during active mining periods) was also recorded.

During each survey, all areas where birds may be found were searched (Figure 2). These areas included 1) the sagebrush flat area 0.5 km south of the open coal pits (SF), 2) the new lekking area located at the top of the ridge at the south end of the sagebrush flat area, 3) the sagebrush patch located just south of the spoils pile (SMSP) and north of the spoils piles (NMSP), 4) the original lekking area (OL), 5) the wet meadow (WM) located in grass/rush/sedge community surrounding the well, 6) the sagebrush area immediately east of the open mine along the lower bench, 7) the conservation area east of the mine site along the upper bench (CA), 8) the bullhog area located south of the new lek, and 9) Ford's Pasture located 10 miles south of Sink Valley.

No dogs were used to assist in locating birds during survey. Over time as the bullhog effort continues, dogs may be beneficial with surveys due to the higher total acreage that should be surveyed.

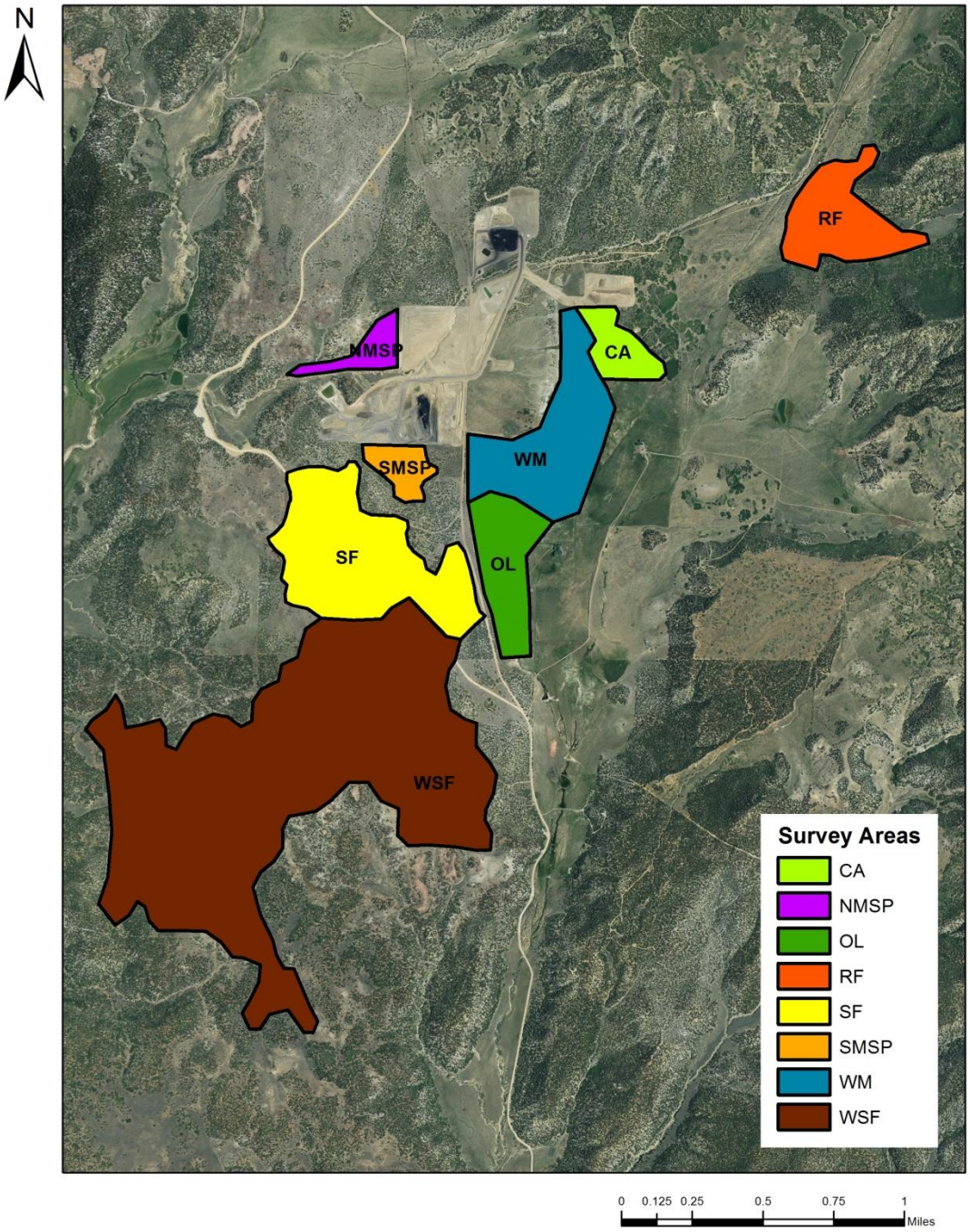



Figure 2. Location of survey areas for greater sage-grouse during the 2012-2016 monitoring seasons. CA = Conservation area, NMSP = North mine sagebrush patch, OL = Original lek, Rabbitbrush field, Sagebrush flat, SMSP = South mine sagebrush patch, WM = Wet meadow, and WSF = West sagebrush fields. Additional sites not shown above include the corridor (C) and the alfalfa fields (AF) south of Alton.

A summary of the results recorded for each monthly sage-grouse survey is provided in table 2. Of all sites observed during surveys, birds were most consistently found in the sagebrush flat area south of the mine, within the new lek area, in the bullhogged area south of the new lek, and in the region surrounding the conservation area (Figure 2).

Habitats where birds were most frequently observed are dominated by black sagebrush (*Artemisia nova* A. Nelson) and mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle). Within these habitats, other species are common including a diversity of perennial grasses and forbs. Chicks and young juveniles were consistently observed using habitat near the well on the east side of the mine (near the conservation area and in the lower sagebrush patch immediately adjacent to the active mining area east of the haul road).

Table 2. Observations from monthly surveys conducted by S.L. Petersen.

| Date | Time of observation | Number of birds | Location |
|---|---|---|---|
| Jan 1, 2016 | 8am-12pm | 40 | Flushed 14 birds at FP (10-11:15pm) while spotlighting. Flushed 26 birds from the spoils pile. No birds flushed in SF or surrounding area. No mining activity. |
| Feb 6, 2016 | 7am–12pm | 26 | 23 birds observed at the SF/NL, 12 males were at the lek (3 displaying). Observed 3 birds at FP, 2 hens and 1 male. Many roost piles and tracks (from 10-20 birds but not observed) |
| March 5, 2016 | 6:30-11am | 21-27 | No birds at FP. 12 males lekking on southeast end of NL and into the new SB. 6-7 hens observed near the lek. 2 males strutting on the west end of the NL. 3 birds at the scraped area (2 males, 1 hen). |
| April 2, 2016 | 6:30-11am | 18 | 8 males strutting at NL and in the middle of SB. 10 birds observed at reclaimed HL. Last week all 12 were observed lekking at that site. Survey limited to prevent flushing hens from nests. |
| May 2, 2016 | 6:30–10am | 21 | 18 birds flushed from the new lek site. 4 flushed on the lek road and east end of NL. Survey limited to prevent flushing hens from nests. Mining activity was high. |
| June 3, 2016 | 7–11am | 16 | 1 hen with 5 chicks in sagebrush flat. 10 birds observed in SB. |
| July 9, 2016 | 7–11am | 4 | 1 hen with 3 chicks from the west CA. |
| Aug 6, 2016 | 6:45am–11pm | 23-31 | All birds in SF and SB. Spotlighted FP. |
| Sept 3, 2016 | 7-11am | 45 | 42 birds in SF and SB. 2 in HL and 1 in upper CA. Spotlighted FP. |
| Oct 6, 2016 | 7:30-11am | 50-53 | 11 in SF, 11 at NL, 31 in SB. Spotlighted FP. |
| Nov 4, 2016 | 8-12am | 41 | 1 at FP (spotlighting). 23 in SF, 13 in SB, and flushed 4 out of CA (first time ever seeing birds in the mechanically treated sagebrush area). |
| Dec 3, 2016 | 7:30-11am | 10 | 4 in SF and 9 in SB. It was a windy and bitter cold. Birds were hesitant to flush. When they did, they didn't fly far. |

**Birds were surveyed along transects within each of the following area. SF** = sagebrush field located along the bypass haul road south of the mine, **MSP** = mine sagebrush patch located adjacent to (south) of the reclaimed area of pit #1, **HL** = historic lek located in Sink Valley, **FP** = Fords pasture located 10 miles south of the mine site, **SP** = Spoils Pile, **AF** = Alfalfa field, located immediately south of the town of Alton, **WSF** = West sagebrush fields located .5 to 1 mile west of SF, **WM** = wet meadow area located in close proximity to the well (pump) southwest of the conservation area, **CA** = conservation area, **NMSP** = North Mine Sagebrush Patch, **NL** = New lek located south of SF, **SB** = South Bullhog.

*1.3 GPS Collaring and Monitoring*

On November 2 and November 3, 2016, K. Nicholes assisted Dr. Nicki Frey and her crew trap birds in the Sink Valley area. On November 2, two hens were collared and 1 young male was caught and released without being collared because he had lost too many feathers during the trapping and collaring process. On November 3, 1 young female was trapped and collared. Of the two birds (one male, one female) that were trapped last year, the hen is still transmitting currently. However, the male is no longer transmitting a signal. Dr. Frey believes that the bird is still alive but that the backpack has malfunctioned.

Dr. Frey is currently monitoring all 4 birds. These data are used to assess habitat use and movement patterns (Figure 3, 4 and 5). All 3 collars were purchased by ACD for use in monitoring the Sink Valley population. Collars provide 4 point locations per day resulting in approximately 112 points per month per bird. ACD (Petersen) also assisted Dr. Frey and the BLM with trapping and collaring birds at the Dog Valley lek, north of Panguitch.

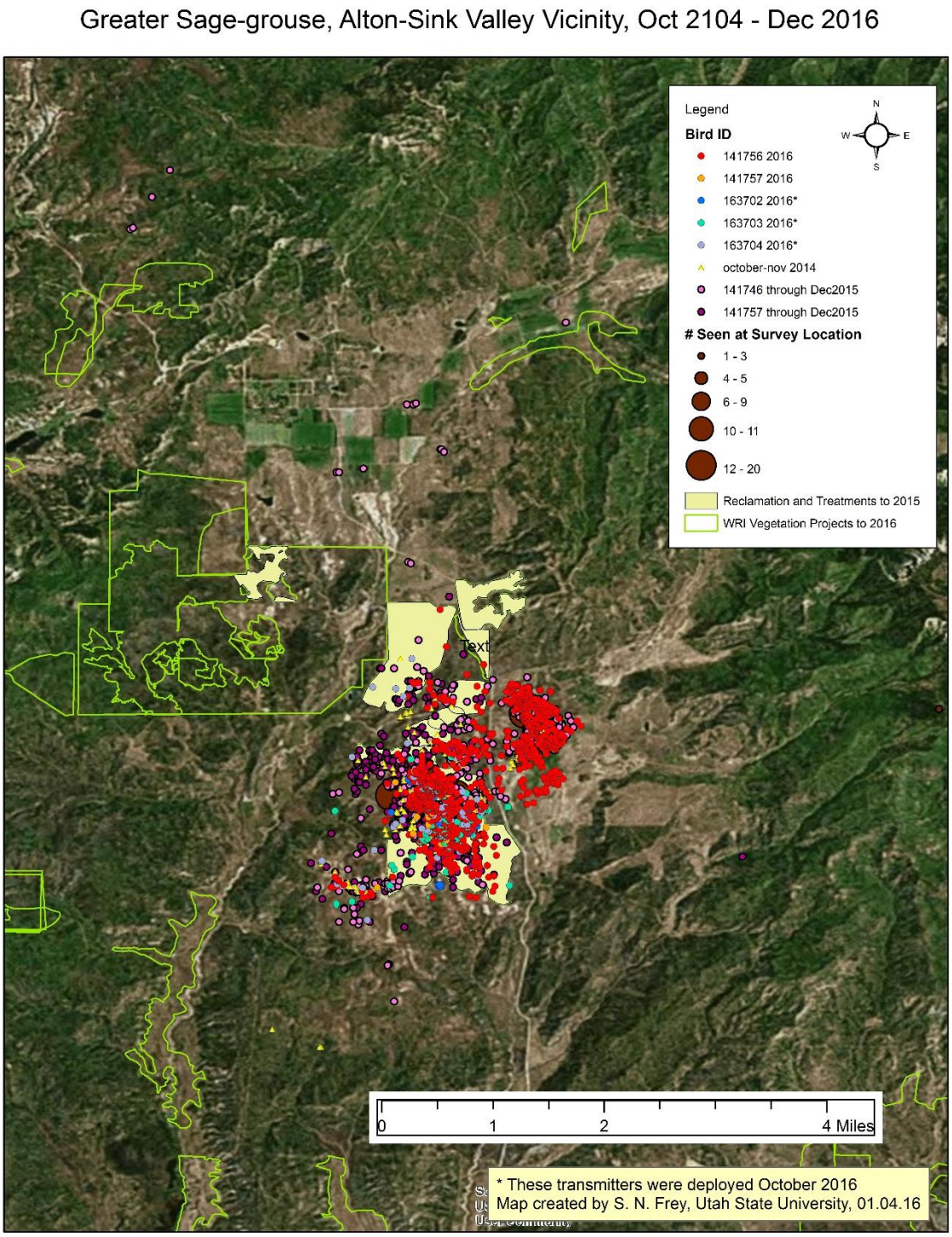



Figure 3. Location of collared sage-grouse in the Sink Valley area. Data were collected during fall and winter 2016. Sage-grouse were collared and monitored by Dr. Nicki Frey.

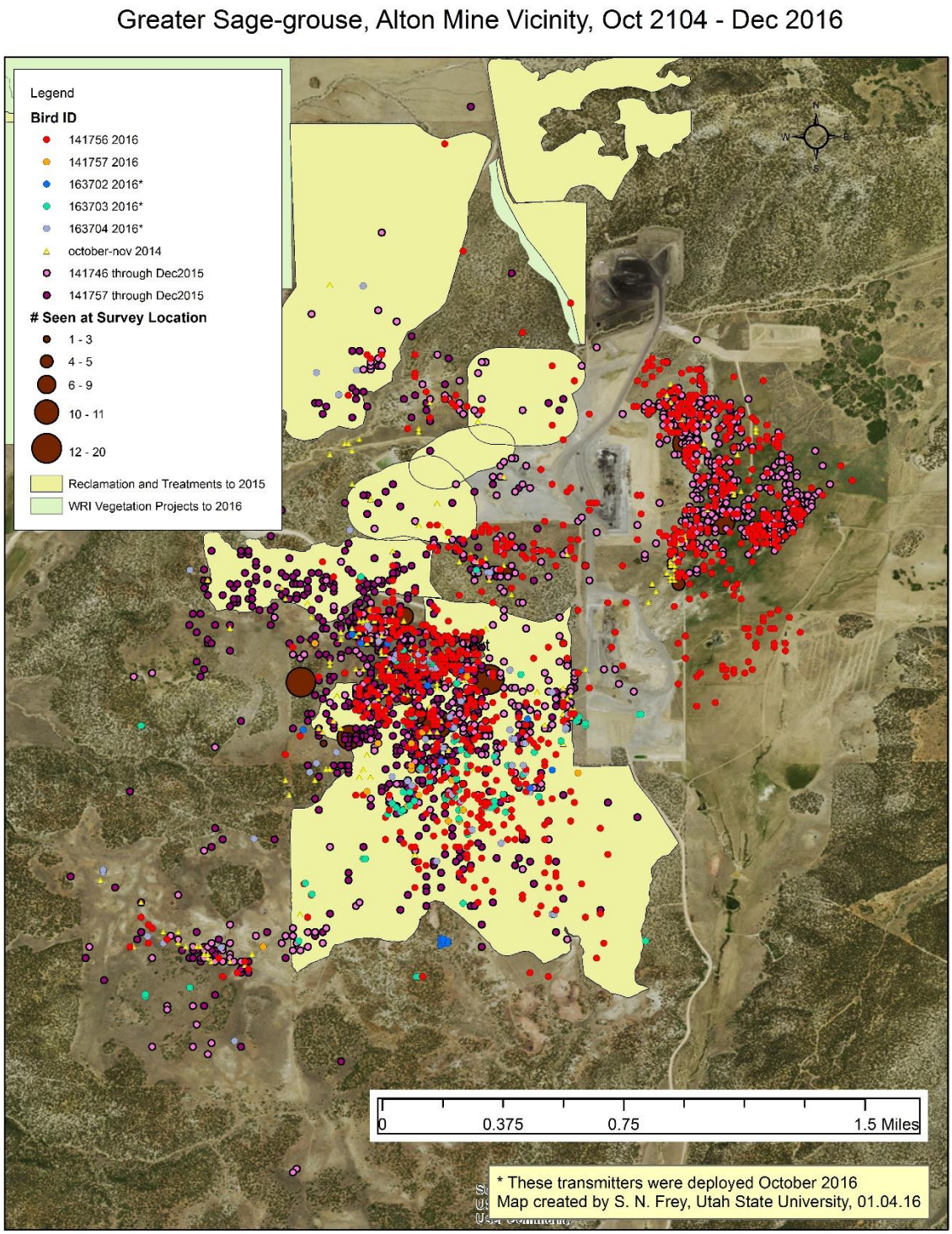



Figure 4. Close-up view of the area where the highest concentration of sage-grouse coordinate locations were collected. Data were collected during fall and winter 2016. Sage-grouse were collared and monitored by Dr. Nicki Frey.

Distribution of tracked Greater Sage-grouse Oct 2104 - Dec 2016

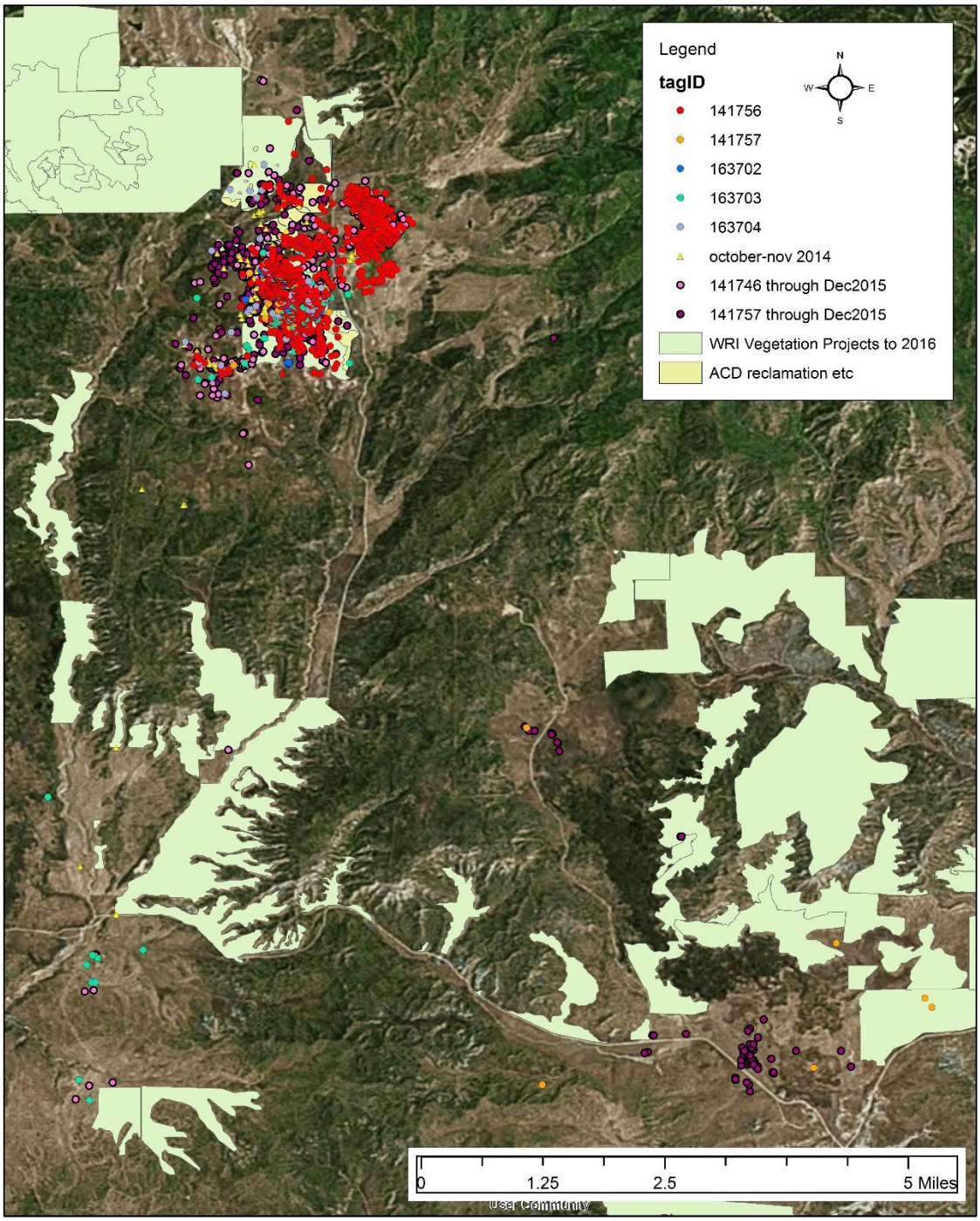



Figure 5. Coordinate locations of sage-grouse located within the southern extent of the species. Birds are observed in Sink Valley, Fords Pasture, and sagebrush habitats in-between both locations. Data were collected during fall and winter 2016. Sage-grouse were collared and monitored by Dr. Nicki Frey.

*1.4 Historic and Current Lek use in Alton/Sink Valley*

Greater sage-grouse have been observed using the Sink Valley and Alton areas of Kane County, Utah for many generation, including breeding activity (at the Sink Valley lek), nesting and brood rearing, and winter habitat use primarily in Sink Valley and the Alton area (personal communication with Kevin Heaton). The density of birds reported using the Sink Valley area has fluctuated widely during the time they have been observed (Figure 6). The most accurate estimates of bird densities in this region are provided by lek counts conducted annually by wildlife biologists with the Utah Division of Wildlife Resources (UDWR).

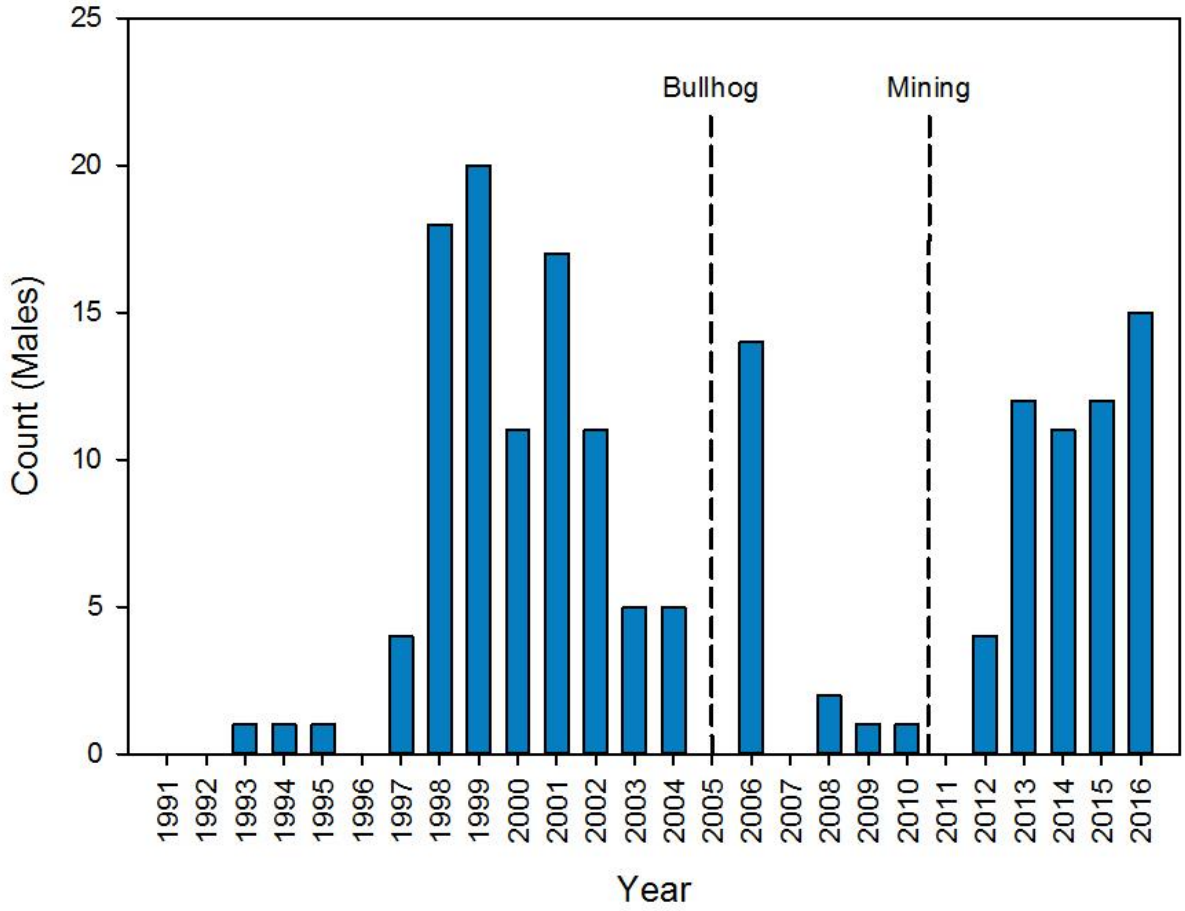



Figure 6. Male bird attendance at the Sink Valley lek, located south of Alton, Utah. Observations were made by Utah DWR employees observing during the spring breeding months (February – April). Both 2005 and 2007 data reported no males at the lek. In 2011, no males were counted, but it was assumed that the bird were displaying at the new lek and went unobserved until the following year. Birds recorded from 2012-16 were located on the new lek. Previous observations were observed at the historic lek.

### *1.5. Manuscript production and publication*

A manuscript of the Sink Valley sage-grouse population was produced using data from the past 10 years. This included an analysis of the Sink Valley lek count data and distribution of sage-grouse surrounding the mine site over time (Petersen et al. 2016). The article was published in the Journal of Human-Wildlife Interactions (Appendix A).

### *1.6 Noise Detection and Sound Assessment*

The influence of sound (noise pollution) on sage-grouse continues to be measured at each observation location when mining activity is active and wind levels are low enough to provide reliable data. Decibels have been recorded using an Extech 407735 Sound Level Meter. Sound levels were monitored during periods of no mining activity (ambient sound levels) and during high mining activity within the Sink Valley area.

Average sound levels across the Sink Valley site were 52.0 ± 2.5 db (mean ± standard deviation) and maximum levels were 60.0. Average sound levels within Sink Valley during mining activities were 60.4 ± 8.6 and maximum levels were 62.1 ± 4.1. The highest average sound levels were recorded at the mine headquarters (77.3 ± 2.8), the sagebrush patch adjacent to the mine on the east (64.6), the conservation area (63.0 ± 6.6), and the well area (61.3 ± 8.3). Other important measurements included the historic lek (58.8), the sagebrush field (55.1 ± 4.0), the spoils pile area (54.6 ± 1.8) and the new lek area (55.8 ± 2.1).

Sounds levels were not recorded near the north lease area because sage-grouse sightings were limited or undocumented (seasonally) in this area, but birds were consistently located within the Sink Valley area occupying the same habitat that they have been observed using both before and since the beginning of mining.

## 2. Habitat Mitigation and Improvements

Land improvements in relation to coal mining are a primary goal for ACD. Most improvements are designed to improve habitat conditions for sage-grouse. To date, a total of 2,296 acres have been treated by ACD (Figure 7).

### *2.1 Reclamation Response*

Post-mining reclamation is critical for stabilizing soils, restoring plant community composition, returning ecological structure and function, and improving habitat for grassland and shrubland species (i.e. sage-grouse, sage sparrows). Dahlgren et al. (2006) found that habitat treatments can improve habitat conditions required by sage-grouse such as forage, shelter and reproduction.

Following mining operations, the landscape has been recontoured to resemble pre-mining landform conditions. Topsoil was then replaced and reseeded using a mix of native and introduced shrub and herbaceous species. Seed was distributed using a seed drill pulled behind a John Deer tractor. To date, a total of 178 acres of land has been reclaimed (Figure 8). Most reclamation has been completed within the Sink Valley area, however, 11 acres have been reclaimed to date in the North Lease area, located 2 miles northwest of the mine crushing facility and headquarters (Figure 9).

Germination and establishment response has been comparable to data collected from the spoils pile in 2015. Reclamation success for much of the reclaimed area has been high, based on species diversity, high plant canopy cover, and relatively low bare ground cover. Quantitative data of plant community response and surface characteristics will be sampled in summer 2017 and included in the 2017 annual report.  Photos of bird use within the reclaimed area are provided in Figure 10.

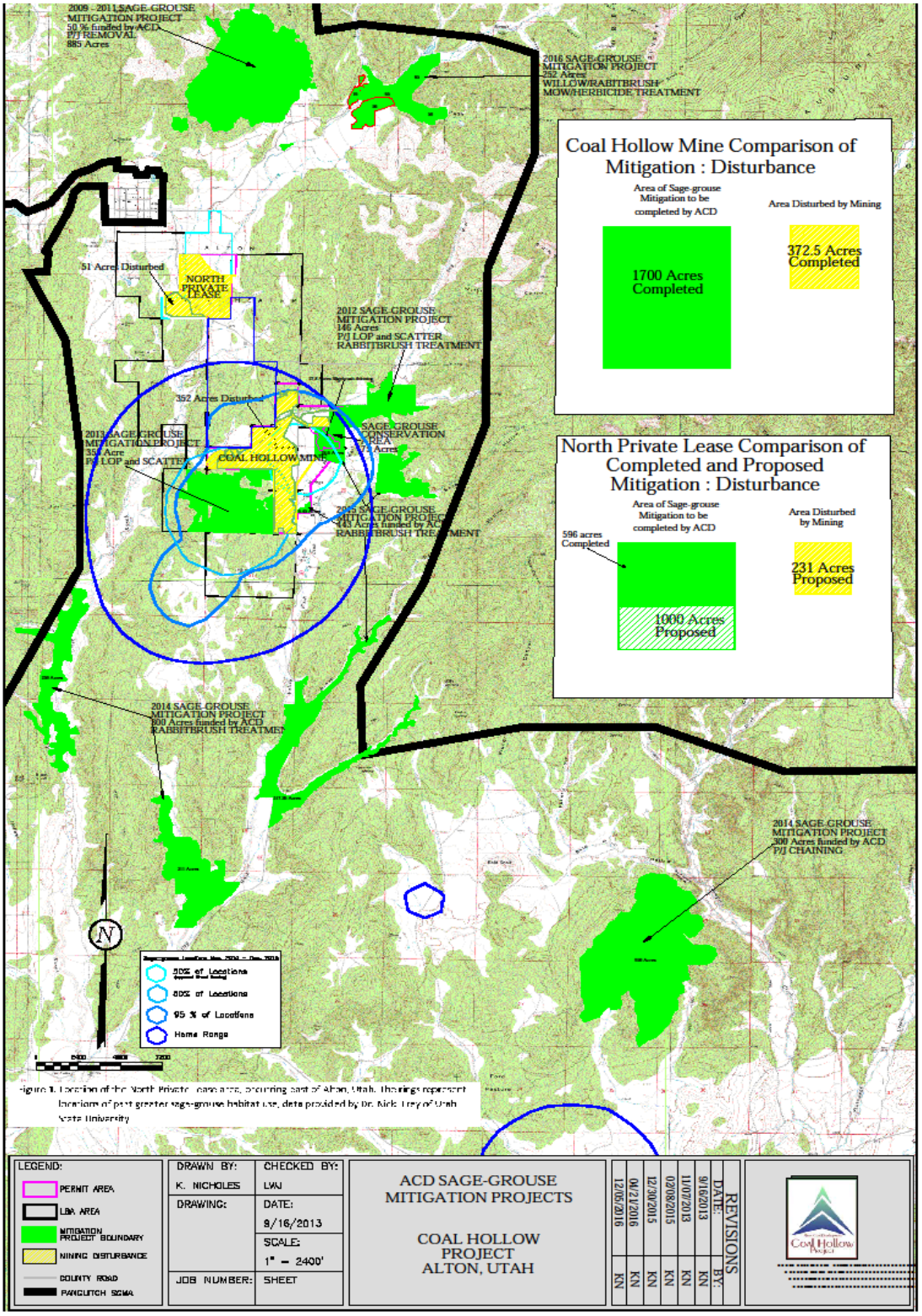



Figure 7. Total mitigation completed for the mine to date.

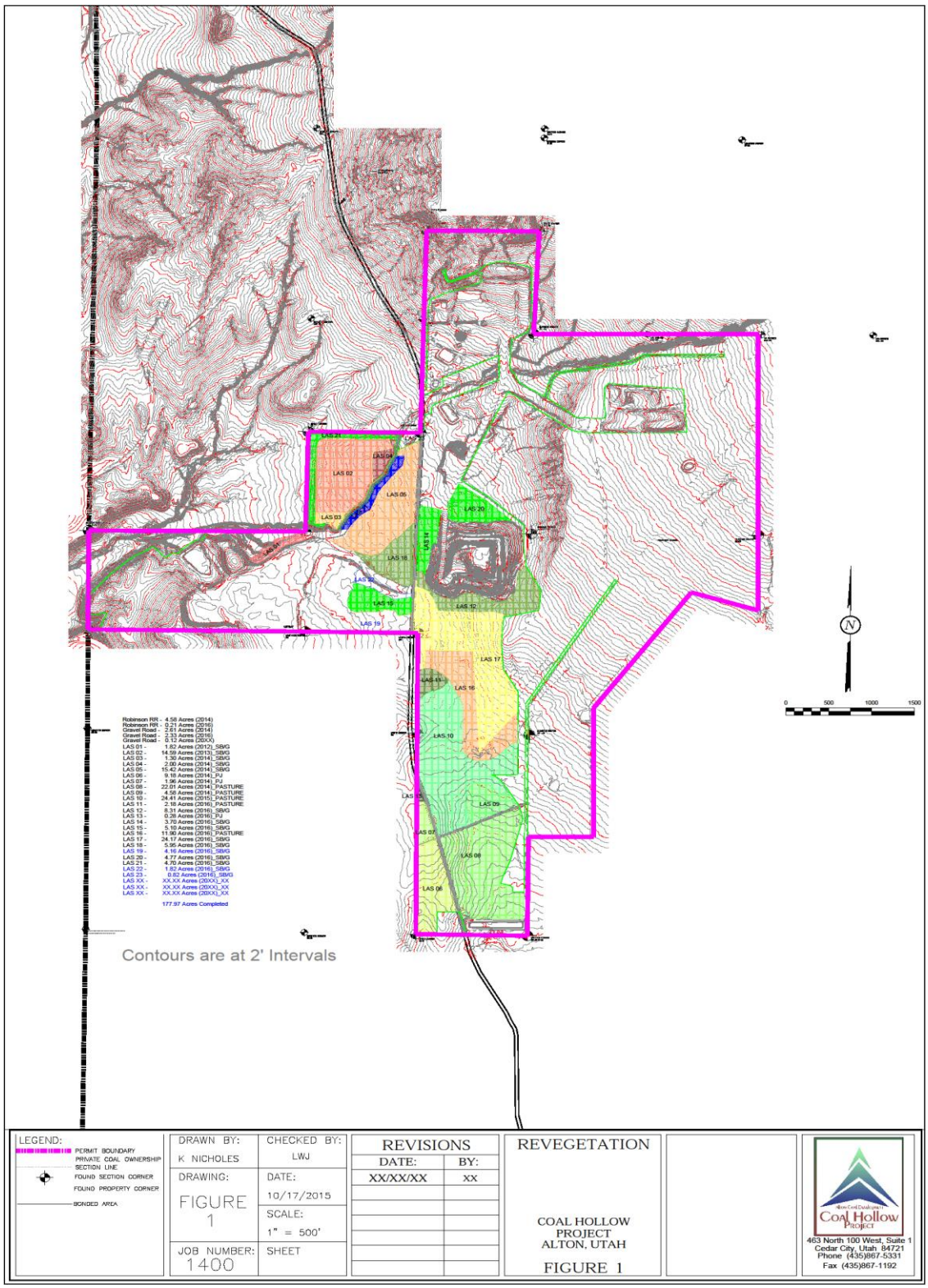



Figure 8. Post-mining reclamation completed to date (Dec. 2016). These areas have been seeded with a mix of native and introduced grass, forb and shrub species. Total area treated is 178 acres.

Figure 9. Reclamation within the North Lease area for a total of 11 acres.

Figure 10. Sage-grouse use in the post-mining reclamation area. All photos are taken of birds located within the Sink Valley reclamation site, located in close proximity to the historic lek.

## *2.2 Juniper Mastication*

Pinyon-juniper mastication being conducted by the BLM (Kanab field office) has resulted in a total of 1,362 acres of woodland removal and habitat improvement by reseeding (Figure 11). Mastication contractors report observing sage-grouse near the treatment areas while operations are underway. According to biologists from the Salt Lake BLM office, this may be due to the high availability of insects that are accessible to birds during the mastication process (personal communication Dec 2016).

Pinyon-juniper woodland mastication continues to serve a primary role in habitat improvement for sage-grouse throughout the mining area. According to Frey et al. (2013), sage-grouse utilize mastication treatment sites throughout much of the year.

## 3. Predator Control Activities

During 2016, sage-grouse predators were removed to increase potential nesting and brood rearing success. The types of predators that were removed included common ravens (*Corvus corax*), American crows (*Corvus brachyrhynchos*), coyotes (*Canis latrans*), and red fox (*Vulpes vulpes*). All predator control activities were conducted by USDA Wildlife Services. Locations where eggs were distributed and coyotes trapped are displayed in Figure 12.

### *3.1 Raven Control*

Teresa Wright, a raven control specialist with USDA wildlife services, has been funded by ACD to control ravens within the Alton/Sink Valley area. Raven control occurred from December 1, 2015 through November 2016. A total of 950 poisoned eggs were distributed within target areas shown in Figure 8. Eggs are hard boiled and then injected with DRC1338, a toxin that targets corvids specifically. According to Teresa, one raven is taken for every 6 eggs applied. Therefore, it is presumed that approximately 158 ravens were killed throughout the year (Personal Communication November 2016). The numbers of eggs distributed was lower than 2015 (1500 eggs) because the toxin DRC1339 was not manufactured this past year. There was also a delay in distributing eggs for several weeks due to a problem related to product labeling.

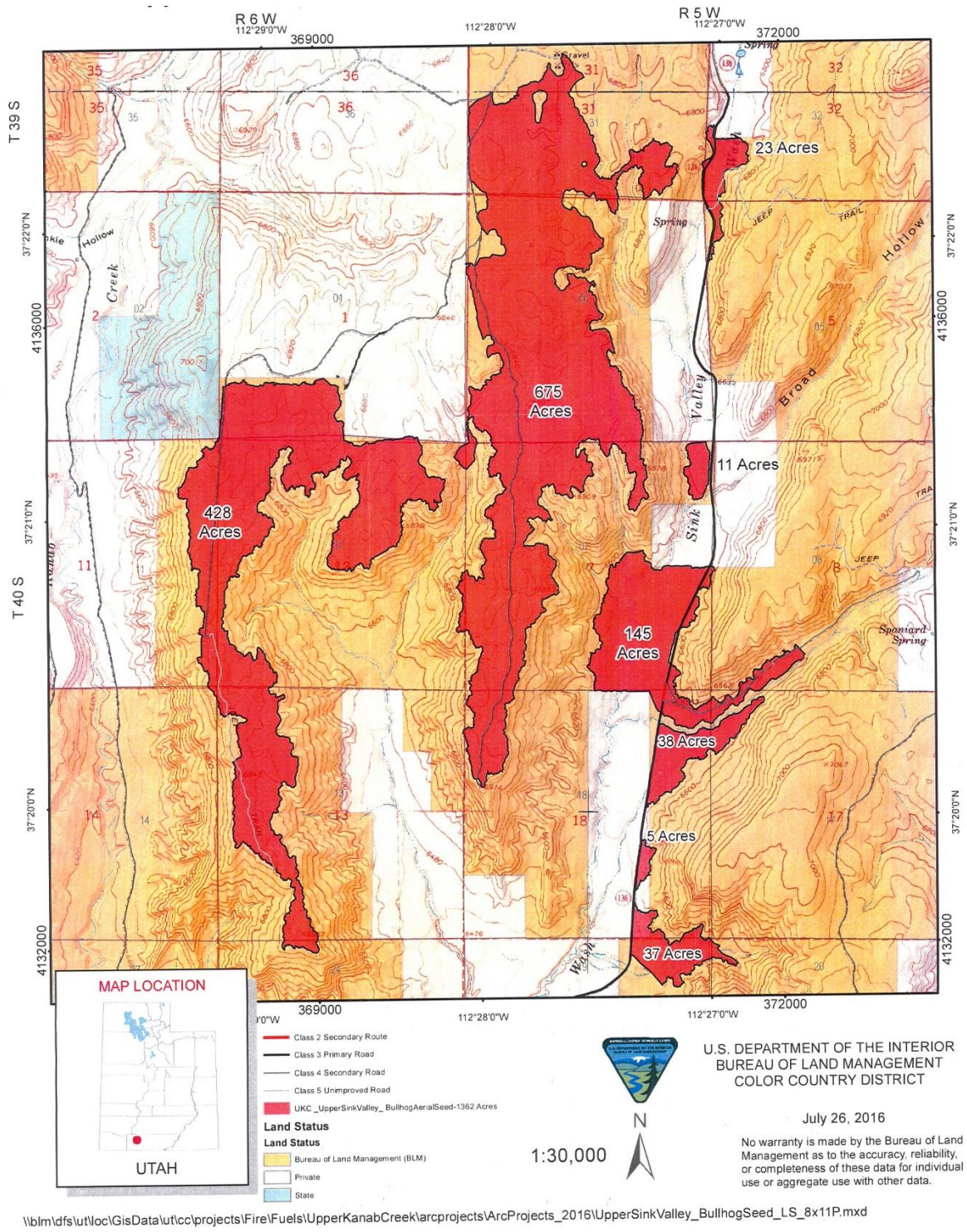



Figure 11. Upper Sink Valley mastication project with aerial seeding. 1362 total acres were treated.

Figure 12. Blue polygons indicate areas where poison eggs were distributed by USDA Wildlife Services for raven control. This includes roadsides near critical habitat and the stock yard near Alton where birds congregate. The yellow polygon represents the location where coyote snares are set and trapped.

## *3.2 Mesopredator Control*

Roger Nauer, USDA Wildlife Services trapper and mesopredator control specialist, harvested 3 coyotes within the mining area. Coyote control occurred from January 1, 2016 through November 1, 2016. Coyotes were killed using foot snares, traps, and fixed-wing aircraft.

## 4. Participation and Involvement with Local Working Groups

ACD participates in the Color Country Adaptive Resource Management (CCARM) bi-monthly meetings. CCARM provides valuable input and support in relation to sage-grouse population and habitat conservation planning (for the Alton/Sink Valley area). Feedback is considered in all aspects of project planning and implementation. Maintaining this cooperation with CCARM has been instrumental in the success of this project.

## References


Boyd, C. et al. 2011. Looking toward a brighter future for lekking grouse. Rangelands 33:2-11.

Braun, C.E., T. Britt, and R.O. Wallestad. 1977. Guidelines for maintenance of sage grouse habitats. Wildlife Society Bulletin 5:99-106.

Baruch-Mordo, S., J.E. Evans, J.P. Severson, D.E. Naugle, J.D. Maestas, J.M. Kiesecker, M.J. Falkowski, C.A. Hagen, and K.P. Reese. 2013. Saving sage-grouse from the trees: a proactive solution to reducing a key threat to a candidate species. Biological Conservation 167:233-241.

Dahlgren, D.K., R. Chi, and T.A.. Messmer. 2006. Greater sage-grouse response to sagebrush management in Utah. Wildlife Society Bulletin 34:975-985.

Doherty, K.E., D.E. Naugle, B.L. Walker, and J.M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187-195.

Frey, S.N., R. Curtis, and K. Heaton. 2013. Response of a small population of greater sage-grouse to tree removal: implications of limiting factors. Human-Wildlife Interactions 7:260-272.

Petersen, S.L., B.K. Nicholes, S.N. Frey, K.M Heaton, and D.L. Eggett. 2016. Response of greater sage-grouse to surface coal mining and habitat conservation in association with the mine. Journal of Human-Wildlife Interactions 10:205-216.


## Acknowledgements


Many thanks to all of those who were involved in planning, implementation of projects, and monitoring of the Sink Valley sage-grouse population and associated habitat. In particular we express our appreciation to Kirk Nicholes (ACD Environmental Scientists), Larry Johnson (ACD Project Manager), Kevin Heaton (USU Extension, habitat reclamation), biologists from UDOGM, Nicki Frey (SUU/USU Extension, sage-grouse collaring and monitoring), Rhett Boswell (UDWR, project planning and assessment), Teresa Wright (USDA WS, raven control), Roger Nauer (USDA WS, coyote control), the Color-Country Adaptive Resource Management group (project feedback and input). The work of this team has continued to result in maintaining a stable sage-grouse population in the Alton/Sink Valley area.

## APPENDIX A

Petersen, S.L., B.K. Nicholes, S.N. Frey, K.M. Heaton, and D.L. Eggett. 2016. Response of greater sage-grouse to surface coal mining and habitat conservation in association with the mine. Journal of Human-Wildlife Interactions 10(2):205-216.

*Human–Wildlife Interactions* 10(2): 205–216, Fall 2016

# Response of greater sage-grouse to surface coal mining and habitat conservation in association with the mine

**Steven L. Petersen**, Department of Plant and Wildlife Sciences, Brigham Young University, 5027 LSB, Provo, UT, 84604 USA *Steven_Petersen@byu.edu*
**B. Kirk Nicholes**, Alton Coal Development, 463 N. 100 W, Cedar City, UT 84721, USA
**S. Nicole Frey**, Department of Wildland Resources, Utah State University, 5230 Old Main Hill, Logan, UT 84322, USA
**Kevin M. Heaton**, Utah State University Cooperative Extension, Garfield County Courthouse, 55 South Main, P.O. Box 77, Panguitch, UT 84759, USA
**Dennis L. Eggett**, Department of Statistics, Brigham Young University, 223 TMCB, Provo, UT 84602, USA

***Abstract:*** Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) is a sagebrush-obligate species that has experienced species-wide declines in population density and distribution. Sage-grouse habitats support human-related needs including domestic livestock grazing, urban development, and energy extraction. The U.S. Fish and Wildlife Service identified energy extraction as a range-wide sage-grouse conservation threat. Mining has been of specific concern because of observed sage-grouse population declines and impaired habitat within close proximity to the activity. Mining may be particularly problematic for small, isolated sage-grouse populations. In southwestern Utah, proactive habitat improvements and predator management have been implemented to mitigate the potential effects of surface mining on the southernmost population of sage-grouse in the United States. We evaluated sage-grouse lek attendance trends before (1991–2010) and during (2011–2016) mining on a lek located near the mine (Sink Valley lek) to assess population responses to coal mining and related mitigation activities. Changes in lek trends have been demonstrated as a valid metric to assess the effects of conservation actions on sage-grouse populations. We used a paired *t*-test to compare differences in male lek attendance before and during mining and analysis of variance to determine if sage-grouse densities and distance to mining changed during the mining period. We recorded bird coordinate location and the number of birds observed at each sighting location along 10 transects within the study site area. Differences in location from mining was tested using Analysis of Variance with $\alpha < 0.5$. There was no difference in the number of males attending the Sink Valley lek before and during mining. Population cycles were consistent over the time period sampled. With the exception of 2013, which had an unusually high number of sage-grouse found within the Sink Valley area, there were no differences in the number of birds observed at each sighting location in relation to the mine center ($P = 0.37$), the coal crushing facility ($P = 0.34$), and the mine boundary ($P = 0.24$). Coupled with ongoing mitigation activities including habitat restoration, pinyon-juniper (*Pinus edulis, Juniperus osteosperma*) removal, aggressive predator control, pre-mining acclimation to human influences, and removal of pinyon-juniper woodlands, surface coal mining had no negative effect on population cycles in the Alton/Sink Valley area.

***Key words:*** *Centrocercus urophasianus*, coal mining, greater sage-grouse, habitat restoration, lek, population cycles, reclamation

Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) have experienced population declines range-wide, due primarily to environmental factors that affect reproduction and survival (Connelly and Braun 1997, Dahlgren et al. 2016*b*). Because sage-grouse rely on sagebrush habitats for year-round habitat needs, anthropogenic developments and large-scale transformations have been reported to decrease suitable sagebrush habitats, alter ecosystem processes, decrease biodiversity, and fragment historic wildlife habitats (Knick et al. 2003, Schroeder et al. 2005, Davies et al. 2011, Miller et al. 2011, Chambers et al. 2014).

Energy demands across western North America (renewable and nonrenewable) have resulted in the extraction of natural resources and exploration of new energy sources within sagebrush ecosystems. The U.S. Fish and Wildlife Service (USFWS) has identified energy development as a range-wide species conservation threat (USFWS 2015). Mining

**Figure 1.** Three male sage-grouse strutting on a lek located approximately 2.2 km from a coal crushing facility (shown in background) and 0.5 km from the nearest mining activity. Birds are lekking on a juniper removal treatment site.

and oil and gas extraction modify sage-grouse behavior and fragment sagebrush habitats to the detriment of sagebrush-obligate and facultative plant and animal species (Connelly et al. 2000, Lyon and Anderson 2003, Holloran et al. 2005, Naugle et al. 2011). While energy extraction practices vary, sage-grouse response to disturbance was related to the intensity of the energy extraction activity, rather than the specific activity type; responses included changes in lekking behavior and lek attendance (Holloran 2005). Similarly, Braun et al. (2002) found that leks located within 200 m of oil and coal mining activities (roads, well sites) in southeastern Alberta resulted in lower lek attendance.

One of the major concerns for sage-grouse above mining impacts is surface disturbance, habitat loss, and noise pollution (Dahlgren et al. 2016*b*). The most effective way to mitigate these impacts is through habitat management and improvement. Dahlgren et al. (2016*a*) found that Utah sage-grouse populations are primarily limited by space. The removal of pinyon-juniper (*Pinus edulis* Engelm.; *Juniperus osteosperma* [Torr.] Little) woodlands (PJ) has been found to significantly increase sagebrush habitat availability. Utah's Greater Sage-grouse Conservation Strategy recognized the potential for mining to impact local sage-grouse populations (UDWR 2013). The plan recommended the implementation of mitigation activities to include creating habitat and predation management to abate these potential impacts. Dahlgren et al. (2016*b*,*c*) recommended habitat restoration projects with the removal of conifers that have encroached into historical sage-grouse habitat as an effective strategy with the potential for immediate populations benefits. Frey et al. (2013) reported immediate sage-grouse use of areas where conifers have been removed.

Increased predation by corvids, particularly common ravens (*Corvus corax*) and mesopredators, have impacted sage-grouse populations throughout some of Utah's sage-grouse management area (UDWR 2013, Baxter et al. 2013), especially in areas associated with human activities (Coates and Delehanty 2004, Bui et al. 2010). Anthropogenic activities, such as resource extraction, transmission lines, and urban development increase food and perching substrates for ravens, resulting in increased raven populations around these areas (Kristan et al. 2004, Messmer et al. 2013). Furthermore, loss of habitat can increase predation on sage-grouse nests by increasing the ability of predators to detect nests and observe hen activity (Coates and Delehanty 2010, Baxter et al. 2013).

Habitat management and predator control can result in stable or even improving sage-grouse populations (Boyd et al. 2011, Baxter et

**Table 1.** Total land disturbed during coal mining at the Coal Hollow Mine in southwestern Utah.

| Year | Hectares disturbed | Hectares reclaimed |
|---|---|---|
| 2010 | 70.8 | 0.0 |
| 2011 | 8.5 | 0.0 |
| 2012 | 9.7 | 0.0 |
| 2013 | 21.9 | 5.5 |
| 2014 | 23.5 | 24.3 |
| 2015 | 4.0 | 11.8 |
| Total | 138.4 | 41.6 |

al. 2013, Dahlgren et al. 2015, Dahlgren et al. 2016*b*). Research in southern Utah determined that sagebrush treatments (mechanical and chemical) created habitat that increased sage-grouse use both within and adjacent to treated areas (Dahlgren et al. 2006, Frey et al. 2013). Baxter et al. (2013) found that enhancing habitat and controlling predators improved sage-grouse survival in Strawberry Valley, Utah. Frey et al. (2013) reported that pinyon-juniper mastication increased sage-grouse habitat and expanded sage-grouse distribution where treatments occurred. One source of possible restoration effort may be in off-site mitigation or habitat restoration within mined landscapes. In areas where the increase in tree density has fragmented or decreased habitat availability, mitigation practices may be used to restore these areas. In areas where sage-grouse habitat has been highly fragmented or deteriorated, it is possible that the benefits of mitigating mining activities may offset the negative impacts to this resource use (UDWR 2013, Dahlgren et al. 2016*c*). The purpose of this study was to determine how mining activities in concert with habitat management and mitigation strategies affect sage-grouse population cycles.

## Study area

The sage-grouse population in the Alton/Sink Valley is the southernmost extent of the species (Dahlgren et al. 2016*a*), adjacent to and south of the town of Alton, Utah (37°26′20″ N 112°20′ W). Average annual precipitation is approximately 43.2 cm, delivered generally in 2 annual wet periods. During winter, cyclic storms bring precipitation as snowfall, and in summertime, storms originating from convection air masses from the Gulf of Mexico or the Pacific Ocean provide rainfall to the region. Of the 2 annual wet cycles, summer rainfall is most reliable and consistent. Monthly average minimum temperatures range from a low of -9.4°C during January to a high of 28.1°C in July. The study area covers approximately 1,575 ha, comprised of both private and public land ownership. The vegetation is dominated by black sagebrush (*A. nova* A. Nelson) that supports a diversity of plant communities including sagebrush grasslands, Gambel oak (*Quercus gambelii* Nutt.) woodlands, seep and spring fed wet meadows, pastures used for livestock grazing, and alfalfa fields. Much of this area has been heavily encroached by pinyon pine (*Pinus edulis* Engelm.) and Utah juniper (*Juniperus osteosperma* [Torr.] Little) woodlands, reducing and fragmenting available and suitable sagebrush habitats (Frey et al. 2013, Dahlgren et al. 2016*b*, Dahlgren et al. 2016*c*).

The habitat occupied by the Sink Valley sage-grouse population has been influenced by human-related impacts and ecological succession pathways (Frey et al. 2013). In addition to providing year-round sage-grouse habitat, this region also supports human development and activity including alfalfa farming, pasture for livestock grazing, residential homes and seasonal cabins, and a network of maintained gravel county roads and unimproved dirt roads that transects the habitat use area (UDWR 2013). Pinyon-juniper (PJ) has expanded into much of the landscape, including tree encroachment into extensive regions that would have once been sagebrush grasslands (Frey et al. 2013). Additionally, PJ woodlands have experienced infill where they have outcompeted sagebrush and other shrub and herbaceous species. This PJ invasion has constricted suitable sage-grouse nesting, brood-rearing, and winter habitat throughout the Alton and Sink Valley (UDWR 2013).

Prior to mining, a relatively small population of sage-grouse have occupied the region that surrounds the Sink Valley lek (UDWR 2013). The study area is part of the Pangutich Sage-grouse Management Area (SGMA), which consists of 245,729 ha. The Panguitch SGMA is one of 11 SGMAs that occur within the state of Utah, serving as high priority habitat for

sage-grouse management and conservation. The occurrence of a coal mine within an SGMA has been of significant importance regarding the relationship between surface coal mining and sage-grouse conservation in the state. It has provided the state of Utah a unique opportunity to assess sage-grouse population patterns in association with disturbance related to surface mining activities (UDWR 2013). The Utah Division of Wildlife Resources (UDWR) conducts annual lek counts of the Sink Valley sage-grouse population. UDWR biologists monitor each lek in the region multiple times per year, recording the total number of strutting males observed at dawn. Lek count data used in this study were provided by the UDWR Cedar City office.

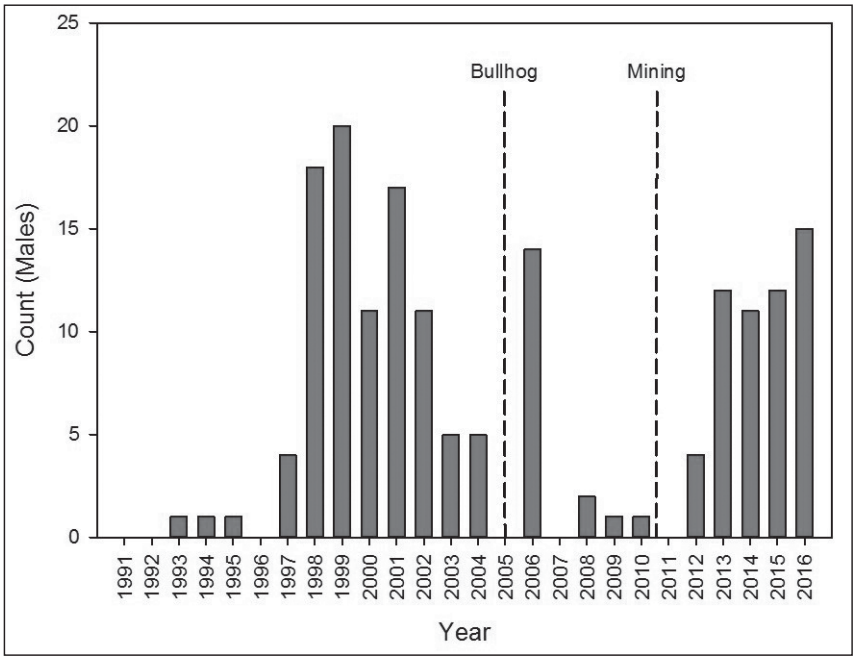



**Figure 2.** Male lek attendance between 1991 and 2016 at the Sink Valley lek located in southwestern Utah. In 2006, a bullhog mastication project was completed to remove encroached pinyon-juniper woodlands and enhance sage-grouse habitat within the region. Coal mining began in fall 2010.

During the breeding season, an average of 6.0 ± 1.6 male birds attended the lek prior to mining activity (1991–2009; UDWR unpublished data; Figure 1). This ranged from no birds in 5 non-consecutive years to a maximum of 20 birds in 1999. Between 1998 and 2006, male lek attendance was highest with 11.2 ± 2.3 males attending the lek annually (based on highest count on a single day). During a period of low lek attendance (2007–2011), an average 3.4 ± 1.9 males were observed. In 2012, a new lek was identified approximately 0.8 km southwest of the historic lek. Lek count data, however, cycle on a period of 9–12 years (UDWR unpublished data), which is a similar pattern observed in the Sink Valley lek data.

The original lek was located along a fenced wet meadow pasture within the valley bottom of the study area (Sink Valley). This site was dominated primarily by pasture grasses (*Poa pratensis*, *Phleum pratense*, *Dactylis glomerata*). Prior to mining, male counts at the original lek dropped to low numbers, including no birds observed. Between 2013–2014, the original lek was mined for coal and then reseeded in 2015 using a mix of native and introduced grasses and forbs. In 2012, males were observed strutting on the new lek area, located 0.8 km southwest of the original lek. This lek was positioned on the top of a ridgeline adjacent to and overlooking the sagebrush field where the highest bird counts and number of observation had occurred. The new lek occurred within a previously bull-hogged area, consisting of scattered shrubs (*Artemisia nova*), perennial grasses (i.e., *Elymus trachycaulus*, *Poa pratensis, Elymus elymoides*), and forbs (i.e., *Melilotus officinalis*). Reclamation of the original lek was assessed with mean values and the coefficient of determination.

## Surface coal mining operations

Land ownership within the mining area is approximately 65% federal (Bureau of Land Management) and 35% private ownership. Private lands are used primarily for livestock production (pasture) and 2 ranch homes and stock yards. Mining operations began in 2010 with coal extracted from shallow coal beds. Since then, 138.4 ha have been mined (Table 1). Initially, topsoil and subsoil were stockpiled or live-hauled for later use in habitat reclamation. Mining operations employed standard, open-pit methods using truck/loader type equipment

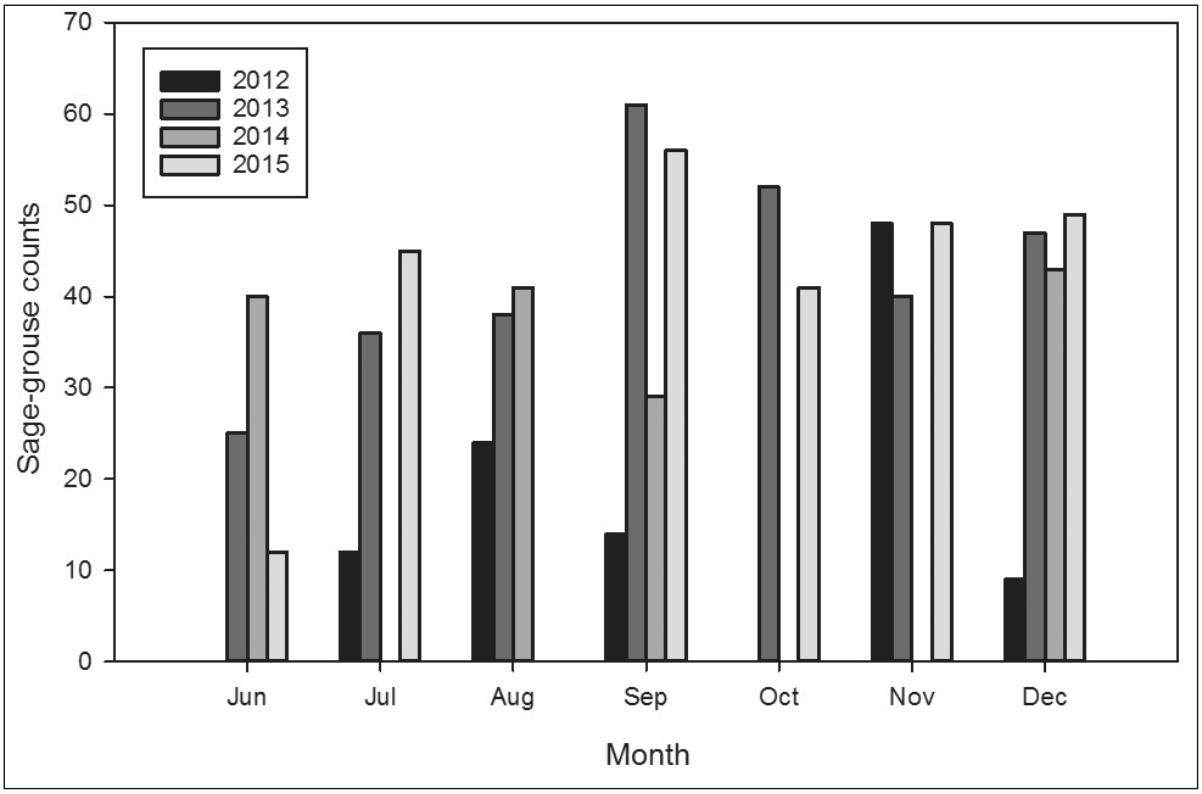



**Figure 3.** Sage-grouse counts during late brood-rearing and winter months within the mining region. All observations occurred <2 km from the center of the mine. No data were due to periods that did not have a survey conducted.

to remove overburden and recover the coal. Mining advanced across the property in successive cuts approximately 76.2 m in width and 243.8–396.2 m in length, with the previous pit being filled to approximate original contour from the current excavation. Extracted coal is transported from open pits to a coal crushing facility where trucks are filled and the coal is hauled from the mine site at a rate of up to 6 trucks per hour. Daily mining activity levels have been variable (4–6 days per week, 10–24 hours per day). Prior to mining, sagebrush habitats located east and south of the mine were excluded from the mining permit because these were identified as critical sage-grouse nesting and brood-rearing habitats. Throughout the mining period, sage-grouse have continued to lek at a new site located 2.2 km south of the coal crushing facility, 0.8 km from the historic lek, and ranging 0.25–0.5 km from the nearest edge of the mine footprint.

## Habitat reclamation, vegetation improvements, and predator control

As part of their mitigation, the mining company reduced all tree canopy cover within the primary habitat areas to increase available sagebrush habitat both inside the mining footprint and throughout mapped sage-grouse habitat in Sink Valley and Alton. Pinyon-juniper woodlands were reduced both before and during mining by both tree cutting and mastication with a bullhog shredder. This was conducted to expand sagebrush grassland habitat that could eventually provide the structure required by sage-grouse for breeding, brood-rearing, and winter use. In 2006, PJ woodlands were thinned by mastication with the intent to increase suitable sagebrush habitat. In 2015, the same areas were treated by clearing trees not removed in 2006, providing more suitable habitat conditions for nesting and brood-rearing. In addition to reducing tree canopy cover, the mining company conducted shrubland habitat treatments to improve existing sagebrush-steppe habitats. Habitat improvements included the reduction of rubber rabbitbrush (*Ericameria nauseosa)* by treating shrubs with the herbicide Tordon 22k® and an increase in sagebrush density, cover, and vigor.

To reduce the impact of common ravens on nest and chick predation, USDA Wildlife

Services (USDA-WS) distributed hard-boiled eggs treated with DRC 1339, an avicide used to control corvid species (Spencer 2002). Eggs were placed along roadsides near the mine, within sage-grouse habitat areas, and at the feedlot located at the north end of town that provides a consistent food source and generates high raven concentrations. Each year (2012–2015) an average of 1,344 (SD = 144) eggs were distributed throughout the area, resulting in an estimated removal of 122–672 ravens from the area (Coates et al. 2007). Wildlife Services removed coyotes (*Canis latrans*) using bait traps placed along fencelines and near dens as well as ground and aerial shooting. From 2012 to 2015, an average of 17.8 (SD = 1.3) animals were removed annually. Both raven and coyote removals were aimed at lessening the degree of predation on chicks, young of the year, and adult sage-grouse.

## Methods

### Sage-grouse response to mining activity and restoration

To determine how sage-grouse responded to mining activities and the reclamation and restoration activities, we analyzed annual lek count data, relative to both pre- and post-mining activity (Dahlgren et al. 2016*b*, Dahlgren et al. 2016*c*). Dahlgren et al. (2016*b*) found that male-based lek counts of sage-grouse are an effective index to overall population change. These data provide insight into population dynamics at sites where the annual lifecycle is undetermined and to be used to examine population dynamics at greater spatio-temporal scales. Furthermore, perturbation analyses such as this long-term demographic analysis is needed to enhance scientific rigor for prioritization of the most cost-effective species conservation and management actions (Akçakaya and Raphael 1998, Cooch et al. 2001, Baxter et al. 2008).

Within the study area, which extends 1.7 km to the south of the mine footprint, 0.7 km to the west, 0.6 km to the north, and 1.1 km to the east, there is 1 lek (Sink Valley Lek). We used the lek count data provided by the UDWR (unpublished data), determined from the highest count recorded following multiple lek visits during the breeding season. For this study, lek counts recorded before and during mining were compared using a 2-way Kruskal-Wallace non-parametric test of variances with $\alpha < 0.5$. Because lek counts were highly variable during pre-mining years, potentially due to typical population cycles (Dahlgren et al. 2016*b*), data were analyzed across all years and for years with >1 bird per lek count in the case that birds were present but not detected.

We recorded the coordinate location of all sage-grouse observed within the mine area between June and January during 2012 to 2016 to detect sage-grouse habitat use and to determine shifting patterns in the distance birds were observed from mining activities. Observations were not conducted during the nesting and early brood-rearing periods (February through May) to prevent any disruption to breeding hens or young chicks. Observations were conducted during morning hours at the beginning of each month. We searched for birds along 10 established transect lines within sagebrush and meadow habitats surrounding the mine/lek area each month. Transect lines ranged between 0.3 and 0.75 km in length and were located in habitat patches that we determined from past studies and observations were the most likely to provide habitat for sage-grouse. The same survey lines were followed each year. The coordinate locations for each sage-grouse observation were recorded using Global Positioning System (GPS) or aerial photographs. The researcher also recorded the time of day, weather conditions, habitat type, number of birds observed, and age/sex when discernable. To avoid repeat counts of the same birds along the transect line. We also took note of the direction flushed birds moved.

To determine the correlation of sage-grouse sightings to mining activity, we used ArcGIS (ESRI 2011) to analyze the locations with spatial information. We calculated the minimum Euclidian distance from each bird/flock sighting and measured the 1) center of the mine, 2) center of the coal crushing facility, and 3) closest area within the mine footprint (boundary). We divided bird sightings into 3 categories (near, mid, far) to compare differences in bird use patterns across years. Bird observations near the center of the mine (0–800 m) were in close proximity to roads, high traffic, and long-term mining activity compared to mid (800–1,500 m) and far (>1,500 m), which included birds with low to no visual or auditory mine-related

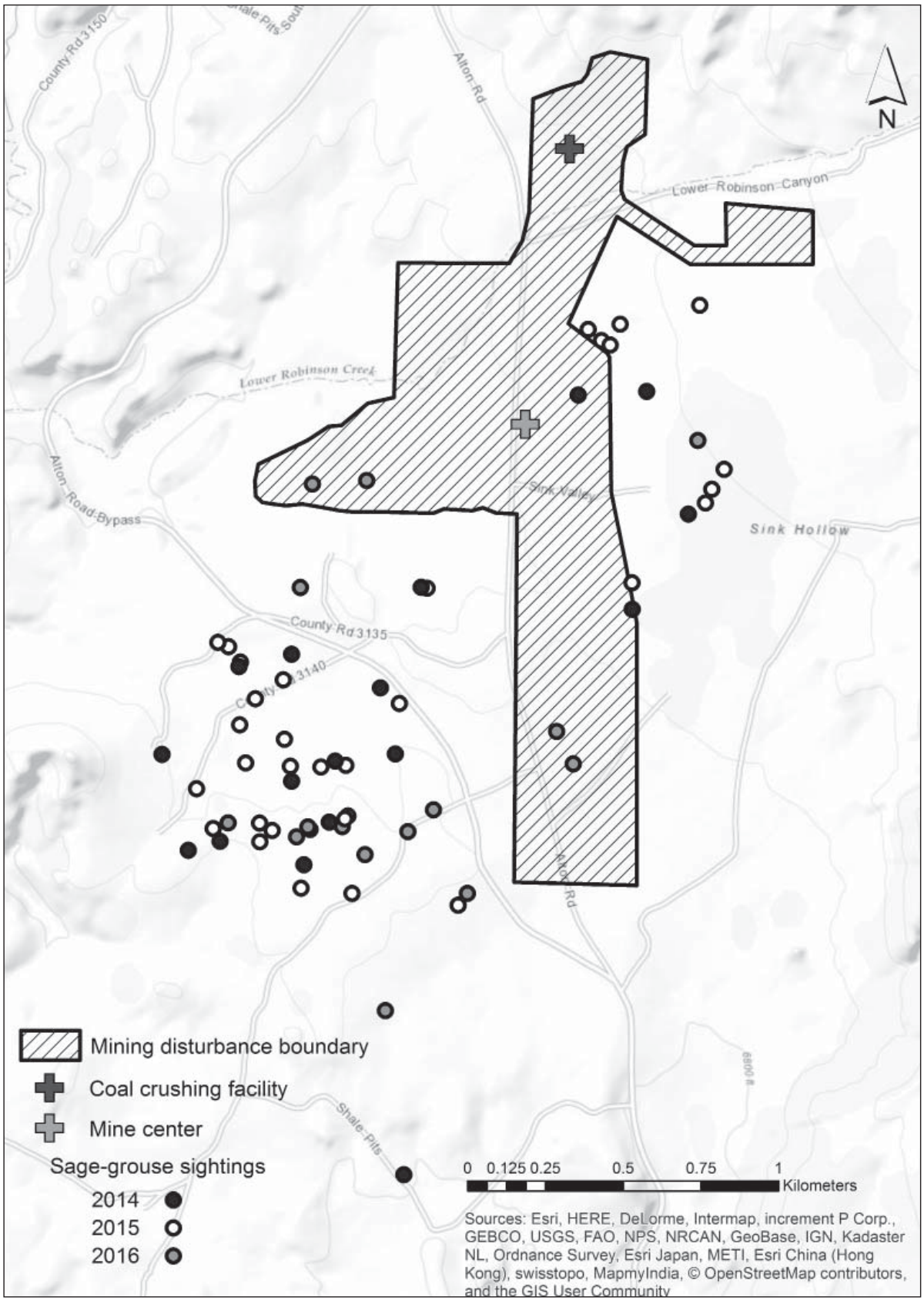



**Figure 4.** Location of sage-grouse habitat use (sightings) 4–6 years since the start of coal mining (Fall 2010). Bird sightings were recorded during ground surveys conducted monthly. The coal crushing facility represents stationary mining while the center of the mine site has high traffic patterns and transitional mining activity.

influences. The coal crushing facility was located at the north end of the mine footprint, adjacent to a PJ woodland and more distant from suitable sage-grouse habitat. Birds located near the coal crushing facility (0–1,500 m) had long-term mining activity, high traffic, with higher occurrence of people outside of vehicles compared to mid (1,500–2,300 m) and far (>2,300 m) distances. The mine footprint is located substantially closer to most of the intact sagebrush habitats, with closer proximity to bird observations compared to the mine center and coal crushing facility. Sage-grouse sighted near the footprint (0–400 m) included short- and long-term mining activity with less consistent traffic and human activity compared to mid (400–850 m) and far (>850 m) distances. We used Analysis of Variance (SAS® 2013) with $\alpha < 0.5$ to detect significant differences among distances and years, including an assessment of interactions between distances and years.

## Results

### Sage-grouse response to mining activity and restoration

When considering all lek count years, there was no difference in male lek attendance before and during mining ($T = 1.10$, df = 24, $P = 0.28$) with 5.6 ± 1.5 and 9.0 ± 2.7 birds observed, respectively (Figure 2). There was similarly no difference in lek counts before and during mining when >1 male was observed ($T = 1.31$, df = 14, $P = 0.98$) with 10.8 ± 2.6 and 10.7 ± 1.7 males observed, respectively. Bird sightings were recorded on average 1.2 ± 0.1 km from the center of the mine, 2.0 ± 0.1 km from the coal crushing facility, and 0.5 ± 0.03 km from the mine footprint. A total of 68.8% of all bird observations were located in the sagebrush-steppe habitat southwest of the mine footprint. Sage-grouse occurrence in this region was year-round. Sage-grouse were observed 9.8% of the time in the wet meadow area east of the mine. Observations occurred primarily from early to late brood-rearing periods. Considering all years combined, there was no intersection between year and location ($F = 1.15$, df = 61, $P = 0.34$) for sage-grouse counts. When testing for main effects, there were differences in bird numbers averaged across all locations among years ($F = 7.53$, $P < 0.001$). This was due to an unusually high number of birds in 2013 (31.3 ± 3.8) compared to 2012, 2014, and 2015 with 10.7 ± 3.4, 9.7 ± 3.2, and 10.2 ± 2.3 birds, respectively (Figure 3). When 2013 was removed from the analysis, there were no differences in the number of birds counted by year ($F = 0.03$, $P = 0.97$).

We detected no significant interactions between year and distance the mine center ($F = 1.09$, $P = 0.37$), the crushing facility ($F = 1.15$, $P = 0.34$), and the boundary ($F = 1.36$, $P = 0.25$). Considering main effects, the distance of birds from mining activity was different across years, with more birds in the mid-range in 2013 compared to the same year in both near and far ($P < 0.001$ for all distances). Similar to count data, an unusually high number of sage-grouse were observed in the region during 2013. With 2013 excluded from the analysis, there were no differences in bird sightings by year for the mine center ($F=0.53$, $P=0.66$), the coal crushing facility ($F=0.60$, $P = 0.62$), and the mine boundary ($F = 0.62$, $P = 0.61$; Figure 4). During our flush surveys, an average of 6.6 ± 3.8 ($\bar{x}$ ± SD) chicks were observed with a hen during both early and late brood rearing periods across all survey years. Hens with chicks were observed during early brood-rearing periods in sagebrush habitats and during late brood-rearing periods in wet meadow habitats approximately 0.59 km and 0.36 km from the active mine site, respectively. Between 2013–2015, an average of 4.8 chicks were observed adjacent to the mine site, primiarly within the wet meadow area east of the mining activity. Chicks were observed 0.08 km from the mine footprint. Since completing reclamation on the historic lek, 12 males have been observed displaying in this location following 5 years of no activity. This area is located 1.9 km from the coal crushing facility and 0.7 km from active mining activity (Figure 5).

## Discussion

Sage-grouse occupied the same general habitat area during breeding and non-breeding periods for the duration of the study. While others have found that sage-grouse are less likely to use habitat within 4 km of energy extraction activity (oil, gas) compared to undisturbed areas (Lyon and Anderson 2003, Doherty et al. 2006, Naugle et al. 2006), the birds occupying our study site were observed within 2 km of the center of the mine throughout the duration of the study period. Before mining, this sage-grouse population was in close

**Figure 5.** Sage-grouse at the reclaimed historic lek following 5 years with no sightings and 2 years with 1 male attending only.

proximity to human-related activities including frequent vehicle traffic, farming and ranching operations, and urban development. Mining equipment and facilities may have provided a similar set of conditions to pre-mining that would create a similar behavioral response. In contrast to this study, Naugle et al. (2006) characterize declining trends in sage-grouse lek attendance relative to natural gas mining activities (permanent wells, power lines, and roads). They observed 516 leks from 1990–2005 and found that overall populations declined with extensive natural gas development (>40% within 3.2 km). They also attribute avoidance behavior to agricultural practices.

It is possible that site and habitat fidelity have played a large role in the location of the grouse in proximity to the mine. There are large patches of suitable habitat >1 km from the mine that are not frequently used by sage-grouse, which suggests that sage-grouse are not so limited in habitat that they are required to use sub-optimal habitat rather than leave the area entirely. We acknowledge that using an area near mining activity does not necessarily indicate that sage-grouse are thriving alongside such activity. However, we suggest that the restoration and habitat mitigation efforts that were initiated during the onset of mining activity, coupled with the reclamation of habitat as mining activity moved across the landscape, worked to maintain the existing sage-grouse population.

Lek counts did not decline as a result of the mining activity; the lek moved (resulting in low lek attendance counts until the UDWR found the new location) but remained stable. According to Dahlgren et al. (2016*c*), population cycles are typical for sage-grouse lek attendance, a pattern detectable at the Sink Valley Lek. Subsequently, attendance by male sage-grouse may not signify successful recruitment. Although this study did assess movement data, there was no data indicating recruitment success in Alton/Sink Valley prior to mining; therefore, we did not attempt to make the comparison of recruitment before and during mining. However, during our monthly observation surveys, we consistently observed hens and chicks, which may indicate that recruitment was occurring within the study area. Additionally, a recent

study designed to monitor hens with GPS radio-telemetry repeatedly identified young hens within the study area, supporting the hypothesis that sage-grouse are successfully rearing brood in the area during the mining activity. Sage-grouse recruitment within 2 km of the mine is potentially increased with a combination of consistent and aggressive predator control, which was conducted as mitigation and increased habitat availability (i.e., PJ mastication, sagebrush treatments).

## Management implications

Effective sage-grouse conservation practices are needed that reduce impacts while sustaining energy development demands. Increasing habitat suitability and availability while reducing threats from predators may contribute to sustainable and stable sage-grouse populations. The impacts of energy development on sage-grouse populations and sagebrush habitats has been a concern for land managers. Applying practices that minimize these impacts are needed. Because we did not evaluate the direct influence of predator control on sage-grouse survival, this aspect of management was not included in this study. However, extensive raven and coyote control was implemented to reduce predator threats to eggs, chicks, and adult sage-grouse. This effort may be an important factor in sustaining sage-grouse populations.

## Acknowledgments

We appreciate B. Nead and Alton Coal Development for funding this research and to the Utah Division of Oil, Gas, and Mining for their project oversight and guidance. We appreciate the Utah Division of Wildlife Resources (R. Boswell, J. Polluck, and D. Schaible) for assisting with bird monitoring and for providing habitat improvement recommendations. We thank the members of the Color Country Adaptive Resource Management (CCARM) counsel for providing helpful feedback and suggestions for improving sage-grouse conservation and habitat improvement efforts. We thank T. Wright and R. Nowers from USDA Wildlife Services for their services in controlling impacts from predators. We appreciate the reviewers of this journal for their helpful recommendations that improved the quality of this article.

## Literature cited

Akçakaya, H. R., and M. G. Raphael. 1998. Assessing human impact despite uncertainty: viability of the northern spotted owl metapopulation in the northwestern USA. Biodiversity and Conservation 7:875–894.

Baxter, R. J., J. T. Flinders, and D. L. Mitchell. 2008. Survival, movements, and reproduction of translocated greater sage-grouse in Strawberry Valley, Utah. Journal of Wildlife Management 72:179–186.

Baxter, R. J., R. T. Larsen, and J. T. Flinders. 2013. Survival of resident and translocated greater sage-grouse in Strawberry Valley, Utah: A 13-year study. Journal of Wildlife Management 77:802–811.

Boyd, C., S. L. Petersen, W. Gilgert, R. Rodgers, S. Fuhlendorf, R. Larsen, D. Wolfe, K. C. Jensen, P. Gonzles, M. Nenneman, R. Danvir, D. Dahlgren, and T. Messmer. 2011. Looking toward a brighter future for lekking grouse. Rangelands 33:2–11.

Braun, C. E., O. O. Oedekoven, and C. L. Aldridge. 2002. Oil and gas development in western North America: effects on sagebrush steppe avifauna with particular emphasis on sage grouse. Transactions of the North American Wildlife and Natural Resources Conference. 67:337–349.

Bui, T. D., J. M. Marzluff, and B. Bedrosian. 2010. Common raven activity in relation to land use in western Wyoming: implications for greater sage-grouse reproductive success. Condor 112:65–78.

Chambers, J. C., R. F. Miller, D. I. Board, D. A. Pyke, B. A. Roundy, J. B. Grace, E. W. Schupp, and R. J. Tausch. 2014. Resilience and resistance of sagebrush ecosystems: implications for state and transition models and management treatments. Rangeland Ecology and Management 67:440–454.

Coates, P. S., and D. J. Delehanty. 2004. The effects of raven removal on sage-grouse nest success. Proceedings of the Vertebrate Pest Conference 21:17–20.

Coates, P. S., and D. J. Delehanty. 2010. Nest predation of greater sage-grouse in relation to microhabitat factors and predators. Journal of Wildlife Management 74:240–248.

Coates, P. S., J. O. Spencer, Jr., and D. J. Delehanty. 2007. Efficacy of CPTH-treated egg baits for removing ravens. Human–Wildlife

Conflicts 1:224–234.

Connelly, J. W., and C. E. Braun. 1997. Long-term changes in sage grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3:229–234.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage-grouse populations and their habitat. Wildlife Society Bulletin 28:967–985.

Cooch, E., R. F. Rockwell, and S. Brault. 2001. Retrospective analysis of demographic responses to environmental change: a lesser snow goose example. Ecological Monographs 3:377–400.

Dahlgren, D. K., R. Chi, and T. A. Messmer. 2006. Greater sage-grouse response to sagebrush management in Utah. Wildlife Society Bulletin 34:975–985.

Dahlgren, D. K., M. R. Guttery, T. A. Messmer, D. Caudill, R. D. Elmore, R. Chi, and D. N. Koons. 2016*b*. Evaluating vital rate contributions to greater sage-grouse population dynamics to inform conservation. Ecosphere 7:1–15.

Dahlgren, D. K., R. T. Larsen, R. Danvir, G. Wilson, E. T. Thacker, T. A. Black, D. E. Naugle, J. W. Connelly, and T. A. Messmer. 2015. Greater sage-grouse and range management: insights from a 25-year case study in Utah and Wyoming. Rangeland Ecology and Management 68:375–382.

Dahlgren, D. K., R. T. Larsen, R. Danvir, G. Wilson, E. T. Thacker, T. A. Black, D. E. Naugle, J. W. Connelly, and T. A. Messmer. 2016*a*. Corrigendum to "greater sage-grouse and range management: insights from a 25-year case study in Utah and Wyoming." Rangeland Ecology and Management 69:235–235.

Dahlgren, D. K., T. A. Messmer, B. A. Crabb, R. T. Larsen, T. A. Black, S. N. Frey, E. T. Thacker, R. J. Baxter, and J. D. Robinson. 2016*c*. Seasonal movements of greater sage-grouse populations in Utah: implications for species conservation. Wildlife Society Bulletin 40:288–299.

Davies, K. W., C. S. Boyd, J. L. Beck, J. D. Bates, T. J. Svejcar, and M. A. Gregg. 2011. Saving the sagebrush sea: an ecosystem conservation plan for big sagebrush plant communities. Biological Conservation 144:2573–2584.

Doherty, K. E., D. E. Naugle, B. L. Walker, and J. M. Graham. 2006. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187–195.

ESRI. 2011. ArcGIS Desktop: Release 10.3.1. Environmental Systems Research Institute, Redlands, California, USA.

Frey, S. N., R. Curtis, and K. Heaton. 2013. Response of a small population of greater sage-grouse to tree removal: implications of limiting factors. Human–Wildlife Interactions 7:260–272.

Holloran, M. J. 2005. Greater sage-grouse (*Centrocercus urophasianus*) population response to natural gas field development in western Wyoming. Dissertation, University of Wyoming, Cheyenne, Wyoming, USA.

Holloran, M. J., and S. H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. Condor 107:742–752.

Holloran, M. J., B. J. Heath, A. G. Lyon, S. J. Slayter, J. L. Kuipers, and S. H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming. Journal of Wildlife Management 69:638–649.

Knick, S. T., D. S. Dobkin, J. T. Rotenberry, M. A. Schroeder, W. M. Vander Haegen, and C. V. Riper. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105:611–634

Kristan, W. B., W. I. Boarman, and J. J. Crayon. 2004. Diet composition of common ravens across the urban-wildland interface of the West Mojave Desert. Wildlife Society Bulletin 32:244-253.

Lyon, A. G., and S. H. Anderson. 2003. Potential gas development impacts on sage-grouse nest initiation and movement. Wildlife Society Bulletin 31:486–491.

Messmer, T. A., R. Hasenyager, J. Burruss, and S. Ligouri. 2013. Stakeholder contemporary knowledge needs regarding the potential effects of tall structures on sage-grouse. Human–Wildlife Interactions 7:273–298.

Miller, R. F., S. T. Knick, D. A. Pyke, C. W. Meinke, S. E. Hanser, M. J. Wisdom, and A. L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Pages 145–184 in S. T. Knick and J. W. Connelly, editors. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology. Volume 38. University of Berkeley Press, Berkeley, California, USA.

Naugle, D. E., K. E. Doherty, B. L. Walker, M. J.

Holloran, and H. E. Copeland. 2011. Energy development and greater sage-grouse Studies in Avian Biology 38:489–503.

Naugle, D. E., B. L. Walker, and K. E. Doherty. 2006. Sage-grouse population response to coal-bed natural gas development in the Powder River Basin: interim progress report on region-wide lek-count analyses. Unpublished Report, University of Montana, Missoula, Montana, USA.

SAS. 2013. SAS Institute Inc., Cary, North Carolina, USA.

Schroeder, M. A., C. L. Aldridge, A. D. Apa, J. R. Bohne, C. E. Braun, S. D. Bunnell, J. W. Connelly, P. A. Deibert, S. C. Gardner, M. A. Hilliard, G. D. Kobriger, S. M. McAdam, C. W. McCarthy, J. J. McCarthy, D. L. Mitchell, E. V. Rickerson, and S. J. Stiver. 2005. Distribution of sage-grouse in North America. Condor 106:363–376.

Spencer, J. O., Jr. 2002. DRC-1339 use and control of common ravens. Proceedings of the Vertebrate Pest Conference 20:110–113.

U.S. Fish and Wildlife Service. 2015. Historic conservation campaign protects greater sage-grouse. U. S. Fish and Wildlife Service, <https://www.doi.gov/pressreleases/historic-conservation-campaign-protects-greater-sage-grouse>. Accessed October 28, 2016.

Utah Division of Wildlife Resources. 2013. Conservation plan for greater sage-grouse in Utah. Utah Division of Wildlife Resources, Salt Lake City, Utah, USA, <https://wildlife.utah.gov/uplandgame/sage-grouse/pdf/greater_sage_grouse_plan.pdf>. Accessed September 24, 2014.

**Steven L. Petersen** received his Ph.D. degree in rangeland resources from Oregon State University (OSU) in 2004. He was an assistant professor at OSU in the Department of Rangeland Ecology and Management through 2007. He is currently an associate professor of wildlife and wildlands conservation in the Department of Plant and Wildlife Sciences at Brigham Young University (BYU) in Provo, Utah. He resides in Elk Ridge, Utah. His research focuses on assessing and characterizing the impacts of natural and human-related disturbance on range, forest, and wildlife habitat using geospatial technology (GIS, Remote Sensing).

**B. Kirk Nicholes** is the environmental specialist for Alton Coal Development, LLC. He has a degree in biology with an agricultural emphasis from Southern Utah State College. He has worked in the mining industry for 28 years, actively working with sage-grouse monitoring and mitigation for the last 6 years.

**S. Nicole Frey** received her Ph.D. degree in wildlife biology from Utah State University (USU) in 2004. She has worked for USU Cooperative Extension since 2004, addressing issues in wildlife conservation, human–wildlife interactions, and youth education in southern Utah. Her interest in wildlife management focuses on increasing the positive interactions between human activity (towns, agriculture, recreation) and wildlife. She currently is an extension wildlife assistant professor for Utah State University and resides in Cedar City, Utah.

**Kevin M. Heaton** received his B.S. degree in agribusiness in 1995 and M.S. degree in nutrition and food science in 1998, both from Utah State University. Since 1999, he has worked for Utah State University Extension as the Kane and Garfield Agriculture/Natural Resource/4-H Extension faculty. His current focus is to provide ecological and economic sustainability to the agriculture and livestock industries in southern Utah. Currently, he is an extension full professor and the county extension director in both Kane and Garfield counties in Utah.

**Dennis L. Eggett** received his B.S. and M.S. degrees in statistics from Brigham Young University (BYU) and his Ph.D. degree in applied statistics from North Carolina State University. He worked for 10 years at Pacific Northwest National Laboratory. Since 1997, has been the director of the Center for Statistical Consultation and Collaborative Research at BYU.

**BIGHORN ARCHAEOLOGICAL CONSULTANTS, LLC**
3706 NICHOLAS DRIVE, SANTA CLARA, UTAH 84765
(435) 632-8250 (801) 437-1736 FAX

**Report Number 16-12**

# Archaeological Testing & Historic Road Reconnaissance in the Alton Coal North Private Lease Area, Kane County, Utah

Prepared by

Dale R. Gourley
Aaron A. Jordan
Samira Z. Hall

for

Alton Coal Development, LLC
Alton, Utah

&

Utah Division of Oil Gas & Mining
Salt Lake City, Utah

Utah Project Authorization Number U16-HO-0136p(e)
Utah Public Lands Policy Coordination Office Permit Number 138

March 2017

## Table of Contents

List of Appendices ..... iv
List of Tables ..... iv
List of Figures ..... iv
Chapter 1: Introduction ..... 1
Project Overview ..... 1
Chapter 2: Physical and Environmental Setting ..... 3
Geology ..... 3
Modern Climate ..... 3
Modern Flora ..... 3
Modern Fauna ..... 4
Chapter 3: Cultural Context ..... 5
Paleoindian Stage ..... 5
Archaic Stage ..... 6
Early Archaic ..... 6
Middle Archaic ..... 7
Late Archaic ..... 7
Formative Stage ..... 8
Sevier Fremont ..... 8
Basketmaker II ..... 10
Basketmaker III ..... 11
Pueblo I ..... 11
Pueblo II ..... 12
Pueblo III ..... 13
Late Prehistoric / Protohistoric / Historic Southern Paiute Stage ..... 14
Historic Euro-American Period ..... 15
Chapter 4: Research Interests ..... 17
Chronology & Cultural Affiliation ..... 17
Subsistence ..... 17
Site Extent, Function & Organization ..... 18
Seasonality & Mobility ..... 19
Historic Themes ..... 20
Chapter 5: Tier I Mitigation Methods ..... 21
Recording Procedures ..... 21
Artifact Collection ..... 21
Post Fieldwork Analysis and Ancillary Studies ..... 22
Curation ..... 22
Chapter 6: Cultural Site Descriptions ..... 23
42KA3077 ..... 23
42KA3097 ..... 23
Chapter 7: Tier I Testing Results ..... 27
42KA3077 ..... 27
Testing Methods ..... 27
STP Results ..... 27
TU1 Results ..... 35

Summary .....37
42KA3097.....38
Testing Methods .....40
STP Results .....41
Summary .....45
Chapter 8: Historic Road Reconnaissance.....46
Chapter 9: Ceramic Analysis .....49
Analytical Methods.....49
Results.....49
42KA3077 .....49
42KA3097 .....50
Ceramic Typologies.....50
Snake Valley Grayware.....51
Southern Paiute Brown Ware .....51
Summary.....52
Chapter 10: Chipped Stone Analysis .....53
Analytical Methods.....53
Results.....54
42KA3077 .....54
42KA3097 .....57
Projectile Point Typologies.....59
Northern Side-notched .....59
Sudden Side-notched.....60
Gypsum Cluster – Gatecliff Contracting Stem.....61
Elko Series.....61
Rose Spring Corner-notched .....62
Desert Side-notched .....63
Obsidian Sourcing & Hydration Dating .....64
Summary.....64
Chapter 11: Ground Stone Analysis .....66
Analytical Methods.....66
Results.....66
42KA3077 .....67
42KA3097 .....70
Summary.....71
Chapter 12: Historic Artifacts.....73
42KA3077.....73
42KA3097.....73
Chapter 13: Discussion & Conclusions .....74
Research Themes .....74
Chronology & Cultural Affiliation.....74
Subsistence .....75
Site Extent, Function & Organization .....75
Seasonality & Mobility .....77
References Cited .....79

## List of Appendices

Appendix A. Testing Results by Unit
Appendix B. Chipped Stone Analysis
Appendix C. Obsidian Sourcing & Hydration Analysis
Appendix E. Ground Stone & Hammerstone Analysis

## List of Tables

Table 3.1. Cultural phases of the area ..... 5
Table 10.1. Chipped stone debitage & formal Tools ..... 53
Table 10.2. Chipped stone artifacts recovered from site 42KA3077 ..... 55
Table 10.3. Debitage from site 42KA3077 ..... 55
Table 10.4. Chipped stone tools from site 42KA3077 ..... 56
Table 10.5. Chipped stone artifacts recovered from site 42KA3097 ..... 57
Table 10.6. Debitage from site 42KA3097 ..... 58
Table 10.7. Chipped stone tools from site 42KA3097 ..... 58
Table 10.8. Obsidian sourcing results ..... 64
Table 11.1. Ground stone from sites 42KA3077 & 42KA3097 ..... 66
Table 11.1. Ground stone from site 42KA3077 ..... 67
Table 11.1. Ground stone from site 42KA3097 ..... 70
Table A.1. Shovel test pit & test unit results from site 42KA3077 ..... A-1
Table A.2. Shovel test pit results from site 42KA3097 ..... A-6
Table B.1. Chipped stone debitage analysis from site 42KA3077 ..... B-1
Table B.2. Chipped stone tools analysis from site 42KA3077 ..... B-3
Table B.3. Chipped stone debitage analysis from site 42KA3097 ..... B-6
Table B.4. Chipped stone tools analysis from site 42KA3097 ..... B-7
Table D.1. Chipped stone tools analysis from site 42KA3097 ..... D-1
Table D.2. Chipped stone tools analysis from site 42KA3097 ..... D-7

## List of Figures

Figure 1.1. Project & Site Location Map ..... 2
Figure 6.1. 42KA3077 Plan Map ..... 25
Figure 6.2. 42KA3097 Plan Map ..... 26
Figure 7.1. Overview of site 42KA3077 looking northwest ..... 27
Figure 7.2. STP locations across site 42KA3077 ..... 28
Figure 7.3. Overview of site 42KA3077 looking south-southeast ..... 29
Figure 7.4. Overview of Feature 1 on site 42KA3077 looking southeast ..... 30
Figure 7.5. Overview of Feature 1 on site 42KA3077 looking west. ..... 31
Figure 7.6. Close-up of STP locations across site 42KA3077 ..... 32
Figure 7.7. Close-up of STP locations across site 42KA3077 ..... 33
Figure 7.8. Close-up of Test Unit 1 and STP locations across site 42KA3077. ..... 34
Figure 7.9. Plan map of Features 1 & 2. ..... 35

Figure 7.10. Southeast profile wall of TU1. .....36
Figure 7.11. Southwest profile of TU1. .....37
Figure 7.12. Southwest profile wall of TU1. .....37
Figure 7.13. Overview of site 42KA3097 looking north. .....38
Figure 7.14. Overview of STP locations across site 42KA3097. .....39
Figure 7.15. Overview of site 42KA3097 looking south. .....40
Figure 7.16. Overview of site 42KA3097 looking southeast. .....41
Figure 7.17. Close-up of STP locations across site 42KA3097. .....42
Figure 7.18. Close-up of STP locations across site 42KA3097. .....43
Figure 7.19. Close-up of STP locations across site 42KA3097. .....44
Figure 8.1. Overview of current county road alignment with modern cattle guard looking south.46
Figure 8.2. Overview of current county road alignment looking northwest. .....47
Figure 8.3. Overview of current county road alignment looking southeast. .....47
Figure 9.1. Southern Paiute Brown Ware sherd .....50
Figure 9.2. Southern Paiute Brown Ware sherd .....50
Figure 9.3. Southern Paiute Brown Ware sherds .....50
Figure 9.4. Southern Paiute Brown Ware sherd & Snake Valley Gray sherds .....51
Figure 9.5. Snake Valley Black-on-gray sherd .....51
Figure 10.1. Northern Side-notched series points .....60
Figure 10.2. Sudden Side-notched series point .....60
Figure 10.3. Gypsum Cluster points from 42KA3077 & 42KA3097 .....61
Figure 10.4. Elko Series points from 42KA3077 .....62
Figure 10.5. Elko Series points from 42KA3097 .....62
Figure 10.6. Elko Series points from 42KA3097 .....62
Figure 10.7. Rose Spring Series point from 42KA3097 .....63
Figure 10.8. Desert Side-notched point from 42KA3077 .....63
Figure 11.1. Quartzite mano & sandstone mano fragment .....67
Figure 11.2. Sandstone mano fragment & sandstone metate fragment .....68
Figure 11.3. Quartzite metate fragment .....68
Figure 11.4. Quartzite metate fragment .....68
Figure 11.5. Quartzite ground stone fragments .....69
Figure 11.6. Quartzite ground stone fragments .....69
Figure 11.7. Quartzite ground stone fragments .....69
Figure 11.8. Quartzite ground stone fragments .....70
Figure 11.9. Quartzite ground stone fragment .....70
Figure 11.10. Quartzite mano fragments .....71
Figure 11.11. Sandstone metate fragment & quartzite ground stone fragment .....71
Figure 11.12. Sandstone ground stone fragments .....72
Figure 11.13. Ground stone fragments .....72
Figure 12.1. Clear glass medicinal(?) bottle from 42KA3077 .....73
Figure 13.1. Significant artifact distribution across site 42KA3077 .....76
Figure 13.2. Significant artifact distribution across site 42KA3097 .....78

# Chapter 1: Introduction

## Project Overview

This report presents the results of the Tier I archaeological site surface mapping and testing, and historic road reconnaissance within the Alton Coal North Private Lease Area, Kane County, Utah. This work was completed prior to the development of an open pit coal mine that is to be worked by Alton Coal Development, LLC (Alton Coal). The project area is located on privately held land within T 39S, R 5W, Sections 7 & 18 and T 39S, R 6W, Sections 12 & 13 (Figure 1; USGS 7.5' Topographic Quad: Alton, Utah).

The project area, identified as the North Private Lease Area (NPLA), has been covered by two previous inventories (Keller 1987, Stavish 2007). These surveys identified two cultural sites, 42KA3077 and 42KA3097, that were at least partially present within the NPLA. Both sites have been determined eligible for the National Register of Historic Places (NRHP) and required mitigation to offset adverse effects that would result from development of the mine. A third site, 42KA6080, also determined eligible for the NRHP, was present just south of the project area and required barricading and monitoring to avoid adverse effects. An examination of historic 19$^{th}$ century maps of the area also indicated the presence of the historic "Road to Kanab" which was depicted as passing through the project area. This road was not identified during the previous inventories of the area, thus, a reconnaissance survey was completed as part of the project area mitigation in an effort to locate any remaining segments.

Mitigation work was initiated at the request of Alton Coal to assist the Utah Division of Oil, Gas & Mining (DOGM) in fulfilling requirements under various state environmental protection laws including the Utah Antiquities Act (UCA 9-8-404). Tier I work was conducted under Utah Project number U16-HO-0136p(e) and supervised by Bighorn archaeologist Steven Hall between 22 February and 10 March 2016. All fieldwork activities were completed under the direction of Dale R. Gourley. Field conditions for the work were good.

The mitigation was guided by a research design established in the Archaeological Monitoring & Historic Properties Treatment Plan (Gourley 2016a) that specifically focused on the collection of data sets that could contribute additional information on aboriginal occupation and adaptation to past environments within the region. The data presented in this report cover the fieldwork involved with the Tier I mitigation work on sites 42KA3077 and 42KA3097, and includes the project research design, descriptions of site testing results, and artifact analysis. Results of the historic road reconnaissance are also presented. Preliminary results of the mitigation work have also been prepared and submitted recommending no further mitigation work beyond the Tier I data recovery efforts (Gourley 2016b, 2017).

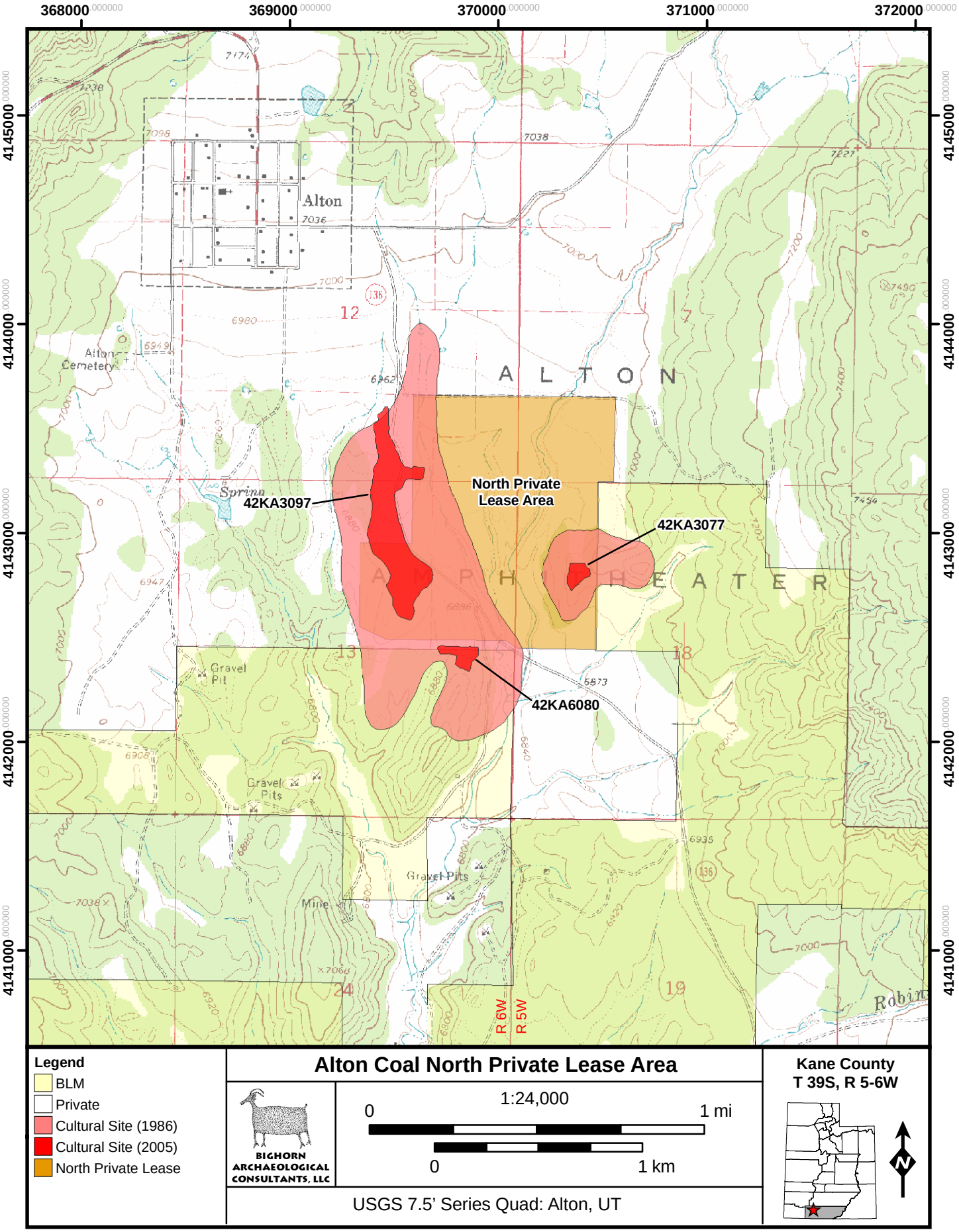



Figure 1.1. Project & Site Location Map

# Chapter 2: Physical & Environmental Setting

The project area sites lie within the Limestone Capped subsection of the Southern High Plateaus Section of the Basin and Range / Colorado Plateau Transition Zone in south-central Utah (Stokes 1986). This area is characterized by a series of cliffs and terraces that rise from the Grand Canyon in Arizona to the summit of the High Plateaus in Utah. The section is bounded on the east by the East Kaibab Monocline, on the west by the Hurricane Fault, on the north by the edges of various high plateaus, and on the south by the Grand Canyon. Within this section, harder rock layers create cliffs and accompanying benches and tablelands, whereas the softer rock units have eroded into slopes and badlands. More specifically, the sites are present along the western edge of the Paunsaugunt Plateau within the broad Alton Amphitheater valley to the south of Alton, Utah, above and overlooking Kanab Creek. The elevation of the sites is approximately 6,880 feet (2,097 m) above sea level.

## Geology

The surface geology of the site areas consists of Holocene to Upper Pleistocene alluvium and undifferentiated mass-movement deposits, and Upper and Lower Cretaceous deposits within three units. These include 1) alluvium (Qa) composed of mostly sand with lenses of silty clay, sandy silt, and gravel deposited in stream beds, washes, adjacent floodplains, and on low alluvial slopes; 2) undifferentiated mass-movement deposits (Qmsc) consisting of very poorly sorted, non-stratified, landslides, slumps, colluvium, talus, and other mass-movement deposits; and 3) Upper Cretaceous aged Dakota Formation and Lower Cretaceous aged Cedar Mountain Formation deposits (Kdcm). The Dakota Formation is yellowish-brown, gray, and white, thin to thick interbedded, sandy shale, carbonaceous shale, shaly sandstone, sandstone, smectitic mudstone, coal, and marl. The underlying Cedar Mountain Formation is yellowish-brown, brown, pale-olive-gray, and gray, commonly variegated, thin to medium-bedded sandstone, smectitic mudstone, and pebble conglomerate (Tilton 2001).

## Modern Climate

The modern climate of the area is temperate and semi-arid with an average annual precipitation of approximately 17.05 inches. The winter average high temperature is approximately 42° F and the summer average high temperature is 82° F. However, maximum temperatures can reach 84+° F during the summer months and 1° F during the winter. The majority of annual precipitation falls as light winter snow and summer rain that is the product of localized thunderstorms. Winter storms generally are the result of frontal movement from the Gulf of Alaska that produce valley and mountain snow.

## Modern Flora

Vegetation in the Alton Amphitheater falls within the Pinyon-Juniper community of the Upper Sonoran vegetation life zone. Plant species within this community consist of pinyon pine (*Pinus edulis*), juniper (*Juniperus sp.*), oak (*Quercus sp.*), barberry (*Berberis sp.*), sagebrush (*Artemisia sp.*), canyon grape (*Vitis sp.*), current (*Ribes sp.*), serviceberry (*Amelanchier sp.*), squawbush

(*Rhus, sp.*), goosefoot (*Chenopodium sp.*), stickleaf (*Mentzelia sp.*), cattail (*Vitis sp.*), sedge (*Carex sp.*), sunflower (*Helianthus sp.*), prickly pear cacti (*Opuntia sp.*), yucca (*Yucca sp.*), onion (*Allium sp.*), Indian ricegrass (*Achnatherum hymenoides*), cheatgrass (*Bromus tectorum*), and crested wheatgrass (*Agropyron cristatum*). Most of these same plant species were also likely present prehistorically in the area.

**Modern Fauna**

Faunal species present in the vicinity of the site areas today include at least 30 species of mammals, 85 species of birds, and six species of reptiles. Historic settlement of the area and subsequent overgrazing has severely affected local animal populations, with grizzly bear, elk, antelope, beaver, lynx, and wolf having completely disappeared from the area, and the deer population has been heavily reduced (Halbirt & Gualtieri 1981:10). Potential mammal resources found prehistorically in the Alton Amphitheater and Sink Valley include mule deer, elk, antelope, red and gray fox, lynx, badger, grizzly bear, wolf, coyote, mountain lion, porcupine, deer mice, wood rat, marmot, ground squirrel, pine squirrel, prairie dog, gopher, jackrabbit, cottontail rabbit, and beaver. Potential bird and reptile resources include wren, mourning dove, hawk, woodpecker, owl, bald eagle, raven, thrush, sparrow, rattlesnake, gopher snake, garter snake, horned toad, and whiptail and swift lizards. For the Southern Paiute who occupied the Alton area, deer was the chief large-game animal, with rabbits and an assortment of rodents taken throughout the year (Kelly 1964:36).

# Chapter 3: Cultural Context

The prehistory of the Eastern Great Basin can be broken down into a series of developmental stages based on changing technologies, economics, and social systems (Table 3.1). A brief overview of these phases is provided below. For more detailed information refer to general syntheses of the regional prehistory (Altschul & Fairley 1989; Geib 1996; Lyneis 1995). Historic exploration and settlement of the area began in1776 with the Dominguez and Escalante Expedition. For more information on the history of the area refer to historic syntheses of the general area (e.g. Bradley 1999).

**Table 3.1. Cultural phases of the area**

| Cultural Phase | Sub-phase | Approximate Time Period |
|---|---|---|
| Paleoindian | | 11000 – 7000 BC |
| Archaic | Early Archaic | 7000 – 4200 BC |
| | Middle Archaic | 4200 – 2600 BC |
| | Late Archaic | 2600 – 1 BC |
| Formative (Virgin Anasazi / Fremont) | Basketmaker II | 100 BC – AD 450 |
| | Basketmaker III | AD 450 – 750 |
| | Pueblo I | AD 700 – 900 |
| | Pueblo II/III | AD 900 – 1300 |
| Late Prehistoric (Southern Paiute / Ute) | Late Prehistoric | AD 1200 – 1700 |
| | Protohistoric | AD 1700 – 1850 |
| | Historic | Post AD 1850 |
| Historic (Euro-American) | Early Exploration | AD 1776-1858 |
| | Mormon Settlement, | AD 1858-1870 |
| | Farming & Ranching | AD 1870-1880 |

### Paleoindian Stage

Evidence is accumulating to indicate that the Americas were initially colonized during the Late Pleistocene sometime prior to 15,000 years ago. Discoveries at sites such as Cactus Hill in Virginia suggest human occupation perhaps as early as 15,070±70 BP (McAvoy & McAvoy 1997:178). However, the earliest wide spread and easily identified cultural complex in North America is known as Clovis and apparently dates from 13,500 to 12,900 years ago (Fiedel 1999:102). This complex is marked by the occurrence of large fluted lanceolate points. Clovis is followed by another fluted point tradition known as Folsom which appear to date from 13,000 to 12,500 years ago. Finally, with the end of the fluted tradition, occur a number of lanceolate and stemmed point complexes which lasted up to approximately 8000 years ago.

Evidence of this early phase of human occupation within the region is fairly rare. One site, Lime Ridge (42SA16857) in San Juan County is attributable to the Clovis complex (Davis 1989). The site consists of a moderately dense scatter of chipped stone debris with approximately 35 tools

and has been interpreted as a short term camp or hunting station. Another Clovis affiliated site known as Hell'n Moriah (42MD1067) occurs in the Tule Valley (Davis et al. 1996). It is interpreted as a retooling station and contained 12 tools as well as 134 flakes. The Montgomery site (42GR1956) in Grand County appears to be related to the Folsom complex (Davis 1985). This site consists of more than 900 artifacts and was interpreted as a base camp. 42MD300 in Millard County and the Silverhorn site (42EM8) in Emery County are apparently multi-component sites with cultural material from both Folsom and Stemmed point traditions (Gunnerson 1956; Simms & Lindsay 1989). Both sites appear to be residential camps. Recent excavations on the Washington Fault Site in the St. George Basin also revealed a Paleoindian surface with a Lake Mojave projectile point (Gourley & Nash 2013). Finally, the Martin site (42UT934) in Utah County at the southern end of Utah Lake produced Late Paleoindian Cody complex artifacts (Janetski 2001). Caves such as Danger and Hogup have also produced material attributed to the Paleoindian tradition (Jennings 1957; Aikens 1970).

In addition to the documented archaeological sites, several diagnostic artifacts attributed to various Paleo-traditions have been reported as isolated surface finds. In southwestern Utah, two Clovis points from Iron County and three Folsom points from Iron and Garfield Counties respectively were reported by Copeland and Fike (1988). According to Kohl (1991) two additional Clovis points were collected from Washington County. On the Arizona Strip, one isolated Clovis point was collected in Sullivan Canyon at site AZ:A:1:17(BLM) (Miller 1978). Great Basin Stemmed projectile points, such as the Silver Lake variety, have also been documented in the general area including one from Washington County (Gourley 2003) and from the Arizona Strip from site AZ:A:1:51(BLM) on the Middle Virgin River (BLM site files).

## Archaic Stage

Changes in environmental conditions with the end of the Late Pleistocene/Early Holocene led to a shift in cultural adaptations. These shifts included the development of new technology, new economic emphasis in plant procurement and small game hunting, and possible changes in social systems and demography. The Archaic Stage is usually further sub-divided into Early (7000-4200 BC), Middle (4200-2600 BC) and Late (2600-300 BC) temporal phases. The beginning of the sequence is marked by the occurrence of certain cultural materials diagnostic of the Archaic such as basketry, distinct sandal styles, side-notched and stemmed points, and milling stones, and ends with the introduction of cultigens. Archaic period sites have recently been investigated in the St. George Basin (Talbot & Richens 2009; Gourley et al. 2010) as well as in the Beaver Dam Mountains region (Moffitt et al. 1978). These latter sites are best characterized as special use localities related to high elevation resource procurement and processing, and demonstrative of highly mobile settlement strategies.

### *Early Archaic*

In the region of Southern Utah and the Arizona Strip, Early Archaic adaptations appear to begin perhaps as early as 7000 BC. Evidence of the Early Archaic comes specifically from discoveries at Walters Cave (Jennings 1980), Dust Devil Cave (Ambler 1996), Atlatl Rock Cave (Geib et al. 1996), Old Man Cave (Geib & Davidson 1994), Sand Hollow (Talbot & Richens 2009), and recent excavations on the Washington Fault Site in the St. George Basin (Gourley & Nash 2013).

Artifacts diagnostic of the sub-stage include Pinto, Northern side-notched, and Sand Dune side-notched projectile points, and Open-twined, Fine-warped, and Plain-weave sandals. On the Arizona Strip some of the earliest evidence for the Archaic comes from the discovery of Pinto points along the Navajo-McCullough transmission line corridor (Moffitt et al. 1978).

### *Middle Archaic*

The Middle Archaic may correspond to increasingly arid conditions of the so-called Altithermal or Hypsithermal interval, a climatic stage of high temperatures and aridity proposed by Antevs (1948). More recent evaluation of the data indicates the climate was more variable than originally believed; although, there is some evidence to support a climate driven reduction in archaeological sites and population that occurs across lowland environments from the Great Plains to the Great Basin and Southwest. Sites such as Cowboy Cave, Old Man Cave, and Dust Devil Cave seem to be largely abandoned or only sparsely occupied and appear to support an apparent decrease in population. However, some sites, such as in Bowns Canyon, Sand Hollow, and along Fort Pearce Wash, and other areas with permanent water availability, suggest the region was not totally abandoned (Geib 1996:33; Gourley et al. 2010); Talbot & Richens 2009). Diagnostic artifacts of the Middle Archaic include Sudden side-notched, Hawken side-notched, Rocker side-notched, and McKean lanceolate points as well as Plain-weave sandals, and during the transition from Middle to Late Archaic, split-twig figurines. On the Arizona Strip, evidence of the Middle Archaic is rare and consists of discoveries of Hawken, Rocker, and Sudden side-notched points (Altschul & Fairley 1989:96).

### *Late Archaic*

The transition from the Middle to Late Archaic apparently coincides with a return to a more equable climate and increasing population. Open sites become relatively common and most exhibit a fairly thick accumulation of midden deposits. Important Late Archaic remains occur in Cowboy Cave, Benchmark Cave (Sharrock 1964), Bechan Cave (Agenbroad et al. 1989), Sand Hollow (Talbot & Richens 2009), and along Fort Pearce Wash (Gourley et al. 2010). However, it appears that while many caves and rockshelters were extensively used, others, such as Dust Devil Cave were only lightly occupied. Hog Canyon Dune, primarily a BMII site located just north of Kanab, also contained a Late Archaic burial (Schleisman & Nielson 1988). A Late Archaic component to the Arroyo site (McFadden 2000), located east of Kanab, was noted as well. Hallmark diagnostics of the Late Archaic include Gypsum, San Pedro/Elko Series, San Rafael side-notched, and McKean lanceolate points, Split-twig figurines, and Plain-weave sandals. On the Arizona Strip evidence for a Late Archaic occupation is more common and consists of several sites on the Kaibab Plateau as well as Rock Canyon Shelter and Antelope Cave. Three sites in the Beaver Dam Mountains, NA11500, NA11634, and 42WS479 have produced Gypsum points associated with aceramic roasting pits (Altschul & Fairley 1989:79; Gourley et al. 2009).

The Late Archaic finally ends with the introduction of horticulture in the region between approximately 3000 to 2200 years ago (Geib 1996:35). However, some researchers have suggested an occupational hiatus in the region near the end of the Late Archaic (Berry & Berry 1986). While there is little evidence in the radiocarbon record, they suggest a lack of continuity

based on the relative position of Gypsum points and split-twig figurines in the temporal sequence and that these items were apparently not manufacture after 3000 BP. Examination of the sequence of basketry types cannot be accounted for in their argument and seems to indicate continuity between Archaic and Early Formative styles. The end of the Archaic can more properly be defined as a transition from a hunter-gatherer lifeway to a mixed gardening and hunting/collecting economy. This Early Agricultural stage appears to retain similarities with the previous Archaic stage such as a heavy emphasis on hunting and collecting and the continued use of the atlatl and dart.

## Formative Stage

The Formative is marked by the adoption and spread of horticulture, the rise and development of sedentary settlements, and later the introduction of ceramics. Data collected from archaeological sites affiliated with this developmental stage also indicate increasingly elaborate technological and cultural practices. In the eastern Great Basin, Formative groups were composed of the Fremont while in the Southwest, Anasazi groups populated the area. The Anasazi is frequently divided into a series of periods known as the Pecos classification. Following the Archaic the earliest period is known as Basketmaker II (700 BC- AD 400), this is followed by Basketmaker III (AD 450-750), then Pueblo I (AD 700-900), Pueblo II (AD 900-1150), and Pueblo III (AD 1150-1300). Two additional periods Pueblo IV and V have been established for post-abandonment Puebloan sites located in the Rio Grande Valley, at the Hopi Mesas, and the Zuni or Cibola region. However, these periods have no bearing on the archaeology of the project area (Lyneis 1995).

### *Sevier Fremont*

A little more than 2,000 years ago, maize was first grown in the eastern Great Basin (Wilde & Newman 1989). As subsistence became more focused on domesticated plants, people began to live in larger groups and became more sedentary. Because people were less mobile, they constructed more substantial houses and storage structures, and began to make pottery. The bow-and-arrow also began to be used during the Archaic-Fremont transition period. From about 1500 BP to 600 BP, people throughout much of the eastern Great Basin were living in pithouses, making and using pottery, and growing domesticated plants. There is some debate over the relative importance of domesticated plants as opposed to marsh resources in certain parts of the Fremont area (Madsen 1980, 1982; Madsen & Lindsay 1977; Nielson 1978), and the relationships among the various peoples subsumed under the Fremont label are not entirely clear.

Simms (1986) and Madsen (1989; Madsen & Simms 1998) have argued that the label 'Fremont' comprises people who employed a variety of subsistence/settlement strategies ranging from sedentary farming to full time hunter-gatherers. It may be, therefore, that 'Fremont' includes the geographical (and cultural?) interface between the hunter-gatherer lifeways typical of most of the Great Basin, and the horticultural lifeways of the Southwest. At a large scale, the frontier between foraging and farming appears to have moved in and out from a core area along the Wasatch Plateau (Talbot & Wilde 1989), but in many specific areas it is unclear whether the Fremont were horticulturalists, full-time hunter-gatherers, horticulturalists who supplemented their diet by substantial gathering and hunting, or some combination of the above.

Questions about subsistence and mobility strategies have often been raised for the Fremont. Madsen and Simms (1998) suggest that the Fremont were a complex of groups sharing many traits and behaviors. This would perhaps explain variances found within the different areas of the Great Basin among the Fremont sites and areas. In particular the variance found in Fremont sites in and around the project area. Several well-known Fremont sites have been excavated in the Parowan valley and share the same general trends in the material culture of the Fremont. Outside of the Parowan Valley however, the settlements become smaller, with fewer occurrences of architecture and occupation appears to be of a seasonal nature.

Whatever the relative importance of gathering, hunting, or horticulture to Fremont populations, they all were likely to be living near the frontier of farming (though that frontier may sometimes have been permeable and poorly defined — more of a mosaic than a line), with "pure" hunter-gatherers occupying essentially all of the rest of North America to the west and north of the Great Salt Lake, and with horticulturalists to the south occupying at least the "core" area along the Wasatch Plateau. Fremont farmers formed the northernmost extension of an immense farming zone that extended from Mesoamerica north through what is now the southwestern United States. Throughout the world, wherever farmers and foragers come into contact, they virtually always interact, and these interactions usually have important consequences for the development of the interacting societies (e.g., Gregg 1988; Spielmann 1986, 1991a, 1991b; Spielmann & Eder 1994). We thus can expect that Fremont economic strategies involved more than adaptation to the local physical environment. They also included some kind of interaction with other populations that likely followed different subsistence strategies (who may nevertheless be considered to be Fremont as well).

Exchange was apparently more important during the Fremont time period than it was earlier. McDonald (1994) documents movement of obsidian, shell, ceramics, and chert, and defines seven interaction networks based on the distributions of these items. The Great Salt Lake wetlands, the Bear River sites, Injun Creek, and the Levee and Knoll sites all include small quantities of marine shell, exotic ceramics, and obsidian which must have come from at least a moderate distance. These sites also contain abundant evidence of non-economic behavior in the form of clay figurines, which presumably have some kind of ritual function, and a variety of beads and pendants.

Several different site types are likely to be associated with the Fremont. Habitation sites are the most easily recognized. These sites often have depressions marking the locations of collapsed pithouses, and sometimes small mounds where adobe or wattle-and-daub surface structures have decayed. They should also have relatively substantial deposits of domestic trash, including ceramics, chipped stone, and ground stone artifacts. Some of these sites are quite large, e.g. Five-Finger Ridge (Talbot et al. 1995), Nawthis Village (Jones & O'Connell 1981), and Backhoe Village (Madsen & Lindsay 1977), although the best-known habitation sites from northern Utah are smaller, consisting of only a few structures each. A variety of short-term campsites and limited activity sites are also likely to date to the Fremont period (e.g., Simms 1986). These can be recognized as Fremont if they have ceramics or projectile points diagnostic of the Fremont period. The diagnostic points are generally small arrow points such as Rose Spring Corner-notched, Uinta Side-notched, and Bear River Side-notched points (Holmer & Weder 1980).

### *Basketmaker II*

Basketmaker II is marked by the initial introduction of horticulture in the region but before the development of ceramics and sedentary settlements. The earliest evidence of maize in the region, especially in the Glen Canyon area, appears to be around the 1st century AD. However, in the Four-Corners area, maize may have appeared around 200 BC, while the area south of the Glen Canyon area dates have been recovered that indicate its presence around 600 BC (Geib 1996:54-55). The stage is also known for a wide variety of cultural materials such as distinctive sandal types, coiled basketry, rabbit fur blankets, human hair cordage, fiber and hide bags, atlatl weaponry, snares, and nets which are often associated with hunting and gathering activities. Manufacturing techniques of these items are distinct from techniques used by earlier Archaic cultures found on the Colorado Plateau. These cultural materials suggest foraging remains an important subsistence method. In terms of important diagnostic artifacts and features of the Basketmaker II period perishable artifacts are paramount. For example, two types of sandals, four-warp wickerware and multi-warp cord with square fringed toes were made. Other perishable artifacts include s-curved throwing or fending sticks, two-rod and bundle basketry (from Basketmaker II to Pueblo III), and Indian hemp twined bags with red and black designs (Altschul & Fairley 1989). In so far as non-perishable artifacts are concerned it is difficult to distinguish Basketmaker II from earlier Archaic materials. Both stages/periods have slab-lined cists, basin milling stones, one-hand cobble manos, and Gypsum and San Pedro/Elko corner-notched points. However, in regard to Basketmaker chipped stone technology there are some unique characteristics. Basketmaker II generally lacks end and side scrapers but does have large triangular square-based knives, snapped denticulates, and shallow side-notched triangular points which do not appear to be part of earlier cultural components.

Archaeological sites with Basketmaker II components are relatively rare but more common across the Arizona Strip and Southern Utah than earlier Archaic affiliated components. The most complete assemblage of Basketmaker materials appears to come from Antelope Cave (AZ:Z:3:1) (Janetski & Hall 1983). Heaton Cave (AZ:B:5:27) near Mount Trumbull also produced Basketmaker II materials (Judd 1926). In Utah, Basketmaker II components were identified at Cave DuPont (Nusbaum 1922), Sand Dune Cave, ZNP-21(Schroeder 1955), South Fork (McFadden 1994), Sand Hollow (Talbot & Richens 2009); and several open sites in the Beaver Dam Mountains. Although identified as Basketmaker III, the pit structure at Hog Canyon (Schleisman & Nielson 1988), just north of Kanab, lacked directly associated ceramics, suggesting it is more likely a BMII, or transitional Basketmaker III component. Two radiocarbon samples from the structure yielded dates bordering on the early Basketmaker III time period. Thompson and Thompson (1974) reported pit structures at the Little Jug Site in the Tuweep Valley area southwest of the current project that yielded radiocarbon dates pre-dating AD 400. Walling (1998) also found a BMII component at the Carling Reservoir Site, near Colorado City, Arizona, with 11 pit structures dating to the first two or three centuries AD. Additional sites in the area have produced an abundance of perishable materials and evidence for corn horticulture and residential stability at least back into the first century BC (Janetski & Wilde 1989; McFadden 2000; Neilson 1998). Of particular note are burials from Cave du Pont and Hog Canyon, both north of Kanab; various shelters just east of Kanab (Edgar 1994; Judd 1926); and, most recently at Kanab itself, where a single interment of 11 individuals was found dating to the

first century BC (Zweifel et al. 2006). Stable carbon isotope analysis on some of these burials demonstrated a strong maize dependence even at this earliest stage of Formative development. In the Moapa Valley of Southeastern Nevada a number of archaeological sites have produced evidence of Basketmaker II pit houses (Harrington 1937; Schroeder 1953; Shutler 1961). Black Dog Cave, also in the Moapa Valley, contains a Basketmaker II occupation as well, based on the presence of 30 slab or grass lined pits (Harrington 1942; Cody 1942; Schroeder 1953).

### *Basketmaker III*

During the Basketmaker III phase, environmental conditions appear to have led to an improvement and intensification of farming, which in turn lead to increasing reliance on cultigens over wild foods. However, hunting and gathering was not totally abandoned. Several new innovations also occur, including two-handed manos and trough metates, the bow and arrow, plain gray sand-tempered ceramics, as well as decorated black-on-gray ceramics. Diagnostic projectile points consist primarily of types associated with the Dolores/Rosegate Series (Altschul & Fairley 1989). Ceramics become the most important diagnostic artifact type. Traditionally, the introduction of pottery has been placed around A.D. 500; however, radiocarbon dates from the Little Jug site suggest an earlier introduction for pottery on the Arizona Strip. A range of dates from 1850±90 and 1630±90 BP indicate gray-ware ceramics were being used between AD 10 and AD 410 (Thompson & Thompson 1974; 1978). Both shallow and deep pit houses, occasionally with encircling interior slab supported benches and round slab-lined cists remain the basic architectural style.

Basketmaker III sites in the region appear to be fairly common in upland settings, however along the Virgin River, sites attributed to the Basketmaker III period appear to be uncommon if not rare (Altschul & Fairley 1989:114). Basketmaker III sites have been found at Hog Canyon Dune (Schleisman & Nielson 1988) and at the Kanab Site (Nickens & Kvamme 1981), and are known to occur on the Arizona Strip at places such as the Paria Plateau (Mueller et al. 1968), around the flanks of the Kaibab Plateau (Altschul & Fairley 1989), House Rock Valley (Altschul & Fairley 1989), along the base of the Vermillion Cliffs between Fredonia and Short Creek (Wade 1967), on the Shinarump Bench (Altschul & Fairley 1989), the south slope of Pine Mountain (Thompson 1971; Thompson & Thompson 1974), and the Shivwits Plateau (Shutler 1961). To the west several Basketmaker III sites have been identified on the benches overlooking the Moapa Valley (Shutler 1961; Soule 1975). Along the Virgin River and its tributaries one site has been identified at the confluence of the Virgin River and Beaver Dam Wash (Altschul & Fairley 1989), as well as two sites (42WS324 & 42WS326-Roadrunner Village) in the middle reaches of the Virgin River (Billat et al. 1992). Sites dating from this period were also identified at Sand Hollow (Talbot & Richens 2009) and at the Hurricane Ridge Site (Buck & Perry 1999).

### *Pueblo I*

Pueblo I appears to be a time of marked increase in population with substantially more complex sites. Archaeological sites attributed to this period become quite common in some areas and appear in both lowland and upland settings leading some researchers to hypothesize that Virgin Puebloans practiced a seasonal round in which they occupied lowlands during the spring and summer and moved into the uplands during the autumn and winter. In terms of material cultural

and technology substantial refinements in ceramics occurred. Several types of well-made pottery were manufactured during this period and are predominated by Tusayan (Virgin) gray and white wares and Moapa brown and white wares. Designated ceramic types in the Tusayan (Virgin) series include Washington Black-on-gray and North Creek Gray while the Moapa series contains Moapa Brown, Boulder Gray, and Boulder Black-on-gray. Several types of trade wares apparently also occur in Virgin area including Kana'a Black-on-white, Wepo Black-on-white, and Kana'a Neck-banded from the Kayenta Puebloans, and Deadmans Gray and Floyd Black-on-gray from the Cohonina on the South Rim of the Grand Canyon. Diagnostic chipped stone tools remain basically unchanged from earlier Basketmaker III period and are dominated by Dolores/Rosegate Series arrow points (Davis et al. 1998).

In terms of architecture, the Pueblo I period exhibits a considerable degree of diversity. Pit houses continue to be important although they are more elaborate in design. These structures are usually circular with a slab-lined bench, central hearth, and several shallow sub-floor storage pits, and range in size from approximately 3 to 5 m in diameter (Allison 2003:personal communication). Associated storage features consist of deep slab-lined or cobble-lined and plastered cists occurring singly or in arching rows around a pit house. Other architectural styles include one or two habitation rooms with several storage rooms appended to one end (Altschul & Fairley 1989). Numerous PI sites are recorded to the west of Kanab on Little Creek Mountain (Heid 1982), at Hildale (Nielson 1998), and along the Virgin River as far east as Mt. Carmel Junction (Dalley & McFadden 1985:43). Antelope Cave, on the Arizona Strip, has a PI component (Janetski & Wilde 1989). Important sites with Pueblo I components that have been excavated and reported include the Kanab Site (Nickens & Kvamme 1981); Cottonwood Canyon Cliff Dwelling site, in which a PI pithouse was found (Judd 1926; Tipps 1989); the Park Wash Site, a recently excavated PI residential site a few miles east of Kanab (Ahlstrom 2000); sites in Johnson Canyon including the Dead Raven site (Walling & Thompson 2004), the Sand Hill site (Aikens 1965), and Bonanza Dune (Aikens 1965); NA9058 at the confluence of Beaver Dam Wash and the Virgin River, ZNP-5 in Zion National Park (Schroeder 1955), Little Man 3 (42WS1349) (Dalley & McFadden 1988), 42WS268 and 42WS388 at Quail Creek (Walling et al. 1986), the Red Cliffs site (42WS503) on Leeds Creek northeast of St. George (Dalley & McFadden 1985), and 42WS479 in the Beaver Dam Mountains (Gourley et al. 2009).

### *Pueblo II*

Pueblo II sites and components are perhaps the most common Puebloan remains in the region. This may be due in part to improved climatic conditions which lead to the establishment of farming in upland areas that were previously marginal and unproductive for such practices. The spread of terraced garden plots, check dams and other horticultural features attest to the increased farming. In addition, the improved conditions led to an increase in local population as well as apparent migrations from the Kayenta region at least along the eastern periphery of the Virgin area.

A wide array of well-made ceramics continues to be the dominant diagnostic artifacts of Pueblo II times. These ceramic types include several black-on-gray or white painted wares as well as corrugated utility wares. Plain utility wares continue to be made but are much less common. Chief painted wares include St. George Black-on-gray, North Creek Black-on-gray, Hurricane

Black-on-gray, Virgin Black-on-white, Mount Trumbull Black-on-gray, and Moapa Black-on-gray. Around A.D. 1050 the Little Colorado series of the San Juan Red wares develop in the region. Finally, after AD 1100, Washington Corrugated and Nankoweap Polychrome make their appearance. During Pueblo II times new arrow point styles, namely the Bull Creek and Parowan Basal-notched varieties, also appear.

Several architectural styles were apparently in use during the Pueblo II period. Typically, many Pueblo II occupations consist of one to three surface residential rooms with numerous associated storage structures. Residential rooms are frequently constructed with a jacal superstructure and clay plastered floors; whereas, storage rooms are made of masonry walls and a stone slab floor. Subterranean round pit houses with peripheral roof supports and a cribbed superstructure, as well as a semi-subterranean round house with surrounding masonry walls set on the surface of the pit, with circular ovoid to rectangular surface rooms of masonry, jacal, alternating courses of adobe, and stone or adobe also occur. Early in the Pueblo II sequence, the majority of communities were still relatively small, consisting of one or two pit houses and a few associated storage facilities and surface rooms. However, one exception has been identified at the Mecca Site (AZ B:1:68(BLM)) (Allison 1988a) where a large pueblo with approximately 80-100 rooms arranged into five arcing sections around four plazas is present.

Sites from this time period have been reported in almost every region of the Virgin Anasazi area. Such site include the Kitchen Corral Wash site to the east of Kanab, which contained eroded structures and two burials (McFadden 2000), the Cottonwood Canyon Cliff Dwelling site and various other sheltered sites in the region. To the west, early Pueblo II sites have been examined on Little Creek Mountain at the Mixmaster site, at the Corn Grower site near Colorado City (see McFadden 2000), ZNP-3 (Schroeder 1955), the Little Man Site 2 (42WS1346) (Dalley & McFadden 1988), the Dead Raven Site (42KA2667) (Walling & Thompson 2004), and 42WS479 in the Beaver Dam Mountains (Gourley et al. 2009). In later Pueblo II times, sites appear to increase in size and pit houses, while still in use, become uncommon. At this time, surface structures begin to dominate Pueblo II architectural plans. Sites attributed to late Pueblo II times include Main Ridge (26CK2148) along the Muddy River (Lyneis 1992), the Bonaza Dune Site (42KA1076) and the Sand Hill Site (42KA1060) in Johnson Canyon (Aikens 1965), small cliff dwellings at Cottonwood Canyon (Judd 1926; Tipps 1989), ZNP-21 (Schroeder 1955), and the Kanab Site (42KA1970) (Nickens & Kvamme 1981).

### *Pueblo III*

There has been a lack of consensus among researchers concerning the Anasazi occupation of the Virgin area during the Pueblo III period. Many maintained that the region was abandoned by AD 1150 (Aikens 1966; Effland et al. 1981; Euler & Chandler 1978; Euler et al. 1979; Schwartz et al. 1980, 1981). Others, however, have obtained late dates from several sites with Pueblo III ceramics suggesting that abandonment might have taken place ca. AD 1200-1300 (James Allison, personal communication 2008; see also Jones 1986:110; Thompson & Thompson 1978; Walling et al. 1986; Westfall 1987:90). Pueblo III sites near the project area include Pottery Knoll in the Park Wash area east of Kanab (Neff et al. 1997); the Arroyo Site downstream from Pottery Knoll (McFadden 2000); the Gnatmare site in Cottonwood Canyon (Metcalf 1981); and the Pinenut Site to the south of Kanab on the Arizona Strip (Westfall 1987).

**Late Prehistoric / Protohistoric / Historic Southern Paiute Stage**

The Late Prehistoric spans the establishment of Numic speaking socio-cultural groups following the collapse of Formative cultures in the region. Generally, it is believed that this phase began around AD 1200 and continuing until the establishment of permanent Euro-American settlements in the area. The movement of Numic speaking peoples from the southwest across the Great Basin and the Colorado Plateau is a subject of much speculation and debate. Linguistic data suggests that Numic speakers began to expand from the Mojave Desert region sometime around AD 1000. The cause of the Numic expansion is poorly understood, although some researchers have suggested deteriorating environmental conditions (Fowler et al 1973; Lamb 1958).

The beginning of the Late Prehistoric phase is marked by the disappearance of Formative (Pueblo) cultures in the region, while the end is represented by the start of indirect influences from the Spanish following the establishment of colonies in New Mexico and California. The Protohistoric ranges from the establishment of Spanish colonies in New Mexico around AD 1600 until the first documented European exploration of the region by Fathers Domínquez and Escalante in AD 1776. The historic period ranges from 1776 to about 1850 and encompasses the period of initial contact between the Paiute and Spanish and later American explorers and settlers. Evidence of contact during this period is generally in the form of European-American manufactured trade goods on otherwise aboriginal archaeological sites. Contact with Europeans slowly expanded during this time, until by the 1850s, a large number of permanent settlers, primarily Mormons occupied the region and essentially pushed the Southern Paiute onto reservations.

Data available indicates that the majority of Southern Paiute bands had a mixed economy of foraging and small-scale farming, although some question exists as to when the Southern Paiute adopted farming. In 1776, Franciscan fathers noted that the Southern Paiute they came in contact with were growing maize and pumpkins or squash in small, irrigated plots along the Virgin River. Documentary evidence by 19th century explorers and settlers from Jedediah Smith to Charles Rich and Jacob Hamblin also indicates a relatively heavy reliance on maize, squash, and bean cultivation. Archaeologically, evidence of Paiute horticulture is fairly rare, however several sites, including three in Washington County at Quail Creek (42WS260 and 42WS275) and at Anasazi Valley, along the Santa Clara River (42WS2188), produced evidence of maize (Allison 1988b). Site 42WS260 produced a date of AD 1280 (670±50 BP); indicating maize was grown fairly early in the Late Prehistoric Numic expansion (Walling et al. 1986). The other sites show evidence of maize horticulture in the 18th and 19th century, prior to the Mormon colonization of the region. Some Paiute groups, such as the Kaiparowits and Panguitch bands were primarily hunter-gatherers and did not farm.

Overall, excavated and fully reported archaeological sites affiliated with the Late Prehistoric Southern Paiute occupation of the region are relatively rare. However, five sites located in the Beaver Dam Mountains have been reported with Late Prehistoric radiocarbon dates (Moffitt & Metcalf 1978). All of these sites appear to be agave processing stations with roasting pits. One site, NA11405 apparently also has evidence of habitation and appears to be a short-term camp. Dates for these sites range between AD1505 and AD 1755. At Quail Creek Reservoir 17

archaeological sites had evidence of a Late Prehistoric occupation (Walling et al. 1986). These sites produced a range of dates from AD 1280 to AD 1840. At Green Spring seven sites, six rockshelters and one open camp with seven hearths were investigated and reported (Westfall et al. 1987). These sites revealed a Late Prehistoric component overlaying a Pueblo occupation with the Paiute remains apparently dating to the mid-19th century. Several Late Prehistoric, Protohistoric, and Historic Southern Paiute components were excavated at Sand Hollow, dating from the AD1500s-1800s (Talbot & Richens 2009). Excavations on four sites along Fort Pearce Wash also yielded dates between the AD 1300s and early 1900s (Gourley et al. 2010). Finally, Anasazi Valley on the Santa Clara River revealed two separate Late Prehistoric components dated to AD 1700 and AD 1830 (Allison 1988b).

**Historic Euro-American Period**

The earliest historic references to this region are found in the 1776 account of the Spanish Fathers Dominguez and Escalante who briefly crossed through the area on their return to Santa Fe, New Mexico. This epic journey was completed in an attempt to find a viable trail between Santa Fe and the Spanish colonies in southern California that would avoid hostile Native American tribes in western New Mexico and Arizona (Alder & Brooks 1996; Bradley 1999). Following the Spanish Fathers, the next recorded visits included quick passing of various mountain men such as Jedediah Smith, George C. Young, and William Wolfskill. Not long thereafter, permanent European/American settlement of what would become the State of Utah began under the colonization efforts of the Church of Jesus Christ of Latter-day Saints (LDS or Mormon).

Important to the LDS colonization of southern Utah was the organization of an Indian mission in Harmony in early 1854. Among those who moved south was Jacob Hamblin, a Mormon explorer and settler of both Washington and Kane Counties, who was called by the church to establish harmonious relationships with the Native Americans. His knowledge of the area also facilitated government exploration and mapping projects, including the John Wesley Powell expedition along the Colorado River in 1871 that documented the landscape of Glen Canyon and the present-day city of Kanab. Settlement of the Long Valley area occurred in 1862 with the arrival of John and William Berry who led a team of ranchers in search of rangeland for their cattle, however the area was abandoned in June 1866 due to conflicts with the Paiute and Navajo tribes. Kane County was officially created on 16 January 1864 by the Utah Territorial Legislature (Bradley 1999:56–59).

The town of Alton is a small ranching community located near the head of Long Valley. The first settler to the vicinity of the town was Lorenzo Wesley Roundy, who brought his family to the area in 1865. They built two log cabins that summer and established the settlement of Upper Kanab and Roundy's Station. Later that year, the Mormon Church ordered inhabitants of Upper Kanab and other small settlements to retreat to Kanab, Dixie, and other larger towns to help fortify them against Paiute raids that became known as the Black Hawk War. Settlers did not return to Upper Kanab until 1870, when Lorenzo Roundy's nephew, Byron Donalvin Roundy, and his wife settled there. In 1882, Edwin D. Woolley and Daniel Seegmiller also brought their families to settle in Upper Kanab. Two buildings, a schoolhouse and a recreation hall, were erected in 1885 at the head of the Virgin River. During the late 1880s, when the federal

government began to crackdown on the polygamists of Utah territory, many Mormon men fled to the area to escape marshals. In 1887, the communities of Ranch, Upper Kanab, and Sink Valley joined together to form an LDS ward. Then, in 1908, the town acquired its present-day name of Alton during a May Day celebration drawing. Charles R. Pugh, who had been reading a book about the Alton Fjord in Norway, suggested the name. The population of the town peaked at 350 in the 1930s, however it has diminished since then. In the post–World War II years, coal reserves were discovered near Alton, and the Smirl-Alton coal mines extracted an average of 40 tons daily in 1949. Today, Alton is home to fewer than 100 people whose main sources of income stem from the timber industry and the potential for coal mining (Bradley 1999).

# Chapter 4: Research Interests

This project was guided by a research design specifically focused on the collection of data sets that could contribute additional information on aboriginal occupation and adaptation to past environments within the region. This report will focus on fundamental issues and propose questions that might realistically be answered with the kind of data expected to be gathered. Critical issues which might be addressed within the scope of this project include cultural affiliation, date(s) of occupation, improved definition of site function, and clarification of relationships to other identified sites within the vicinity.

## Chronology & Cultural Affiliation

Establishing a firm and refined chronology for the sites is essential to place them within the larger local and regional context, and to help in understanding their relationship with other sites in the area. This can be accomplished through relative dating of ceramic sherds, point types, and other diagnostics, as well as absolute dating using radiocarbon samples and tree-ring dating, should such samples be recovered. Surface indications recorded for the sites implied they functioned as open artifact scatters of Late Archaic, Virgin Anasazi, and Southern Paiute cultural affiliations.

### *Research Questions*

1) During what prehistoric period or periods were the sites occupied or used? Can the sites augment the knowledge for this particular area, specifically, the Archaic, Formative, and Late Prehistoric periods?
2) Is there evidence to suggest single use or multiple occupations for the sites?
3) How do the sites relate to other sites in the area?
4) Are there any artifacts that represent trade items or locally obtained materials?

*Data Requirements:*

- Plant or other organic materials for radiocarbon dating. When available, maize or other short-lived species will be a preferred dating material.
- Tree-ring dating if appropriate samples become available.
- Diagnostic artifacts in context.

## Subsistence

Faunal remains, flotation, and pollen samples should provide data concerning the economic lifeways of the groups inhabiting the sites. From such samples determinations can be made on whether the occupants relied on hunting and foraging, such as would be expected with Archaic groups, or on hunting, foraging, and agriculture, or any combination of these activities, as might be expected with Formative and Late Prehistoric groups. Flotation and pollen, as well as faunal remains, will be collected from any features examined and from general subsurface contexts. Pollen and blood residue samples may also be available from ground stone artifacts recovered

from the site. Specific stone tools, such as projectile points, scraper types, and expedient tool types may help inform on subsistence practices as well.

***Research Questions***

1) Is there evidence to support the use of specific resources by the prehistoric inhabitants of the sites? Can we determine their relative importance within their diet?
2) Are domesticates represented on the sites?
3) Do the faunal remains indicate a preference for small or large game animals?

*Data Requirements:*

- Documentation of the range of material remains that are present from the sites, and in particular chipped and ground stone tools, bone, and plant remains (including, hopefully, corn) and/or areas of culturally rich soils for floral analysis.
- Documentation of structures, surfaces, and other features, including houses, possible storage pits, grinding bins, middens, etc. where appropriate sampling of soils and retrieval of dietary information may be obtained.
- Appropriate chronological control to tell us what subsistence and dietary related evidence is available for which time periods.

**Site Extent, Function & Organization**

By examining the current surface manifestations of the sites, updated boundaries may be established. Limited testing beyond the surface manifestations, but within the original site boundaries identified in 1986 (Weaver 1986), will also allow for a better idea of the physical extent of the cultural materials associated with the sites. An examination of the relationship between various features and artifacts on the sites could also allow us to discern site function. It is hoped that a number of features will be exposed that will indicate the occupation sequences and abandonment of the sites. Also, the types of features may indicate how intensively the sites were occupied at any given time. For example, the occurrence of well-made hearths or fire-pits, as well as habitation structures, would indicate the sites were occupied for a relatively longer duration than if the features were expediently constructed. The size and number of related features may also give some idea of the relative number of people on the sites at any given time. The occurrence of well-constructed shelters (semi-subterranean house pits), of Archaic date, though relatively rare in southern Utah, may indicate a less nomadic, somewhat semi-sedentary, lifestyle. Possible pit structures or dwellings then can be compared with other such features to examine relationships between other sites and cultural complexes. The distribution of artifact types may also indicate specific activity areas across the sites.

***Research Questions***

1) Do cultural deposits extend below the surface and if so in what areas? What are the characteristics of these deposits?
2) Do surface artifacts or features on the sites indicate the types of activities performed?

3) Are distinct use areas represented on the sites? How are these activity areas distributed across the sites and do they reflect changes through time?

*Data Requirements:*

- Identification of artifacts on the surface through intensive surveys across the original site areas.
- Recovery of subsurface artifacts or identification of cultural features through limited testing across the site areas.
- Feature and general site construct data obtained through testing, including documentation of activity/use areas and general associations (intra-site and stratigraphic level associations) of cultural features/surfaces.
- Radiocarbon and/or artifact data relating to identified levels and features.
- Comparisons of feature types and general dating.
- Documentation and mapping of diagnostic artifacts within feature areas.

**Seasonality & Mobility**

Examination of botanical remains and faunal remains may provide information concerning the seasonality of site occupation. Likewise, some faunal remains and botanical remains may also indicate the level of mobility practiced by the inhabitants. For example, faunal remains of large ungulates, such as bighorn sheep, or the occurrence of pinyon pine nuts may suggest groups traveling to higher elevations in order to exploit these resources. The occurrence of non-local or exotic raw materials, such as tool stone or materials used for ornaments, may also indicate mobility, but this may also represent trade as well. Unique types of raw materials may occur in a limited geographical location and may indicate mobility, especially direction of movement. Of course, many plants species are only available during certain times of the year and a substantial quantity of pollen or macro-botanical remains of these plants may indicate the season in which the sites were occupied.

***Research Questions***

1) Do the resources utilized by the prehistoric inhabitants of the sites reflect season of use?
2) Were the sites part of a seasonal round or do they reflect less frequent utilization?
3) Are exotic resources present and in what quantity? Does their presence reflect mobility or trade?

*Data Requirements:*

- Documentation of the presence of structures, thermal features, use surfaces, middens, etc. in test areas.
- Evidence for floral and/or faunal materials conducive to seasonality/mobility inferences, such as seasonally available plants or animals, etc.
- Material goods that might be inferred to have been accessed directly by site inhabitants, during seasonal rounds or as part of a logistical strategy.

- Material goods evidencing long-distance relationships inferential to exchange that would highlight mobility options (direction of exchange and mobility requirements) for the site inhabitants.

## Historic Themes

The "Road to Kanab" was an historic road that represented an important transportation corridor utilized during the late 19th and early 20th centuries. The road had a significant impact on the settlement and history of the area. Thus, Transportation/Immigration is thought to be a relevant theme.

### *Transportation & Immigration*

One of the greatest challenges facing the communities along Upper Kanab Creek and Long Valley was access to the outside world. Due to the rugged nature of the terrain in the surrounding area and lack of permanent water, springs and creeks in and around this region would have defined the earliest routes and trails for travel. These wagon roads played a significant role in the early settlement and development of the Upper Kanab Creek/Long Valley area and other settlements in Kane County.

*Research Questions*

1) Is there any indication that abandoned segments of the former road exist within what are now agricultural fields?
2) Do these segments follow the approximate alignment(s) indicated on historic maps?

<u>Data Requirements:</u>

- Identification of linear depressions or overgrown two-track roads.
- Identification of historic trash and/or features along the approximate road alignment.

# Chapter 5: Tier I Mitigation Methods

Bighorn completed the Tier I mitigation according to the research objectives stated in the treatment plan (Gourley 2016a). The focus of the fieldwork was placed on identifying the presence of surface features and areas with potential for subsurface features, as well as the recovery of diagnostic artifacts. The historic properties treatment plan called for surface collection of any significant artifacts and the placement of a series of shovel probes in high potential areas of the site and known areas of construction. If any suspected features were identified, then appropriate sized test pits or trenches were to be placed over the identified features. As stated in the historic properties treatment plan, all test pits, trenches, and units, if implemented, were to be taken down to sterile soil or bedrock, or to a depth of approximately 10 cm below which artifacts were encountered.

Tier I mitigation began with surface collection and mapping of significant artifacts such as ceramic sherds, obsidian, and lithic tools. This was completed as part of a general surface investigation of the sites that included the updated site boundaries established in 2005 as well as the area within the original site boundaries as documented in 1986 for those portions of the sites that were present within the NPLA. This was followed by excavation of a series of shovel probes in high potential areas of the site. Efforts were also made to identify cultural features noted during the 1986 recordings.

**Recording Procedures**

Artifacts collected during the intensive surface examination of the site were point plotted using a Trimble GeoXT global positioning system (GPS). Ground stone artifacts were GPS plotted and analyzed in the field. The GPS was also used to record the locations of each of the shovel probes and test units within the sites, as well as any identified cultural features. Test excavation records were kept using a modified Jennings Feature System. That is, individual stratigraphic levels, features, artifact clusters, or other physical attributes were assigned separate feature numbers and detailed notes kept on each. Any occupation surfaces or features defined were photographed, and both plan and line profiles drawn to scale. All hand-excavated units were conducted in accordance with current archaeological methods, including stratigraphic separation of sediments as possible. General feature fill sediments were screened through at least a ¼ inch hardware mesh and collection of artifacts and bulk soil samples was completed by horizontal and vertical provenience. All hand-dug test units were excavated down to sterile soil, or the terminus of the cultural deposit.

**Artifact Collection**

All cultural materials recovered during the Tier I mitigation work were bagged; all tools were bagged separately. Artifact bags recorded specific horizontal and vertical provenience, along with special instructions on care or handling, if necessary. Field specimen (FS) numbers were assigned to maintain control of component and complex artifact collections. Fire-cracked rock was not collected, unless particular circumstances warrant such collection. Surface collection was limited to significant artifacts, such as tools, obsidian, ceramic sherds, and bone. All surface

artifact collection and sub-surface artifact retrieval was conducted on private land within the NPLA and completed with private land owner approval.

**Post Fieldwork Analysis & Ancillary Studies**

Upon completion of Tier I mitigation work, all recovered materials, including all artifacts and ancillary materials, were brought back to the laboratory for processing where they were sorted and organized by FS number and analysis specific categories. Cataloging followed with cleaning, labeling, and sorting of materials. A database file with types, proveniences, and other pertinent information for each FS sample was constructed. Artifacts were then turned over to Aaron Jordan for detailed analysis. That analysis includes all artifacts collected during the mitigation fieldwork and is incorporated into this final report. Appropriate maps, figures, and tables were produced as needed to convey the data in the most appropriate format.

**Curation**

All recovered artifacts will be turned over to the private land owners per agreements signed prior to the Tier I mitigation work. Kirk Nicholes, Environmental Specialist with Alton Coal, will deliver the materials to the land owners.

# Chapter 6: Cultural Site Descriptions

### 42KA3077

Site 42KA3077 was originally recorded in 1986 by the Museum of Northern Arizona (MNA) and subsequently revisited and a site form update completed by Montgomery Archaeological Consultants (Thornton & Montgomery) in 2005 (Stavish 2007). It consists of a fairly large prehistoric open artifact scatter of Late Archaic-Basketmaker II and Southern Paiute cultural affiliations. The site is located within a 130 by 108 m (9,003 $m^2$) area on a knoll within the broad Alton Amphitheater valley to the south of Alton, Utah (Figures 1.1 & 6.1). Soil on the site consists of sandy gray/tan loam. Vegetation in the area includes scattered pinyon pine and juniper trees, low sagebrush, and various grasses and forbs. The site has been impacted by erosion, a fence line along its northern edge, and grazing.

Prehistoric material on the site noted during the revisit by Montgomery in 2005 comprised approximately 33 chipped stone artifacts and two lithic tools. The debitage was dominated by interior core reduction and flake fragments, with limited quantities of primary and secondary core reduction, and shatter present. A maximum artifact density of artifacts was 2/$m^2$. Material types consisted of various colors of chert and quartzite. Lithic tools included a quartzite core fragment and a mottled gray chert biface fragment. No diagnostic artifacts or features were noted.

The original site documentation completed in 1986 by MNA was much larger than that noted in 2005 and included eight diagnostic projectile points, which were collected at that time, along with ground stone artifacts and obsidian. Seven hearth features consisting of rock clusters with soil staining were also noted, six being on the western site area. Trowel probes into the site indicated at least 20 cm of cultural depth (MNA 1986a). None of the features or ground stone artifacts noted in 1986 were relocated during the 2005 site recording.

Site 42KA3077 has been determined eligible for the NRHP under criterion (d). The site appeared to retain integrity, despite impacts, and shallow stratified or buried in situ cultural prehistoric deposits are likely. The site was determined to have the potential to provide additional information important in understanding the prehistory of the area. Research questions that could possibly be addressed included site structure and function, lithic tool production, resource selection and procurement strategies, trade, subsistence, dating, and land use patterning.

### 42KA3097

Site 42KA3097 was originally recorded in 1986 by the Museum of Northern Arizona (MNA) and subsequently revisited and a site form update completed by Montgomery in 2005. It consists of a large prehistoric open artifact scatter of Late Archaic, Virgin Anasazi, and Southern Paiute cultural affiliations. The site is located within a 1,029 by 243 m (135,337 $m^2$) area on a gentle slope within the broad Alton Amphitheater valley to the south of Alton, Utah (Figure 1.1 & 6.2). Soil on the site consists of sandy gray/tan loam. Vegetation in the area includes scattered low

sagebrush, Indian ricegrass, cheat grass, and various other grasses and forbs. The site has been impacted by erosion, a fence line, grazing, agricultural use, and a bladed county road.

Prehistoric material on the site noted during the revisit by Montgomery in 2005 comprised 100+ chipped stone artifacts, numerous lithic tools, and ceramic sherds. The debitage was dominated by flake fragments and interior core reduction, with lesser quantities of secondary core reduction and shatter fragments present. A maximum density of lithic artifacts was $4/m^2$. Material types consisted of various colors of chert and quartzite, and obsidian. Lithic tools included eight untyped projectile points/fragments, an Elko Corner-notched projectile point, three Gypsum projectile points, two Bull Creek projectile points, a Desert Side-notched projectile point, 16 bifaces/fragments, two drills, and a scraper. Ceramic artifacts included five North Creek Gray body sherds and one North Creek Gray bowl rim sherd. A maximum density of ceramics was $4/m^2$. No features were noted.

The original site documentation completed in 1986 by MNA was much larger than that noted in 2005 and encompassed what was later recorded as site 42KA6080. Artifacts noted in 1986 included 20 diagnostic projectile points, which were collected at that time, along with ground stone and burned faunal bone. Lithic material types comprised obsidian, quartzite, basalt, chert, and petrified wood. Ceramics noted included Shinarump Brown, St. George/Washington Black-on-Gray, North Creek Gray, and North Creek Corrugated sherds. At least 11 hearth features consisting of rock clusters with stained soil were also noted. Trowel probes into the site indicated at least 20 cm of cultural depth (MNA 1986b). None of the features, ground stone artifacts, or burned faunal bone were relocated during the 2005 site recording.

Site 42KA3097 has been determined eligible for the NRHP under criterion (d). The site appears to retain integrity, despite impacts, and shallow stratified or buried in situ cultural prehistoric deposits are likely. The site has the potential to provide additional information important in understanding the prehistory of the area. Research questions that may be addressed include site structure and function, lithic tool production, resource selection and procurement strategies, trade, subsistence, dating, and land use patterning.

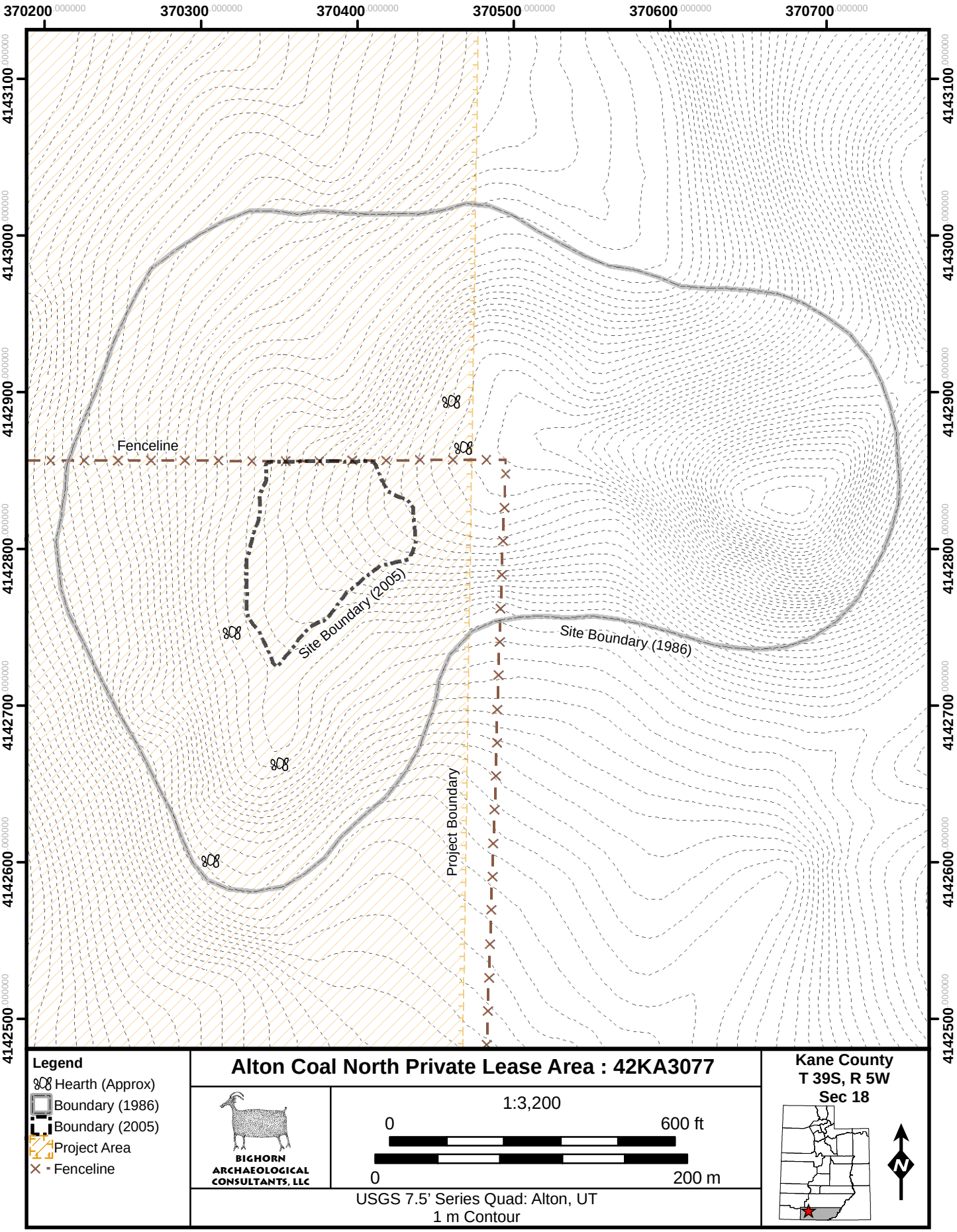



Figure 6.1. 42KA3077 Plan Map

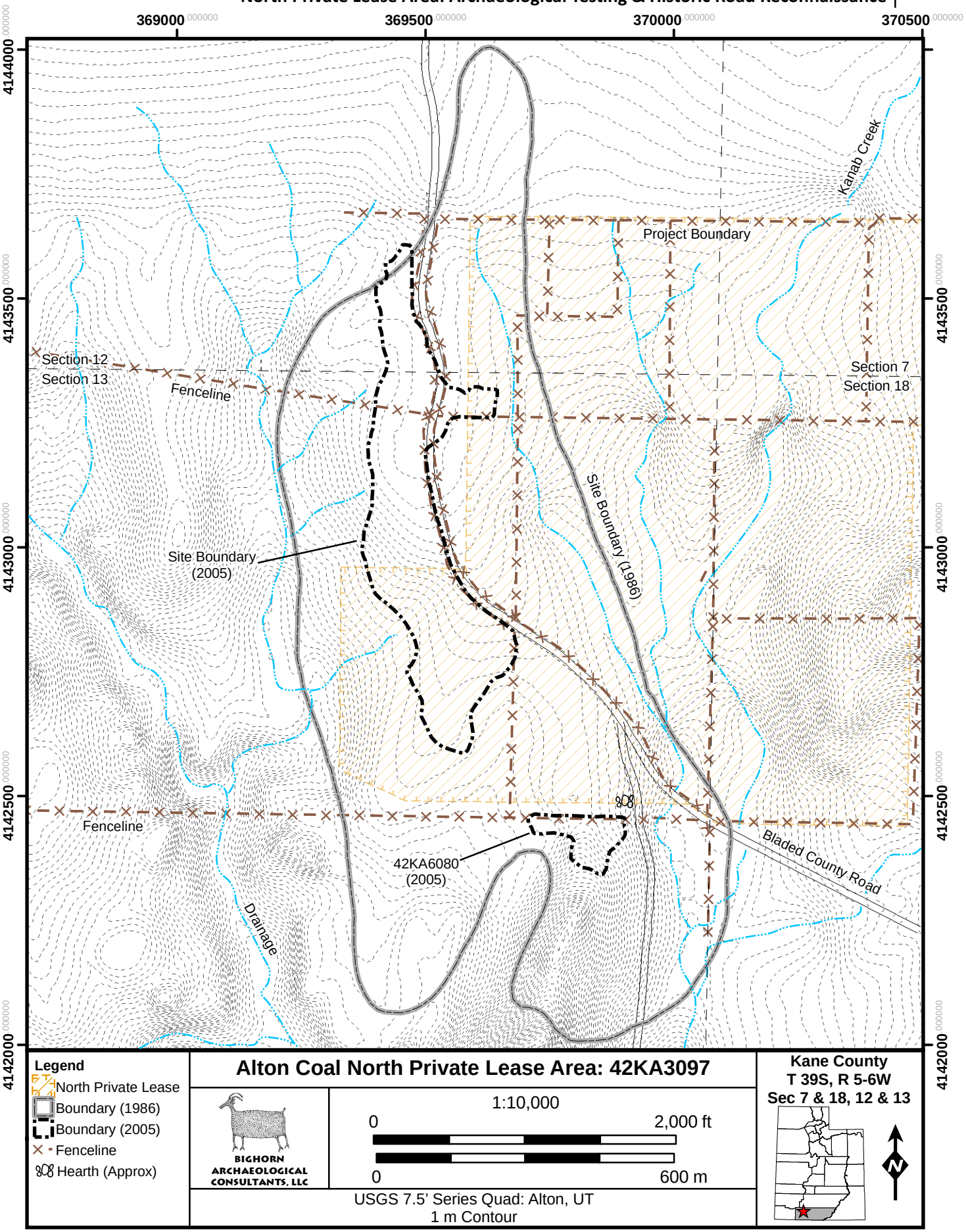



Figure 6.2. 42KA3097 Plan Map

# Chapter 7: Tier I Testing Results

## 42KA3077

Tier I testing on site 42KA3077 was completed between 24 February and 10 March 2016, and included mapping, surface collection of tools and diagnostic artifacts, excavation of a series of exploratory shovel probes, and a test unit. Results of the Tier I testing are presented below.

**Figure 7.1. Overview of site 42KA3077 looking northwest**

### *Testing Methods*

An examination of the site area within the NPLA found much of the site to have been impacted by tree removal activities related to use for grazing (Figures 7.1, 7.3-7.5). Initial surface examination of the site consisted of multiple, parallel 10 m pedestrian transects across the original 1986 site boundary within the project area and collection of significant artifacts. This undertaking resulted in the discovery of two possible surface stains and a circular rock alignment (Feature 1) with an internal rectangular rock alignment (Features 1-2). Significant artifacts from the surface included four projectile points, 18 bifaces, two unifaces, two scrapers, seven choppers, seven hammerstones, four mano fragments, 11 untyped ground stone fragments, a polishing stone, five ceramic sherds, four obsidian flakes, a piece of fire-cracked rock, and an historic glass jar. Each of these artifacts and potential features was point plotted with a Trimble GeoXT global positioning system (GPS). All prehistoric tools and obsidian were collected for further analysis while the ground stone and the historic glass had in-field analysis completed that

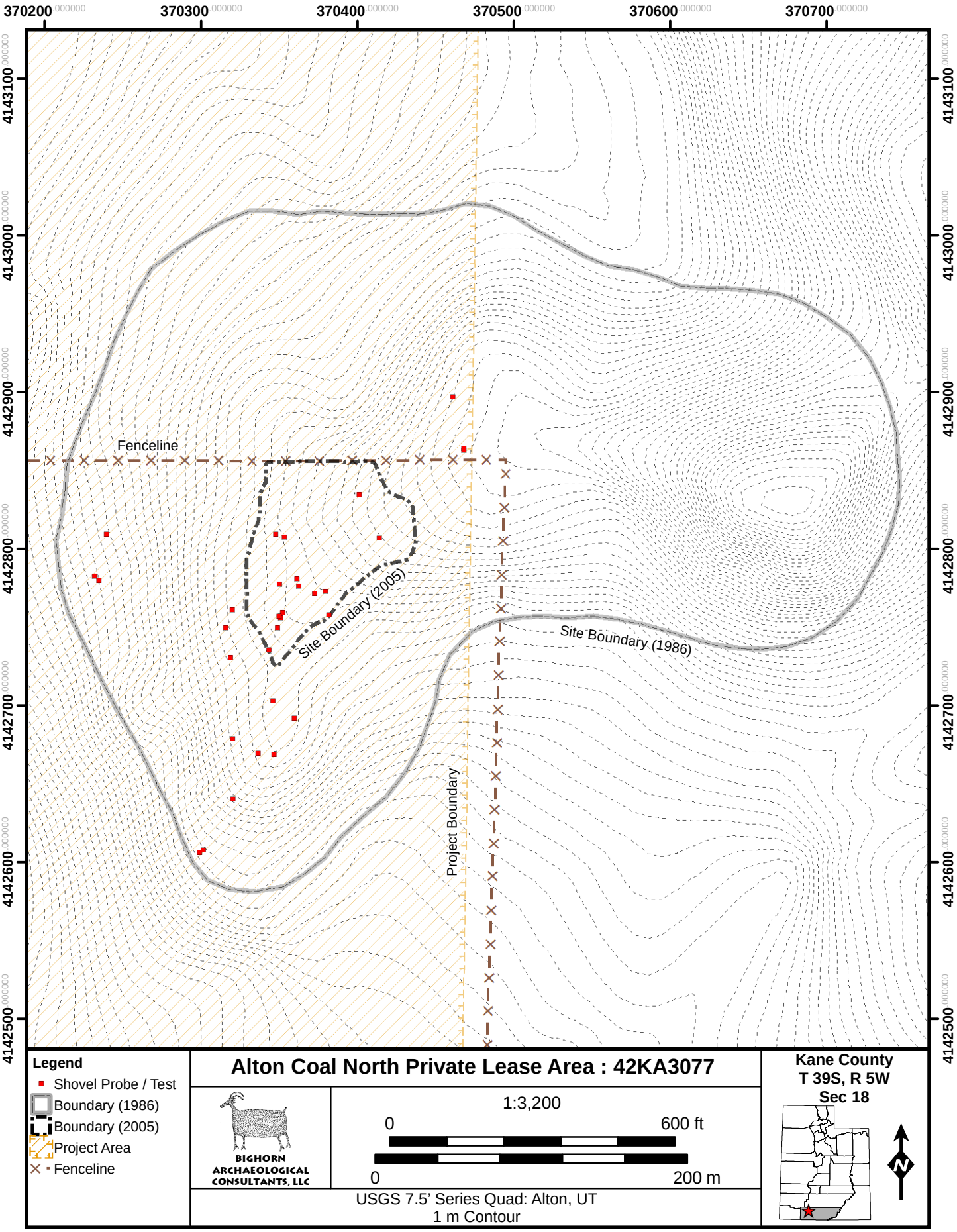



Figure 7.2. STP locations across site 42KA3077

included measurements and photographs. This was followed by the excavation of 32 shovel probes (25 x 25 cm) placed across the site area in high potential areas and other prospective locations within the original 1986 boundary within the NPLA to allow for a better idea of the physical extent of the cultural materials associated with the site. A 1 x 1 m test unit was also excavated within the circular rock alignment (Feature 1). Each shovel test pit (STP) and the test unit (TU) was point plotted with a Trimble GeoXT GPS (Figures 7.2, 7-6-7.8). An overview of the results by STP and for TU1 is provided in Appendix A.

**Figure 7.3. Overview of site 42KA3077 looking south-southeast**

Five prehistoric hearth features/feature areas were documented within the NPLA in the original 1986 recording of the site, most of which were present on west facing slopes. These features were characterized by concentrations of sandstone rock with soil staining in association with ground stone fragments and flaked debitage. None of these features was relocated during the 2005 site documentation. An attempt to relocate these features was completed during the intensive surface survey of the site in 2016 with one of them potentially identified as an area of soil staining with associated fire-cracked rock (FCR). At least one STP was placed in the approximate vicinity of each of these features during the Tier I testing of the site and are briefly discussed below.

### *STP Results*

Testing of site 42KA3077 included placement of 32 shovel probes (25 x 25 cm) placed across the site area in high potential areas and other prospective locations within the original 1986 boundary contained in the NPLA to allow for a better idea of the physical extent of the cultural

materials associated with the site (Figures 7.5-7.8). Of the 32 STPs excavated across the site, nine contained evidence of subsurface cultural materials, with three of these revealing soil staining, three with FCR, and four yielded artifacts that included chert flakes, a projectile point base, and a mano fragment. Those units positive for cultural artifacts included STP 11 in which a mano fragment was recovered at 0-10 cm below the surface; STP 14 that contained an obsidian Elko Corner-notched projectile point basal fragment at a depth of 0-10 cm below the surface; STP 16 that contained seven chert tertiary flakes at 0-10 cm and two chert tertiary flakes at 10-20 cm below the surface; and STP 28 which revealed a chert shatter fragment at 0-10 cm below the surface.

**Figure 7.4. Overview of Feature 1 on site 42KA3077 looking southeast**

Two STPs were placed in the approximate location of the southern-most of the hearth feature areas identified in 1986 within the NPLA. No surface indications of a feature were noted and no tools were present at this location. Excavation of STP 2 identified several fragments of fire-cracked rock present to a depth of 20 cm below the surface. No soil staining or artifacts were present suggesting a thermal feature may have been present but was now deflated and limited to only the few pieces of FCR. STP 3 was placed 3 m to the southwest with negative results for cultural materials or evidence of a thermal feature (Figure 7.8).

Moving north, one STP was placed in the approximate location of another of the southern hearth feature areas identified in 1986 within the NPLA. No surface indication of a feature was noted and no tools were present at this location. Excavation of STP 5 yielded negative results for both cultural material and evidence of a thermal feature (Figure 7.8).

**Figure 7.5. Overview of Feature 1 on site 42KA3077 looking west**

Moving north again, one STP was placed in the approximate location of yet another of the southern hearth feature areas identified in 1986 within the NPLA. No surface indication of a feature was noted and no tools were present at this location. Excavation of STP 9 yielded negative results for both cultural material and evidence of a thermal feature. As noted above, a surface soil stain with associated FCR was identified on the site during the intensive surface survey and may represent the actual location of the 1986 feature on this portion of the site. This potential feature is present about 36 m to the east-northeast of STP 9. Four STPs were excavated in this area to investigate. STP 11 revealed soil staining to a depth of 20 cm below the surface and contained a mano fragment within the upper 10 cm. No additional artifacts were recovered to a depth of 30 cm. STP 12 was placed about 3 m to the northeast with negative results for both cultural material and evidence of a thermal feature. STP 31 was excavated 1 m south of STP 11. Mottled soil staining was present from 4-15 cm below the surface, however no artifacts were recovered. This was followed by excavation of STP 32 which was placed 1 m to the west of STP 11. Soil staining was again noted from 2-11 cm below the surface where it became mottled (Figures 7.6-7.7). A 1 m long shovel width trench was then excavated to connect STPs 11 and 32. No artifacts were recovered from STP 32 or from the trench.

Near the center of the site, along the edge of the NPLA, was another potential hearth feature identified in 1986. Two STPs were placed in this area. No surface indication of a feature was noted, however a biface was present. Excavation of STP 25 found some FCR but no evidence of soil staining or artifacts suggesting a thermal feature may have been present but was now deflated and limited to a few pieces of FCR. STP 26 was placed 1 m to the north and yielded negative results for both cultural material and evidence of a thermal feature (Figure 7.6).

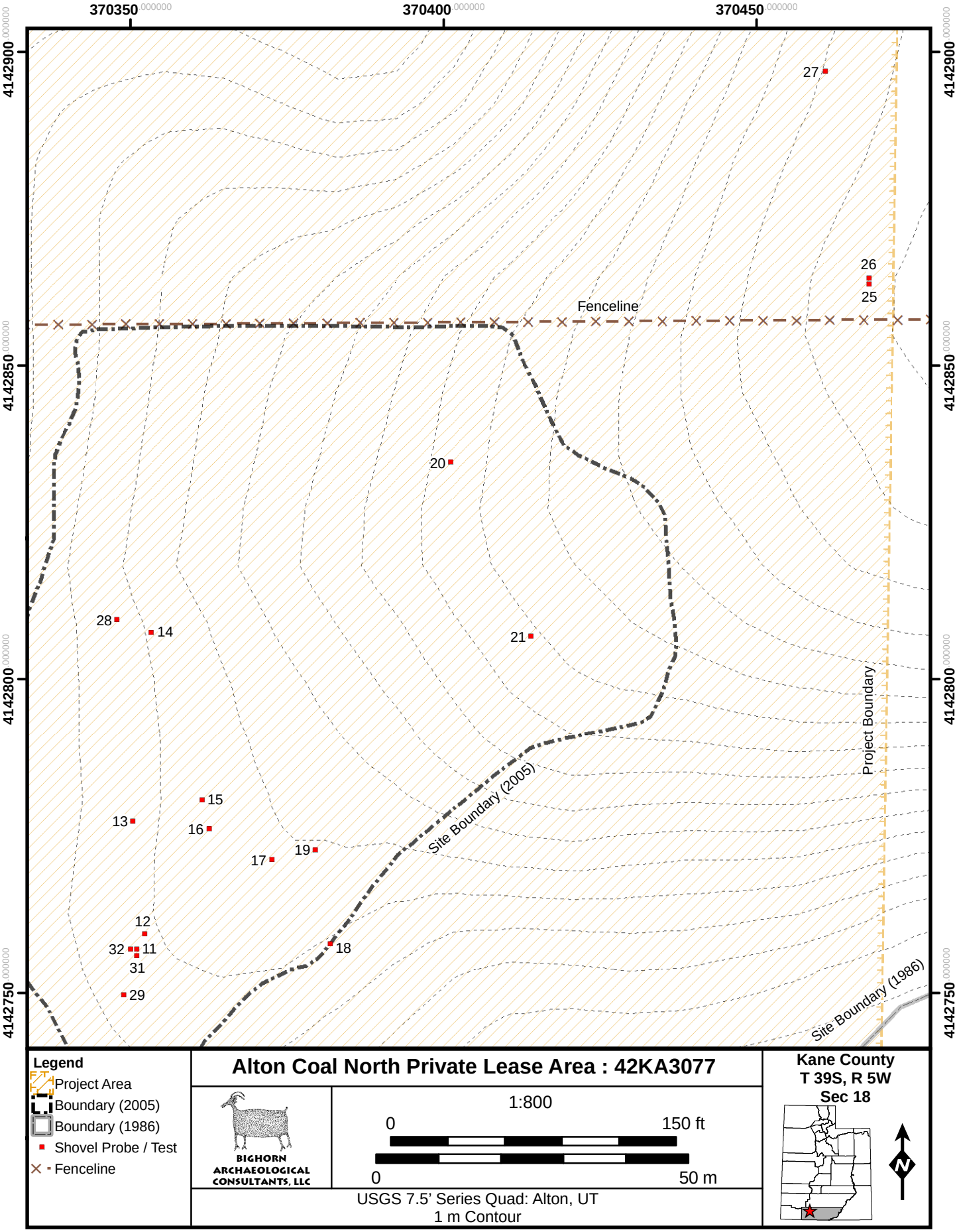



Figure 7.6. Close-up of STP locations across site 42KA3077

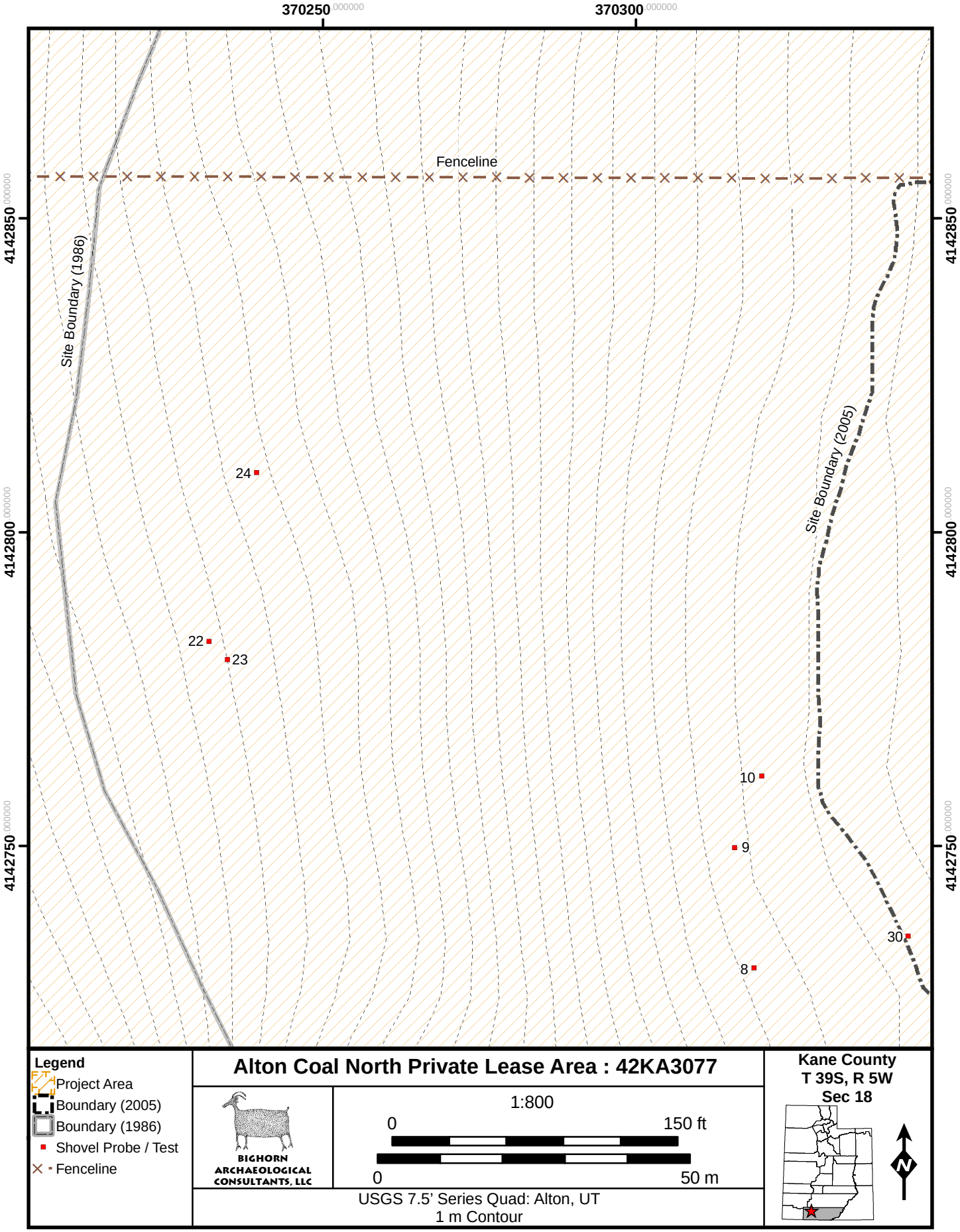



Figure 7.7. Close-up of STP locations across site 42KA3077

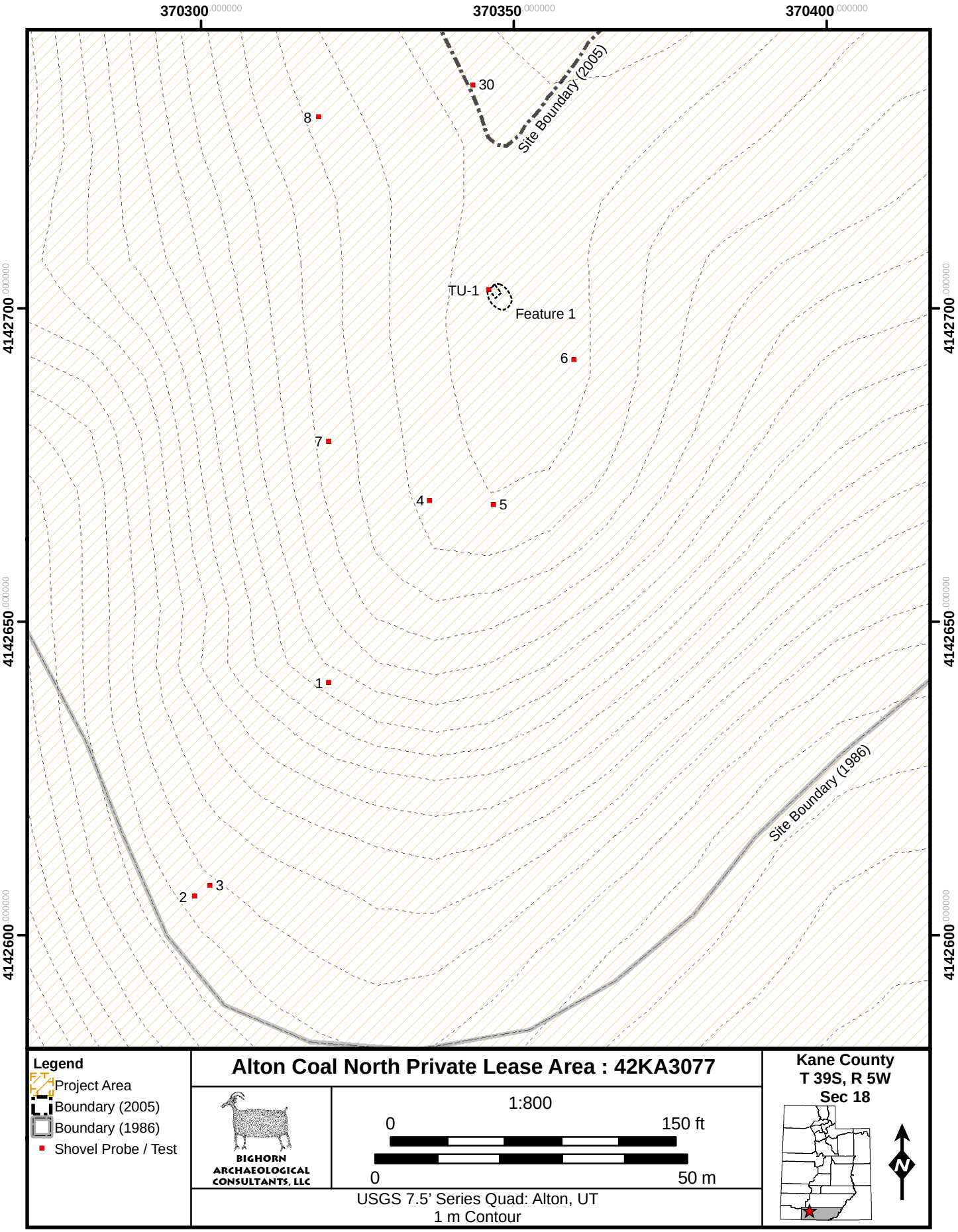



Figure 7.8. Close-up of Test Unit 1 and STP locations across site 42KA3077

The last hearth feature area identified in 1986 within the NPLA was about 34 m north-northwest of STP 26. One STP was placed in this area. No surface indication of a feature was noted and no tools were present at this location. Excavation of STP 27 yielded negative results for both cultural material and evidence of a thermal feature (Figure 7.6).

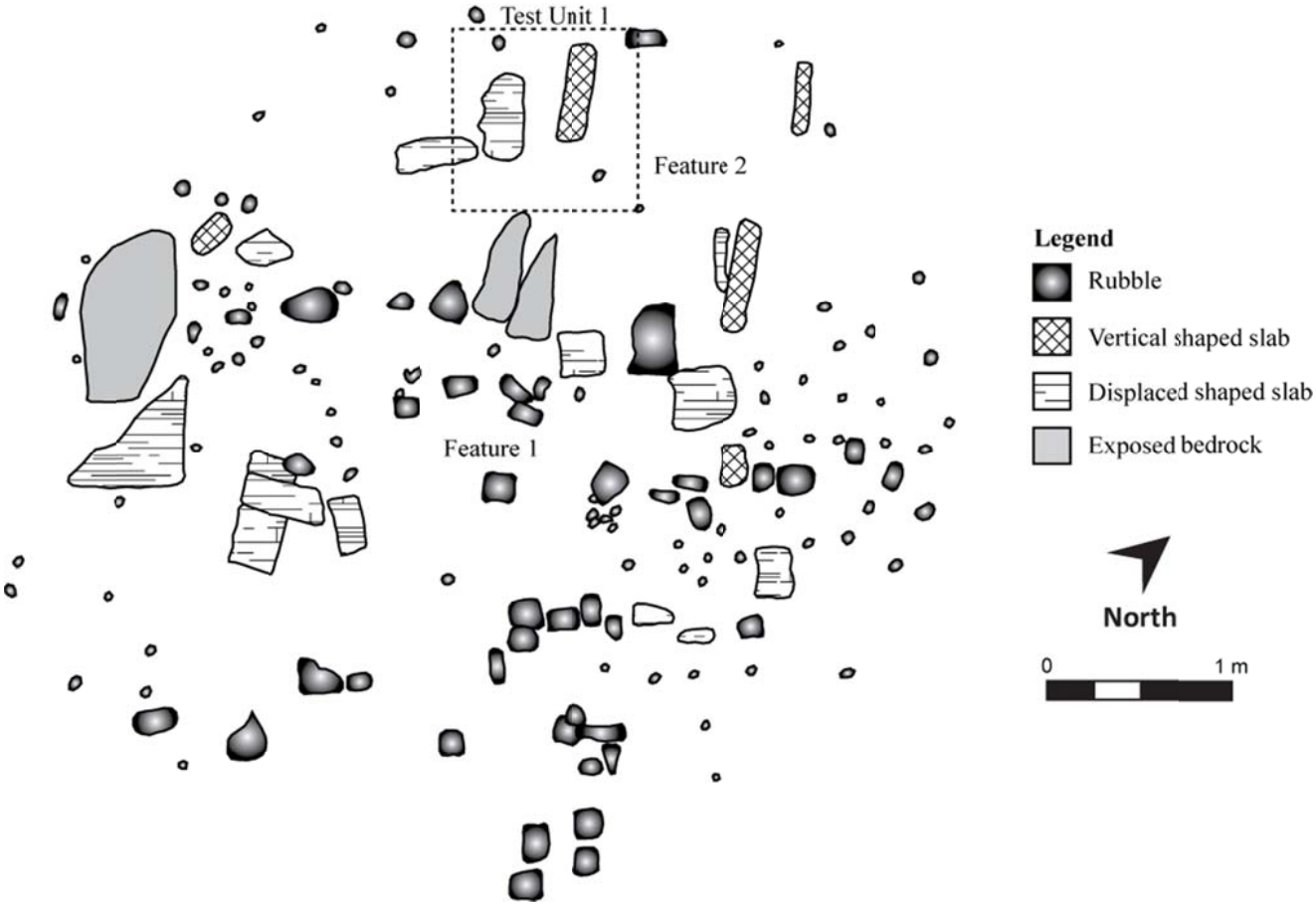



**Figure 7.9. Plan map of Features 1 & 2**

### *TU1 Results*

Test Unit 1 was a 1 x 1 m unit placed along the edge of a circular rock alignment (Feature 1) documented during the surface inspection of the site (Figures 7.8-7.9). Feature 1 appears to represent a slab-lined pithouse constructed of tan sandstone slabs that has been severely impacted by cattle. The structure is present on the edge of a ridgeline where the majority of the artifacts on the site are found, most of which are within a saddle area to the north of the feature. It measures 4.2 x 3 m with the southern portion of the structure eroding down slope. During the mapping process of Feature 1, a second feature was determined as separate, representing what appears to be a 1.7 x 1.2 m rectangular storage cist present in the northwestern portion of Feature 1. The feature is also constructed of tan sandstone slabs with three intact upright slabs present, two along the eastern wall and one along the western wall. Test Unit was 1 was located over the northwestern corner of the storage feature and edge of Feature 1. Excavation of TU1 found the

soils within and outside of the features to be consistent in color with no soil staining detected, although the gravel content was significantly less within the features. The soil stratum forming the fill of the features varied in depth from 4-13 cm with one white chert flake recovered from 20 cm below the surface within Feature 2. No definitive floor zone was identified for the features within the test unit; however the structural stones forming their walls were set into a more compact clayey stratum below the features. Flotation and pollen samples were collected for further analysis.

**Figure 7.10. Southeast profile wall of TU1**

Soils encountered within TU1 included three distinct strata (Figures 7.10-7.12). Stratum 1 was the surface duff that consisted of brown (10YR 4/3) silty sand with a high percentage of organics (pine needles, seeds, leaves, and twigs) from the surrounding trees and cattle dung. This stratum varied in depth across the unit between a maximum depth of 2 cm to 3.5 cm within Feature 1 and up to 10 cm below the surface within Feature 2. Stratum 2 was a very dark brown (10YR 2/2) sandy clay loam that contained approximately 20% gravel inclusions outside of the features and significantly less within the structures. This stratum extended to a maximum depth of 17 cm below the surface in Feature 1 and 11 cm below the surface in Feature 2. Stratum 3 formed the base for the features, with structural stones set into a compact, dark brown (10YR3/3), clay layer that contained about 20% gravel inclusions. This stratum was encountered to a depth of 30 cm below the surface where excavation of the unit was terminated due to a lack of artifacts and a change in the stratum to a more densely compacted, possibly decomposing bedrock matrix.

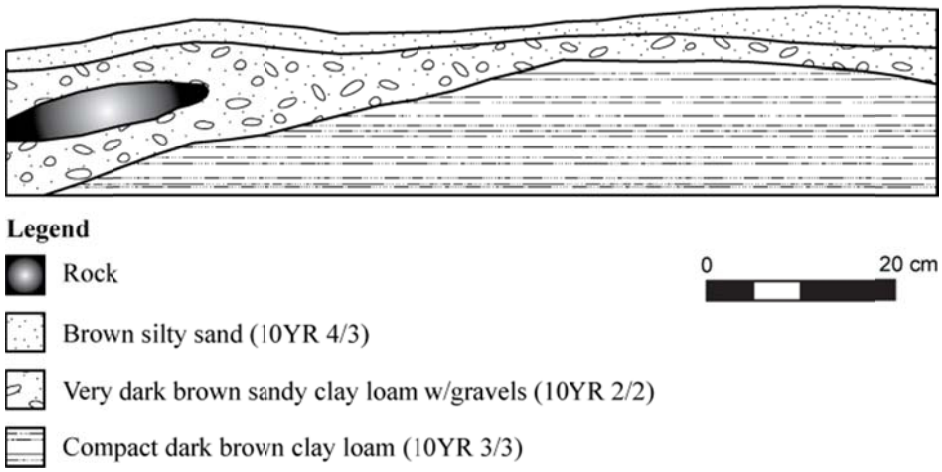



**Figure 7.11. Southwest profile of TU1**

**Figure 7.12. Southwest profile wall of TU1**

***Summary***

Testing of site 42KA3077 included placement of 32 STPs across the site area and one test unit. Surface examination and collection resulted in the identification of a nice array of prehistoric tools, and several ceramic sherds. Of the 32 STPs excavated across the site, nine contained evidence of subsurface cultural materials, with three of these revealing soil staining, three with

FCR, and four yielded artifacts that included chert flakes, an Elko Corner-notched projectile point basal fragment, and a mano fragment. Test Unit 1 was placed along the edge of circular rock alignment Feature 1 and internal Feature 2. One subsurface artifact was recovered from the feature which appeared to represent a rock lined pithouse or wickiup with internal rock lined storage cist. No subsurface cultural material or evidence of features was encountered below a depth of 20 cm beneath the surface. Ground stone artifacts encountered were analyzed in the field.

Bighorn recommended that no further data recovery work be conducted at the site as the testing suggested that cultural materials were relegated primarily to the surface of the site, with only nine STPs indicating shallow subsurface materials that were limited to the upper 20 cm of soil. Three of these STPs indicated possible deflated thermal features that were limited to a few FCR fragments only, while a grouping of three STPs showed evidence of shallow soil staining that may represent another deflated thermal feature or use surface. Test Unit 1 indicated that Features 1 and 2 represented the shallow, deflated remains of what appeared to be a rock lined pithouse or wickiup with internal rock lined storage cist. These features were also relegated to the upper 20 cm of soil and have been severely impacted by cattle.

**42KA3097**

Tier I testing on site 42KA3097 was completed between 22-23 February and 1 March 2016, and included mapping, surface collection of tools and diagnostic artifacts, and excavation of a series of exploratory shovel probes. Results of the Tier I testing are presented below.

**Figure 7.13. Overview of site 42KA3097 looking north**

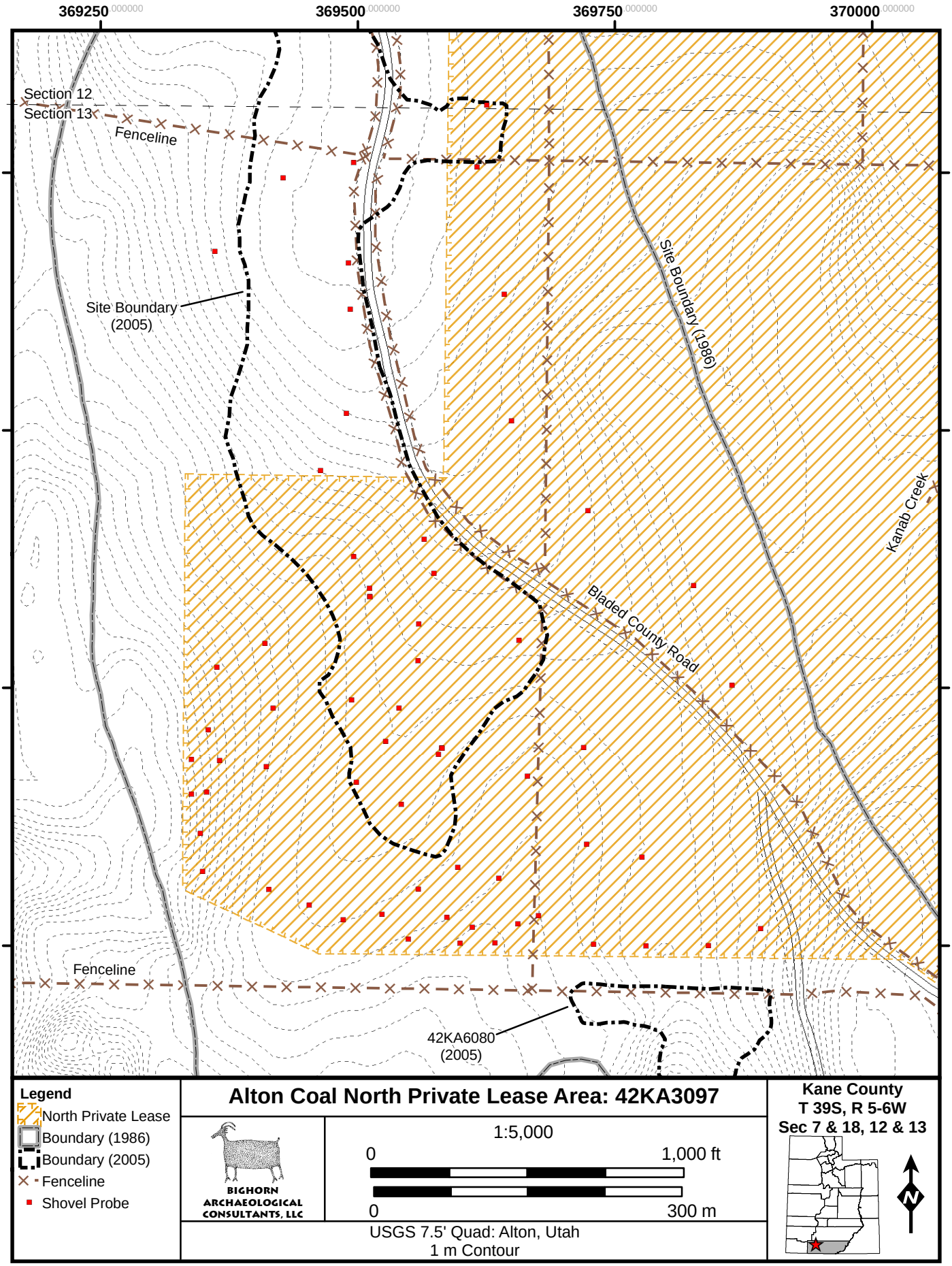



Figure 7.14. Overview of STP locations across site 42KA3097

### *Testing Methods*

An examination of the site area within and around the North Private Lease project area found the site to have been impacted by agricultural use over the years to include plowing and tree removal activities (Figures 7.13, 7.10-7.16). Initial surface examination of the site consisted of multiple, parallel 10 m pedestrian transects across the original 1986 site boundary within the project area and collection of significant artifacts. This undertaking resulted in the discovery of one potential depression, 12 bifaces, a drill fragment, three projectile points, three gray ware ceramic sherds, a scraper, a core/scraper, a uniface, a chopper/hammerstone, three hammerstones, seven mano fragments, five ground stone fragments, a concentration of five ground stone fragments, an obsidian flake, and two small concentrations of historic glass. Each of these artifacts and potential features was point plotted with a Trimble GeoXT global positioning system (GPS).

**Figure 7.15. Overview of site 42KA3097 looking south**

Results of the surface examination found the site boundaries established in 2005 to be fairly accurate with the current extent of artifacts and point plotted artifacts were almost exclusively within that boundary. All prehistoric tools and obsidian were collected for further analysis while the ground stone and historic glass had in-field analysis completed that included measurements and photographs. This was followed by placement of 62 shovel probes across the site area in high potential areas and other prospective locations within the original 1986 boundary to allow for a better idea of the physical extent of the cultural materials associated with the site. Each shovel test pit (STP) was point plotted with a Trimble GeoXT GPS (Figures 7.14, 7.17-7.19). An overview of the results by STP is provided in Appendix A. Placement of the STPs was based on surface manifestations, planned construction activities, and other higher potential areas within the original 1986 boundary that lacked surface artifacts but that could reveal subsurface cultural

materials. No evidence of the surface feature identified by MNA in 1986 (sketch map key, items 20-21) was noted within the NPLA. This feature was originally described as a probable hearth composed of several small, upright slabs in a 0.8 m diameter area within a diffuse scatter of Virgin Anasazi sherds that also contained a tabular sandstone metate fragment and a vesicular, tabular basalt metate fragment (MNA 1986b). An examination of the site surface in the approximate vicinity of the feature did not locate any evidence of ceramic sherds or the basalt metate fragment identified in the original site recording within the NPLA.

**Figure 7.16. Overview of site 42KA3097 looking southeast**

### *STP Results*

Examination of the STPs revealed that the plow zone across the site extended to a depth of about 10 cm below the surface (cmbs). Of the 62 STPs, 18 had artifacts present on their surface and one had an artifact adjacent; none of these resulted in materials recovered subsurface (see Appendix A). Soils encountered within the STPs consisted of silty clay loam that varied slightly in color across the site between grayish brown (2.5YR 4/2-5/2; 10YR 5/2), dark gray (7.5YR 4/1), dark yellowish brown (10YR 4/4), dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2), brown (10YR 4/3-5/3), and dark brown (10YR 3.3). Some gravel content was noted within the soil matrix in areas but was limited to about 5%. Excavation of STP 26 found no evidence to suggest that the possible depression identified during the surface collection on the site was indeed a feature, thus no further testing of that location was conducted.

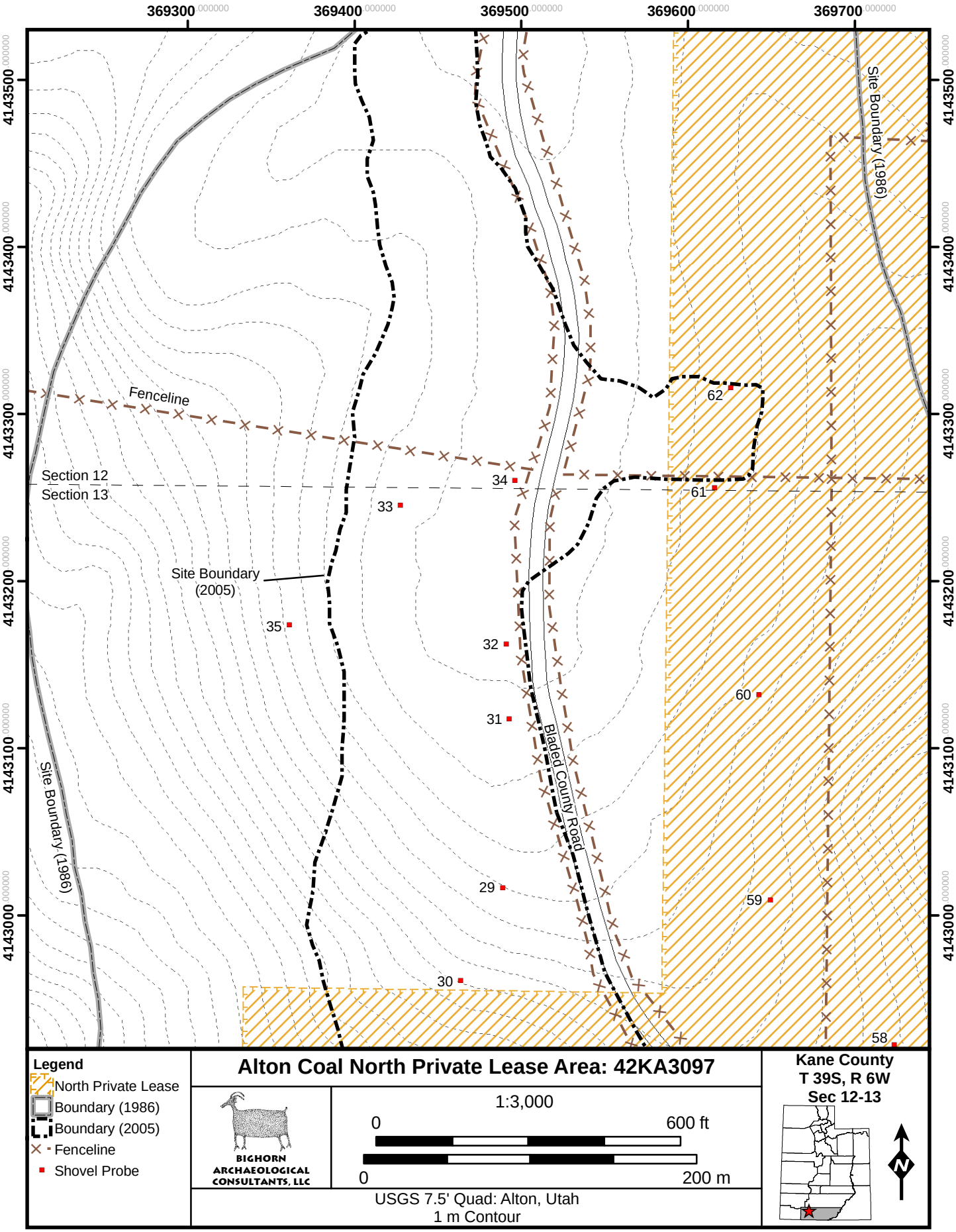



Figure 7.17. Close-up of STP locations across site 42KA3097

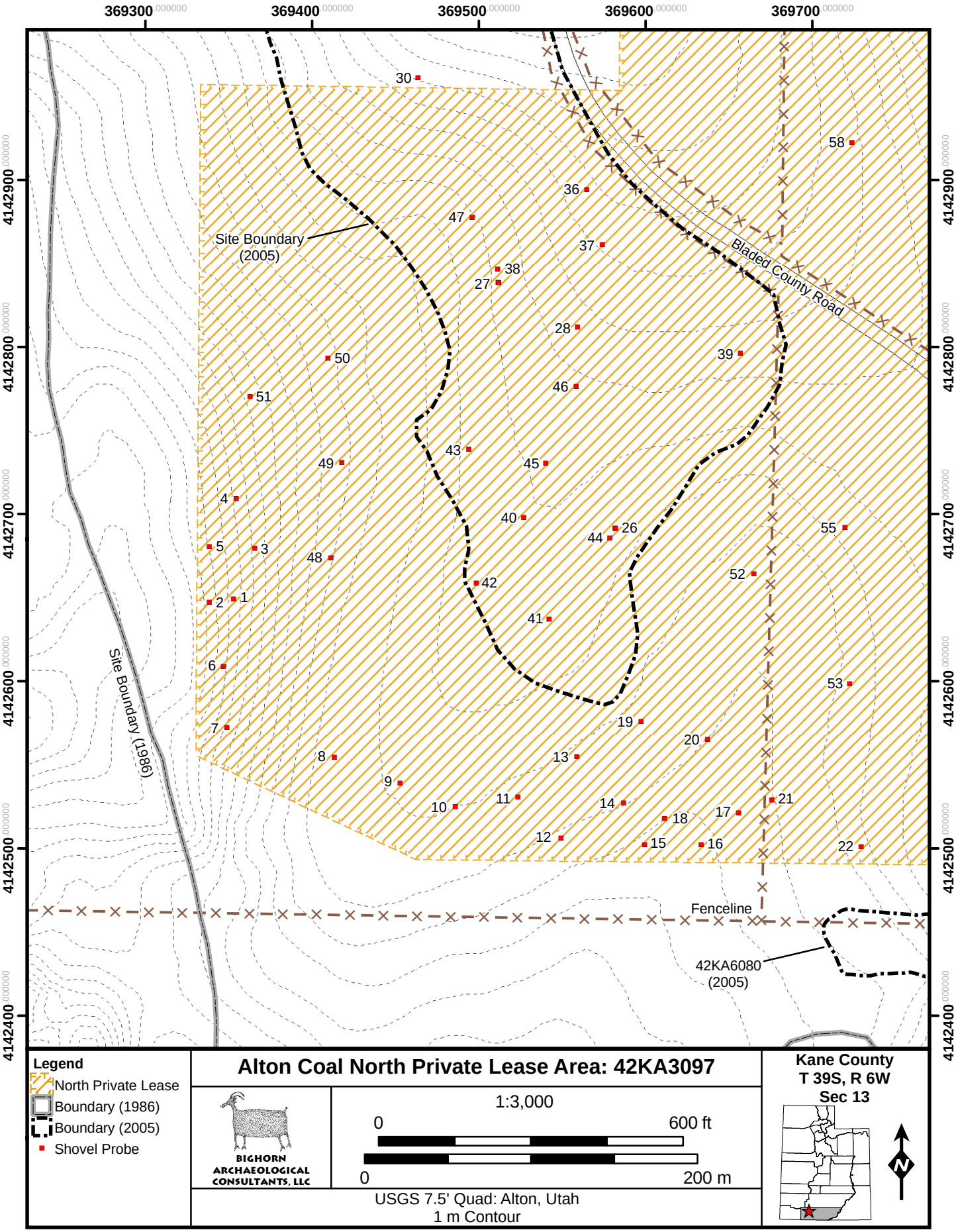



Figure 7.18. Close-up of STP locations across site 42KA3097

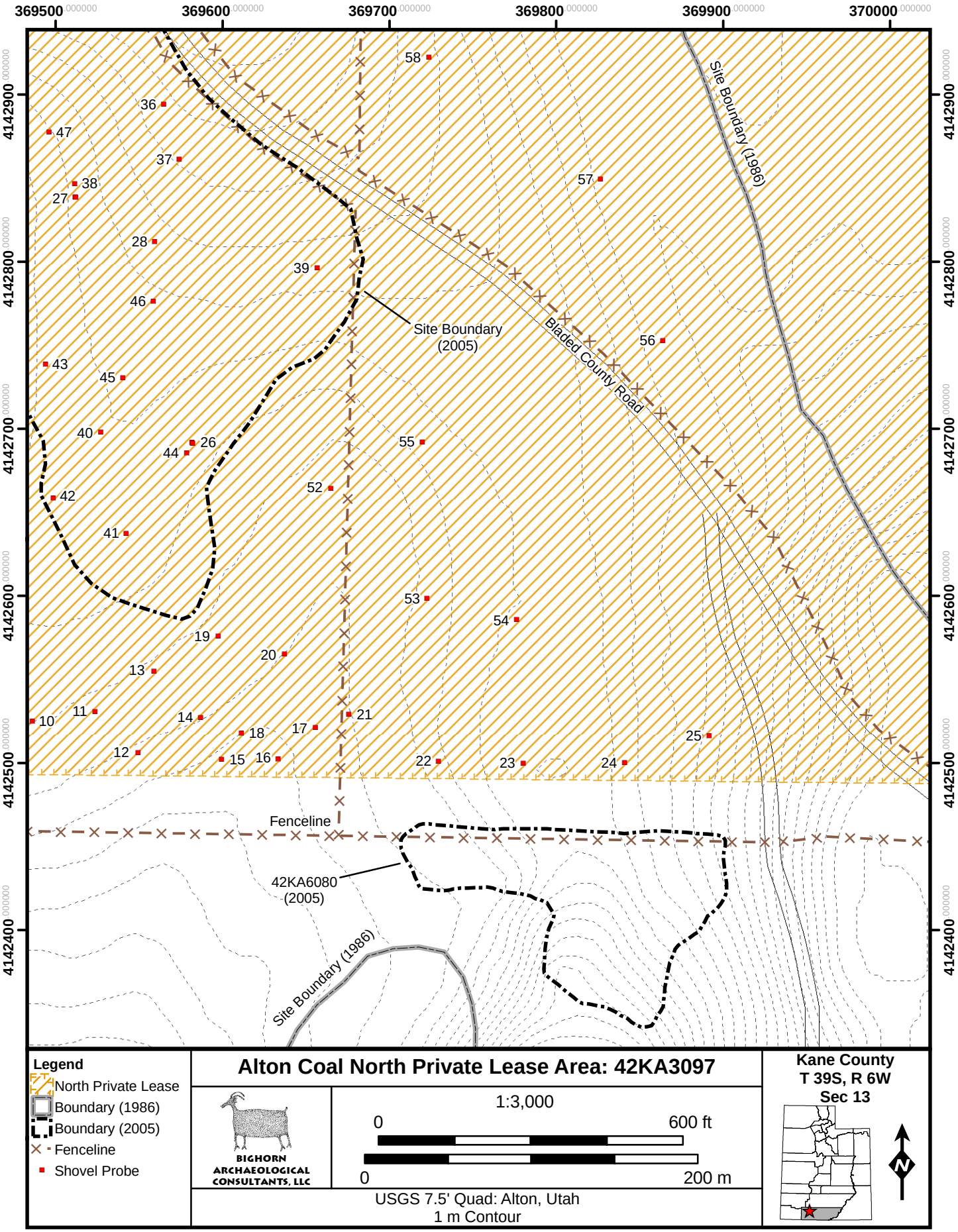



Figure 7.19. Close-up of STP locations across site 42KA3097

***Summary***

Testing of site 42KA3097 included placement of 62 STPs across the site area. Surface examination and collection resulted in the identification of a nice array of prehistoric tools, several ceramic sherds, and two small concentrations of historic glass. No subsurface materials were recovered from any of the STPs completed as part of the Tier I testing. Ground stone artifacts encountered were analyzed in the field. Bighorn recommended that no further data recovery work be conducted at the site as the testing verified that cultural materials were relegated to the surface of the site which has been disturbed by agricultural use. Testing also found no evidence of intact cultural features.

# Chapter 8: Historic Road Reconnaissance

## Road to Kanab

The historic "Road to Kanab" and another branch road are depicted on GLO maps of the area dating from 1877 and 1885 (GLO 1877a, 1887b, 1885), both of which are shown passing through the NPLA. The alignment of the main road varied somewhat between the two maps but generally followed the route of the present county road through a portion of the western part of the NPLA. An aerial photograph of the area taken for the Soil Conservation Service in 1938 (SCS 1938) indicates the current county road alignment was in place and departed from the path of the older road alignment(s) near the southwestern portion of the NPLA. No documentation of the old road alignments has been completed in this area.

**Figure 8.1. Overview of current county road alignment with modern cattle guard looking south**

No evidence of any abandoned segments of the former historic road alignments noted on GLO maps and mid-20th century aerial photographs was found within the NPLA with the exception of the current county road alignment. This would be due to the project area having been plowed and used extensively as agricultural fields over the years. The current county road alignment was evaluated during the surface evaluation of the project area and found to follow the same route as that depicted on an aerial photograph of the area dating from 1938. It appears as a graded dirt road that is approximately 5 m wide and has been maintained over the years. Modern improvements include widening of the original alignment to accommodate two-way traffic and installation of cattle guards and culverts in places over drainage crossings and at Kanab Creek

**Figure 8.2. Overview of current county road alignment looking northwest**

**Figure 8.3. Overview of current county road alignment looking southeast**

(Figures 8.1-8.3). As such, the historic fabric of the original road has been obliterated, thus, the road does not meet the requirements established for documentation as either a site or isolated linear feature (Utah Professional Archaeological Council 2008).

While historic material was observed on the surface within the NPLA, it is not possible to tie these artifacts specifically to the road. These artifacts are most likely out of context, having been displaced over the years in open agricultural/ranching fields, however, they do reflect the historic nature and activities that were being conducted in the Alton Amphitheater during the early 20$^{th}$ century, namely farming and ranching conducted by small family groups.

# Chapter 9: Ceramic Analysis

By Aaron A. Jordan

## Analytical Methods

Analysis of the ceramic material was first begun by size sorting the sherds recovered from sites 42KA3077 and 42KA3097. All sherds larger than approximately 2 cm in size were nipped to expose a fresh cross section and examined under low power (15 or 20X) magnification in order to determine type of temper used. These sherds were then classified into formally defined ceramic types or residual categories based on observations of temper and paste. Ceramic classification was based on commonly used ceramic typologies of the region using information from reports by Baldwin (1950), R. Madsen (1977), D. Madsen (1986), Lyneis (1994), and Watkins (2009). Sherds were then counted and weighed, using a digital scale, by ceramic type to obtain an accurate view of the amounts of varying ceramic types represented at each site. Sherds less than 2 cm in size were not examined other than to be included in both the overall sherd count and weight to address issues of site duration and microrefuse retrieval. Digital calipers were used to determine maximum and minimum thickness of each sherd.

All sherds were examined for any surface deposit, including smoked or sooted exterior or interior, pigment residue on the exterior or interior, and charred organic residue on the exterior or interior. At the same time, the ceramic material was also examined for specific type of ware. The types of ware found in this sample were smoothed or polished exterior, scraped exterior, unfinished exterior, and incised/fingernail-impressed. Finally, the sherds were examined to determine form. Three types of form were identified: body sherd, bowl rim, and jar rim. Rim sherds were analyzed in detail for information about chronology (based on rim eversion) and in order to document vessel forms and size classes represented. Inferences can be made concerning vessel function based on vessel form and size as well as direct evidence provided by the presence of sooting and interior pitting. These data points can be utilized to ascertain the kinds of subsistence related tasks that were carried out at the site and what it implies about site function and group size and how these may have varied through time.

## Results

A total of nine ceramic sherds were recovered from sites 42KA3077 and 42KA3097 during the Tier I mitigation work within the NPLA.

### *42KA3077*

Surface collection and testing on site 42KA3077 resulted in the recovery of five ceramic sherds from the surface of the site. All five of these sherds were Southern Paiute Brown Ware sherds. One was the basal fragment from a jar and the other four were body sherds. Four of the five sherds were fingernail-impressed on their exterior surface while the remaining body sherd had no visible surface treatment on either its interior or exterior (Figures 9.1-9.3). The five sherds, including the plain body sherd, were all generally uniform in thickness (ranging from 7.4 mm to 7.9 mm) and paste indicating that they are likely from a single vessel.

**Figure 9.1. Southern Paiute Brown Ware sherd**

**Figure 9.2. Southern Paiute Brown Ware sherd**

**Figure 9.3. Southern Paiute Brown Ware sherds**

***42KA 3097***

Surface collection and testing on site 42KA3097 resulted in the recovery of four ceramic sherds from the surface of the site (Figures 9.4-9.5). This small ceramic assemblage included one Southern Paiute Brown Ware sherd and three Snake Valley Gray Ware sherds (two Snake Valley Gray and one Snake Valley Black-on-Gray). Of the Snake Valley Gray Ware sherds, one was a rim sherd and the remaining two were body sherds. One of the body sherds was painted on its interior using black organic based pigment. The identifiable design element exhibited on this black-on-gray sherd formed a large diamond (Figure 9.5). The Southern Paiute Brown Ware sherd was fingernail-impressed on its exterior and thick walled, measuring 8.5 mm thick.

**Figure 9.4. Southern Paiute Brown Ware sherd & Snake Valley Gray sherds**

**Figure 9.5. Snake Valley Black-on-gray sherd**

## Ceramic Typologies

### *Snake Valley Grayware*

The Snake Valley Grayware type (including Snake Valley Gray and Snake Valley Black-on-gray) account for 33 percent (n=3) of the ceramics in this analysis. All three sherds were recovered from site 42KA3097. This ceramic type is culturally associated with the Fremont Indian who inhabited this region during the Formative period (between AD 300 and 1300). Temper of all three sherds was comprised of fine, clear, angular, quartz and/or feldspar and abundant biotite mica. Paste color was generally a gray or light gray.

### *Southern Paiute Brown Ware*

Southern Paiute Brown Ware sherds account for the remaining 67 percent (n=6) of the ceramics recovered at both sites 42KA3077 and 42KA3097. This ceramic type is culturally associated with the Southern Paiute who inhabited this region during the Late Prehistoric period (post- AD 1300) on into the historic period. The temper of these sherds was a combination of fine grained

sand, coarse crushed angular quartzite, and feldspar. The temper was set within a granular crumbly clay matrix. Paste color was generally a reddish-brown or light brown.

**Summary**

A total of nine ceramic sherds were recovered from sites 42KA3077 and 42KA3097 during the Tier I mitigation within the NPLA. Of these, six were typed as Southern Paiute Brown Ware sherds and three as Snake Valley Grayware. The ceramics collected and analyzed from the two sites within the project area are typical of prehistoric ceramics found in the Upper Kanab and surrounding region and represent two distinct cultural traditions; namely the Fremont Indian and Southern Paiute. The presence of these two ceramic types indicate that both sites 42KA3077 and 42KA3097 were utilized by the Southern Paiute during the Late Prehistoric period, and that site 42KA3097 was also utilized by the Fremont culture during the Formative period.

# Chapter 10: Chipped Stone Analysis

By Aaron A. Jordan

A total of 86 chipped stone artifacts were recovered from sites 42KA3077 and 42KA3097 during the Tier I mitigation within the NPLA. The collection consists of 13 pieces of debitage and 72 tools (Table 10.1).

**Table 10.1. Chipped stone debitage & formal tools**

| Site | Projectile Point | Drill | Biface | Uniface | Scraper | Chopper | Hammer stone | Core | Debitage | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 42KA3077 | 4 | - | 18 | 2 | 2 | 7 | 7 | - | 11 | **51** |
| 42KA3097 | 10 | 1 | 14 | - | 2 | 2 | 3 | 1 | 2 | **35** |
| **Total** | **14** | **1** | **32** | **2** | **4** | **9** | **10** | **1** | **13** | **86** |

## Analytical Methods

Analysis began by first separating chipped stone tools from the debitage. Chipped stone tools are defined here as lithic artifacts exhibiting human modification in the form of percussion and/or pressure flaking, while the debitage is the refuse from such modification. Each tool was categorized by type, material, completeness and wear. Length, width and thickness of each tool were recorded in millimeters and weight in grams. Other salient features including presence of cortex and provenience were noted. Chipped stone debitage is defined as chipped stone tool production byproduct. Each piece of debitage was categorized by material type, size, weight, flake stage, provenience and weight in grams.

Tools recovered from the testing were classified into one of the following three general types: bifaces, unifaces, or cores. No other chipped stone tool types were present within the lithic assemblage recovered from the two sites and, therefore, are not addressed within this analysis. Although cores are not generally classified as tools per se, for the sake of this analysis, cores were included within the chipped stone tool analysis in order to include the sub-categories of core-scraper or core-chopper. Bifaces are defined as stone artifacts with flake scars covering two distinct faces. Bifaces, for this analysis, were subdivided into three hypothetical stages of production. Early stage bifaces vary in quality and quantity of flake scars, intermediate stage bifaces begin to exhibit some refined flake scares, thinning and basic shaping, while late stage bifaces exhibit only refined flake scares, and elaborate thinning and shaping. For this analysis both projectile points and drills were sub-categorized within the late stage biface category. Projectile points are thinned, often bifacially flaked tools that have been worked to a point on the distal end. They exhibit two basic characteristics: 1) a well-defined blade, or the piercing portion of the implement; and 2) a hafting element that takes the form of a basal stem or a modification of the base, such as notching. Drills are thinned, bifacially flaked tools that have protruding lateral margins on the base and a long, thin body (Andrefsky 1998:7). Unifaces are defined as stone artifacts with flake scars covering only one distinct face. One sub-category of unifaces in this analysis is scrapers. A core is a mass of lithic material purposely reduced to obtain pieces of

stone (flakes) which could be processed into tools. Two types of cores were considered in this analysis; unidirectional and multidirectional. A unidirectional core has flake scars that extend in one primary direction, usually removed from one striking platform and a multidirectional core has several striking platforms and flake scars that extend in numerous directions (Andrefsky 1998:13, 15). Two sub-categories of cores identified in this analysis are core-scraper and core-chopper. Core-scrapers are defined as a repurposed core with steep edge angles produced by percussion or pressure flaking. The angle of the scraper edge is often >45°. Core-choppers included utilized cores and cobbles having at least one long edge exhibiting crushing wear (Elson and Clark 1995:14).

Debitage was classified using the following five flake types; primary core reduction flakes, secondary core reduction flakes, interior core reduction flakes, bifacial thinning flakes, and shatter. Primary core reduction flakes are defined as flakes with nearly all (75-100%) of the dorsal surface covered with cortex and seldom has more than one flake scar. Secondary core reduction flakes are defined as flakes with less than 75% of the dorsal surface covered by cortex and more than one flake scar. Interior core reduction flakes are defined as a catch-all category for a variety of flake types without cortex that do not fit the definition of bifacial thinning flakes or shatter. Bifacial thinning flakes are defined as often thin, fan-shaped flakes with multiple dorsal flake scars and flake scars evident on the platform. Shatter is defined as thick, angular waste, lacking a bulb of percussion, platforms and dorsal ridges.

Once the debitage was initially typed, they were then further divided into two flake stage categories: Early and Late. Primary core reduction flakes and secondary core reduction flakes are usually associated with the initial (early) stages of lithic reduction, while Interior core reduction flakes and Bifacial thinning flakes are more likely to be associated with retouching and bifacial reduction activities (late). Shatter, though more likely to be present during Early stages of lithic reduction than Late, can be present at all stages and therefore was not included in any one specific category, but simply noted as being either present or absent.

**Results**

A total of 13 pieces of chipped stone debitage were recovered during the Tier I mitigation completed on sites 42KA3077 and 42KA3097 (Table 10.1) within the NPLA. Flake types included only late stages of reduction from materials that included chert, quartzite, and obsidian. No primary or secondary core reduction flakes were present within the debitage assemblage.

Chipped stone tools recovered during Tier I mitigation totaled 73 tools (62 formal, seven hammerstones, and 1 core) with material types that included chert, quartzite, and obsidian (Table 10.1). Analysis of chipped stone tools and debitage was performed by Aaron A. Jordan of Bighorn.

***42KA3077***

Surface collection and testing on site 42KA3077 resulted in the recovery of 11 pieces of flaked debitage and 40 chipped stone tools (Table 10.2).

**Table 10.2. Chipped stone artifacts recovered from site 42KA3077**

| Artifact Type | Testing Depth (cm) | | | |
|---|---|---|---|---|
| | Surface | 0-10 | 10-20 | Total |
| **Debitage** | 6 | 2 | 3 | **11** |
| **Bifacial Tools** – (Sub-Total) | 21 | 1 | - | **22** |
| Biface | 18 | - | - | **18** |
| Drill | - | - | - | **-** |
| ***Projectile Points*** *– (Sub-Total)* | 3 | 1 | - | **4** |
| Elko Series | 1 | 1 | - | **2** |
| Gatecliff Contracting Stem (Gypsum Cluster) | 1 | - | - | **1** |
| Desert Side Notched | 1 | - | - | **1** |
| **Unifacial Tools** – (Sub-Total) | 2 | - | - | **2** |
| Uniface | 2 | - | - | **2** |
| Scraper | - | - | - | **-** |
| **Core Tools** – (Sub-Total) | 16 | - | - | **16** |
| Scraper | 2 | - | - | **2** |
| Chopper | 7 | - | - | **7** |
| Hammerstone | 7 | - | - | **7** |
| **Total** | **45** | **3** | **3** | **51** |

*Debitage*

A total of 11 flakes representing only late stages of lithic reduction were recovered from site 42KA3077 (Table 10.3). The dominant type of flake was interior core reduction flakes (n=9), which comprised 82 percent of the debitage assemblage. The only other flake type present within the assemblage was shatter (n=2) which accounted for the remaining 18 percent of the debitage. The 11 pieces of debitage consisted of three different types of stone material. The majority of the debitage was chert (n=6), which comprised 55 percent of the assemblage. Obsidian was the second most common (n=4) comprising 36 percent of the debitage. Only a single quartzite interior core reduction flake was present within the recovered debitage (n=1) accounting for the remaining nine percent of the debitage assemblage.

**Table 10.3. Debitage from Site 42KA3077**

| Artifact Type | Obsidian | Chert | Quartzite | Total |
|---|---|---|---|---|
| Primary Decortication | - | - | - | **-** |
| Secondary Decortication | - | - | - | **-** |
| Interior Flake | 3 | 5 | 1 | **9** |
| Bifacial Thinning Flake | - | - | - | **-** |
| Shatter | 1 | 1 | - | **2** |
| **Total** | **4** | **6** | **1** | **11** |

As stated above, the debitage assemblage recovered from this site represents solely late stages of core reduction and retooling activities. Of the 11 pieces of chipped stone debitage recovered from this site, all but two were interior core reduction flakes. The high quantity of this flake type suggests later stages of core reduction were likely a dominate activity practiced at the site. Seven of the nine interior core reduction flakes were small (<12.7 mm in size) tertiary and pressure

flakes suggesting final production of tools and retooling were the primary activity of this assemblage. However, it should be noted that the relatively low quantity of debitage recovered, possibly as a result of the type of testing method employed at the time of testing and data recovery, may bias this interpretation somewhat.

*Chipped Stone Tools*

The chipped stone tools collected from site 42KA3077 consisted of 22 bifacial tools, two unifacial tools, and 16 core tools. Bifacial tools included four projectile points (three chert and one obsidian) and 18 bifaces (all chert) (Table 10.4). The projectile points include a complete Desert Side-notched point, two Elko Corner-notched (one complete and one fragment), and a Gypsum Contracting Stem point fragment (Figures 10.3a, 10.4 & 10.8). The projectile point types indicate utilization of the site during both the Archaic and Late Prehistoric periods. The bifaces include one early stage fragment, nine intermediate stage (one complete and eight fragments), and eight late stage fragments. Unifacial tools consisted of one uniface made from a large blade flake and one uniface/graver made from a large interior core reduction flake. Both unifaces are made from the same chert material. Core tools included two quartzite scrapers, seven quartzite choppers, and seven quartzite hammerstones.

**Table 10.4. Chipped stone tools from site 42KA3077**

| Tool Type | Form | Material | Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|---|---|---|
| Projectile Point | Elko Corner-notched (fragment) | Obsidian | 8.2 | 16.8 | 3.7 |
| Projectile Point | Elko Corner-notched (complete) | Chert | 33.8 | 22.7 | 4.5 |
| Projectile Point | Gatecliff Contracting Stem (fragment) | Chert | 20.9 | 19.4 | 5.6 |
| Projectile Point | Desert Side-notched (complete) | Chert | 20.3 | 13 | 2.6 |
| Biface frag | Late-stage | Chert | 11.5 | 15 | 3.9 |
| Biface frag | Late-stage | Chert | 24.8 | 32.1 | 6.9 |
| Biface frag | Mid-stage | Chert | 19.7 | 29.7 | 13.4 |
| Biface frag | Late-stage | Chert | 23.4 | 17.6 | 4.4 |
| Biface frag | Mid-stage | Chert | 28.8 | 28.7 | 5.6 |
| Biface frag | Mid-stage | Chert | 25.8 | 22.8 | 7.2 |
| Biface frag | Mid-stage | Chert | 23.3 | 27.3 | 7.2 |
| Biface frag | Mid-stage | Chert | 13.7 | 18.2 | 4.8 |
| Biface frag | Mid-stage | Chert | 42.6 | 28.7 | 11 |
| Biface frag | Mid-stage | Chert | 19.3 | 18.6 | 5.4 |
| Biface frag | Late-stage | Chert | 14.8 | 20.3 | 4.5 |
| Biface frag | Late-stage | Chert | 16.6 | 13.6 | 4.5 |
| Biface frag | Late-stage | Chert | 34.7 | 21.2 | 6.3 |
| Biface frag | Late-stage | Chert | 18.4 | 16.4 | 4 |
| Biface frag | Early-stage | Chert | 21 | 25.3 | 8 |
| Biface | Mid-stage | Chert | 37 | 38.4 | 6.5 |
| Biface frag | Mid-stage | Chert | 43.6 | 38.3 | 16.6 |
| Biface frag | Late-stage | Chert | 24.5 | 30.9 | 6.3 |
| Uniface | - | Chert | 30.4 | 15.7 | 4.6 |

| Tool Type | Form | Material | Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|---|---|---|
| Uniface/Graver | - | Chert | 20.7 | 33.6 | 3.7 |
| Scraper | Low-edge (<45° edge) | Chert | 42.6 | 51.8 | 17.2 |
| Scraper | High-edge (>45° edge) | Quartzite | 57 | 54 | 18 |
| Chopper | - | Quartzite | 70 | 47 | 32 |
| Chopper | - | Quartzite | 90 | 55 | 30 |
| Chopper | - | Quartzite | 78 | 55 | 27 |
| Chopper | - | Quartzite | 120 | 70 | 41 |
| Chopper | - | Quartzite | 100 | 57 | 44 |
| Chopper | - | Quartzite | 76 | 77 | 35 |
| Chopper | - | Quartzite | 57 | 54 | 18 |
| Hammerstone | - | Quartzite | 64 | 50 | 33 |
| Hammerstone | - | Quartzite | 60 | 40 | 50 |
| Hammerstone | - | Quartzite | 77 | 53 | 30 |
| Hammerstone | - | Quartzite | 62 | 62 | 60 |
| Hammerstone | - | Quartzite | 71 | 54 | 22 |
| Hammerstone | - | Quartzite | 50 | 53 | 27 |
| Hammerstone | - | Quartzite | 65 | 57 | 41 |

### *42KA3097*

Surface collection and testing on site 42KA3097 resulted in the recovery of only two pieces of flaked debitage and 78 chipped stone tools (Table 10.5).

**Table 10.5. Chipped stone artifacts recovered from site 42KA3097**

| | Testing Depth (cm) | | | |
|---|---|---|---|---|
| **Artifact Type** | **Surface** | **0-10** | **10-20** | **Total** |
| **Debitage** | 2 | - | - | **2** |
| **Bifacial Tools** – (Sub-Total) | 25 | - | - | **25** |
| Biface | 14 | - | - | **14** |
| Drill | 1 | - | - | **1** |
| ***Projectile Points*** *– (Sub-Total)* | 10 | - | - | **10** |
| Elko Series | 4 | - | - | **4** |
| Northern Side-notched | 2 | - | - | **2** |
| Sudden Side-notched | 1 | - | - | **1** |
| Gatecliff Contracting Stem (Gypsum Cluster) | 1 | - | - | **1** |
| Unclassified Point | 1 | - | - | **1** |
| Rose Gate Series | 1 | - | - | **1** |
| **Unifacial Tools** – (Sub-Total) | - | - | - | **-** |
| **Core Tools** – (Sub-Total) | 7 | 1 | - | **8** |
| Scraper | 2 | - | - | **2** |
| Chopper/Hammerstone | 2 | - | - | **2** |
| Hammerstone | 3 | - | - | **3** |
| Core | - | 1 | - | **1** |
| **Total** | **34** | **1** | **-** | **35** |

*Debitage*

A total of two flakes representing only late stages of lithic reduction were recovered from site 42KA3097 (Table 10). These two flakes were collected off the surface of the site as part of the surface collection phase since they were both made from obsidian. No other lithic debitage was collected from the surface collection portion of the Tier I mitigation and no lithic debitage was encountered during the testing phase. Since only two flakes were collected from the site, this data set is too incomplete to interpret or speculate on.

**Table 10.6. Debitage from site 42KA3097**

| Artifact Type | Obsidian | Chert | Quartzite | Total |
|---|---|---|---|---|
| Primary Decortication | - | - | - | **-** |
| Secondary Decortication | - | - | - | **-** |
| Interior Flake | 1 | - | - | **1** |
| Bifacial Thinning Flake | 1 | - | - | **1** |
| Shatter | - | - | - | **-** |
| **Total** | **2** | - | - | **2** |

*Chipped Stone Tools*

The chipped stone tools collected from site 42KA3077 consisted of 25 bifacial tools and eight core tools. Bifacial tools included 10 projectile points (nine chert and one obsidian) 14 bifaces (all chert) and one chert drill (Table 10.7). The projectile points include an Elko Eared point fragment, two Elko Corner-notched point fragments, an Elko Side-notched point fragment, two Northern Side-notched point fragments, a Sudden Side-notched point fragment, a Gatecliff Contracting Stem point fragment, a Rose Spring Corner-notched point fragment, and an unclassified point fragment (Figures 10.1, 10.2, 10.3b, 10-5-10.7). The projectile point types indicate utilization of the site during both the Archaic and Formative periods (see brief discussions of each point type below). The bifaces include two intermediate stage fragments and 12 late stage fragments. All 14 biface fragments are made from chert as is the drill fragment. Core tools included two chert scrapers, two chopper/hammerstones (one chert and one quartzite), three quartzite hammerstones, and one exhausted chert core.

**Table 10.7. Chipped stone tools from site 42KA3097**

| Tool Type | Form | Material | Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|---|---|---|
| Projectile Point | Northern Side-notched (fragment) | Obsidian | 24.1 | 22.1 | 4.3 |
| Projectile Point | Northern Side-notched (fragment) | Chert | 14 | 16 | 6 |
| Projectile Point | Sudden Side-notched (fragment) | Chert | 19.4 | 21.3 | 6.5 |
| Projectile Point | Gatecliff Contracting Stem (fragment) | Chert | 15 | 18 | 6 |
| Projectile Point | Elko Eared (fragment) | Chert | 19.2 | 19.3 | 5.2 |
| Projectile Point | Elko Corner-notched (fragment) | Chert | 17.3 | 20.9 | 5.9 |
| Projectile Point | Elko Corner-notched (fragment) | Chert | 25.8 | 26.9 | 5 |

| Tool Type | Form | Material | Length (mm) | Width (mm) | Thickness (mm) |
|---|---|---|---|---|---|
| Projectile Point | Elko Side-notched (fragment) | Chert | 12.5 | 20.4 | 5 |
| Projectile Point | Rose Spring Corner-notched(fragment) | Chert | 15.5 | 14.1 | 2.5 |
| Projectile Point | Unclassified Point Base (fragment) | Chert | 21.6 | 14 | 4.5 |
| Biface frag | Late-stage | Chert | 24 | 12 | 4 |
| Biface frag | Late-stage | Chert | 37.5 | 15.3 | 8.2 |
| Biface frag | Late-stage | Chert | 24.6 | 21.8 | 6.8 |
| Biface frag | Late-stage | Chert | 16.4 | 14.5 | 5.1 |
| Biface frag | Late-stage | Chert | 29.1 | 24.3 | 5.9 |
| Biface frag | Late-stage | Chert | 20.5 | 17.5 | 4.6 |
| Biface frag | Mid-stage | Chert | 34.5 | 20 | 7.2 |
| Biface frag | Late-stage | Chert | 21.2 | 20.2 | 3.9 |
| Biface frag | Late-stage | Chert | 23.4 | 18.8 | 4.9 |
| Biface frag | Mid-stage | Chert | 25 | 31.6 | 7.9 |
| Biface frag | Late-stage | Chert | 24.1 | 18 | 6 |
| Biface frag | Late-stage | Chert | 17.6 | 17.7 | 3.5 |
| Biface frag | Late-stage | Chert | 24.6 | 16.7 | 3.9 |
| Biface frag | Late-stage | Chert | 35.5 | 34.5 | 8 |
| Drill | Late-stage | Chert | 23.5 | 20.4 | 5.5 |
| Scraper | Low-edge (<45° edge) | Chert | 38.6 | 48.9 | 18.3 |
| Scraper | High-edge (>45° edge) | Chert | 59.6 | 32.1 | 21.3 |
| Chopper/Hammerstone | - | Chert | 57.8 | 55.7 | 30.5 |
| Chopper/Hammerstone | - | Quartzite | 92.6 | 87.3 | 67.3 |
| Hammerstone | - | Quartzite | 67.8 | 51.3 | 42 |
| Hammerstone | - | Quartzite | 84.8 | 51.1 | 43.3 |
| Hammerstone | - | Quartzite | 66 | 45.2 | 48.1 |
| Core | - | Chert | 31.2 | 46.1 | 18.9 |

## Projectile Point Typologies

Fourteen projectile points were recovered from sites 42KA3077 and 42KA3097 during the Tier I mitigation of the NPLA (Table 8 & Table 11). Collected projectile points were classified into eight types including Norther Side-notched, Sudden Side-notched, Gatecliff Contracting Stem, Elko Eared, Elko Corner- and Side-notched, Rose Spring Corner-notched, and Desert Side-notched. Two projectile points were unclassified.

### *Northern Side-notched*

Two Northern Side-notched projectile points made from obsidian and chert were recovered from site 42KA3097 (Figure 10.1). Northern Side-notched points are characterized by a triangular blade with straight to slightly convex edges, horizontal notches located moderately high on the sides, and a contracting base that is typically concave (Holmer 1978). These points have a relatively short time span on the northern Colorado Plateau, ca. 6900-6300 BP (Holmer 1978; Tipps 1989; Justice 2002). The two specimens collected from the project include the base of a

point made of opaque, black obsidian and the base of a point made from opaque, white chert. Trace element analysis on the obsidian point revealed it was of the a Wild Horse Canyon volcanic glass chemical type, suggesting that the artifact, or at least the material from which it was fashioned, was obtained from the Mineral Mountains in Beaver County, approximately 70 miles to the northwest.

**Figure 10.1. Northern Side notch series points**

***Sudden Side-notched***

One Sudden Side-notched projectile point was recovered from site 42KA3097 (Figure 18). Sudden Side-notched points are characterized by a large triangular body with high, horizontal notches placed along both blade edge, and a straight basal edge (Holmer 1978:49; Justice 2002). This point type is found throughout central and southern Utah (Tipps 1988:84) and dates to between 6400 and 4700 BP on the northern Colorado Plateau (Holmer 1978; Tipps 1988; Justice 2002). The specimen collected from the project is the base of a point made of opaque white chert.

**Figure 10.2. Sudden side notch series point**

### *Gypsum Cluster – Gatecliff Contracting Stem*

One Gatecliff Contracting Stem projectile point was recovered from site 42KA3077 (Figure 10.3a) and another from 42KA3097 (Figure 10.3b). This point type is characterized by a triangular blade with convex edges and a contracting stem with a narrow convex or square base (Holmer 1978). Gypsum Cluster points are the most common Archaic point type on the Colorado Plateau (Geib et al. 2001:202), and date to between 2500-1000 BC, although the terminal date has not been determined for southern Utah. The two specimens collected from the project include the bases of points made from opaque chert.

**Figure 10.3 Gypsum cluster points from 42KA3077 & 42KA3097**

### *Elko Series*

Elko Series points make up half of the projectile point types recovered during the Tier I mitigation from sites 42KA3077 and 42KA3097. Of the six Elko points collected (two from 42KA3077 and four from 42KA3097), one was an Elko Eared point, four were Elko Corner-notched points, and one was an Elko Side-notched point (Figures 10.4-10.6). Elko Series points are characterized by large, triangular blades with straight to slightly convex edges. The corner- and side-notched varieties have slightly concave to convex bases, while the Elko Eared points are side-notched and have markedly concave or deeply notched bases. Elko Series points span over a 7000 year period beginning about 6000 BC (Holmer 1986; Justice 2002), and are found throughout the Archaic period as well as the Formative Period, and are typically not considered diagnostic. The eared variety may be temporally diagnostic of the Late Archaic period. In the eastern Great Basin and northern Colorado Plateau, Elko Eared points terminate during the late Archaic at Hogup and Cowboy Caves (Holmer 1986), and have been radiocarbon dated to the Late Archaic period elsewhere on the Colorado Plateau (Geib et al. 2001; Janetski 1999). One of the Elko Series specimens recovered and analyzed from the project was made from black obsidian while the other five were made from various colors of chert. Only one of the Elko series points was complete and the other five were basal fragments. Trace element analysis on the obsidian point revealed it was of the a Wild Horse Canyon volcanic glass chemical type, suggesting that the artifact, or at least the material from which it was fashioned, was obtained from the Mineral Mountains in Beaver County, approximately 70 miles to the northwest.

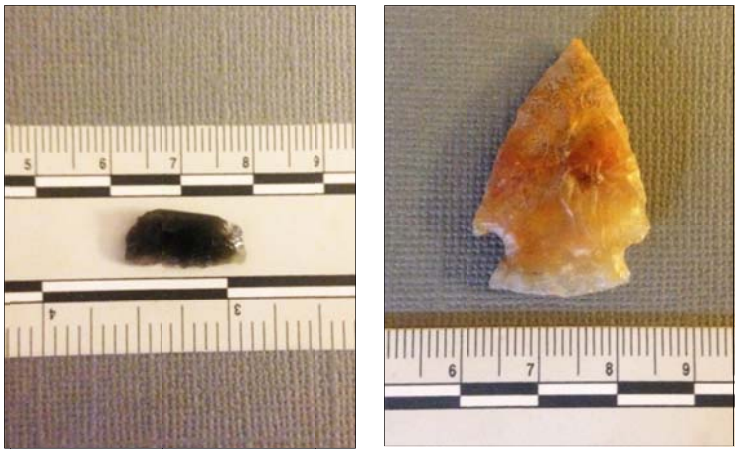


**Figure 10.4 Elko series points from 42KA3077**

**Figure 10.5. Elko Series points from 42KA3097**

**Figure 10.6. Elko Series points from 42KA3097**

***Rose Spring Corner-notched***

One Rose Spring Corner-notched point was recovered from 42KA3097 during the project (Figure 10.7). Rose Spring Corner-notched points are small and characterized by thin, narrow,

triangular blades and corner notches. The corner notches create squared shoulders or barbs and a narrow, slightly contracting stem (Heizer & Hester 1978; Justice 2002). The barbs do not extend as long as the base and blade is often slightly serrated with straight edges. The appearance of these points marks the beginning of bow and arrow technology, and typically date to about AD 300-950 on the Colorado Plateau (Geib et al. 2001; Holmer & Weder 1980; Justice 2002), although they have also been associated with late Fremont occupations (Marwitt 1968; Talbot et al. 2000:395). The Rose Spring Corner-notched specimen collected from the project was made from chert and showed evidence of having been re-worked.

**Figure 10.7. Rose Spring Series point from 42KA3097**

***Desert Side-notched***

One Desert Side-notched projectile point was recovered from site 42KA3077 (Figure 10.8). Desert Side-notched points are characterized by a triangular shape with squared to wing-like side-notched tangs, and a V-shaped basal notch (Holmer & Weder 1980; Justice 2002). This point type is diagnostic of the Southern Numic expansion into the region around AD 1300 (Geib et al. 2001; Justice 2002) and continued into historic times. The specimen from the project was a complete point made of translucent white chert.

**Figure 10.8. Desert Side-notched point from 42KA3077**

## Obsidian Sourcing & Hydration Dating

Eight obsidian samples were submitted for trace element analysis to determine their source of origin. Of the eight artifacts submitted, seven were large enough to generate reliable quantitative data (Table 10.8). Results of the analysis indicated that seven of the artifacts were of the Wild Horse Canyon volcanic glass chemical type, five were of the Panaca Summit (Modena area) chemical type, one was of the Black Rock area chemical type, one was of the Malad chemical type, one was of the Brown's Bench area chemical type, and two others were from an unidentified geographical source area (Hughes 2017; Appendix C).

**Table 10.8. Obsidian sourcing results**

| Site No. | Artifact Type | Source Area | | | |
|---|---|---|---|---|---|
| | | Wild Horse | Panaca Summit | Unknown | Total |
| 42KA3077 | Lithic Flake | 1 | 2 | - | **3** |
| | Projectile Point | - | - | 1 | **1** |
| 42KA3097 | Lithic Flake | 2 | - | - | **2** |
| | Projectile Point | 1 | - | - | **1** |
| | **Total** | **4** | **3** | **1** | **7** |

Obsidian hydration dating….

## Summary

Of the 13 pieces of chipped stone debitage recovered from sites 42KA3077 and 42KA3097, all but two were interior core reduction flakes. The remaining two pieces were small pieces of shatter that containing no cortex. The presence of this flake type on-site generally suggests later stage core reduction activities taking place, such as final production of tools and/or retooling. Seven of the 10 interior core reduction flakes recovered from the two sites were small (<12.7 mm in size) tertiary and pressure flakes suggesting final production of tools and retooling were the primary activity of this assemblage. However, it should be noted that the relatively low quantity of debitage recovered from both sites, possibly as a result of agricultural and ranching use of the area, and the type of testing method employed at the time, may bias this interpretation somewhat. Even so, when the lithic debitage is viewed in conjunction with the lithic tool assemblage recovered from sites 42KA3077 and 42KA3097, it would appear that the interpretation of both sites lithic activities being primarily dedicated to final production of tools and/or retooling may have some validity. Of the 73 chipped stone tools recovered from sites 42KA3077 and 42KA3097, 65 percent (n=47) were bifacial tools. All but one of the 32 bifaces in this analysis were in their latter to final stage of production. Adding in all 14 projectile points, single drill fragment, and two unifaces from the sites only helps to bolster this argument. The remaining 35 percent (n=24) of the chipped stone tool assemblage comprised of core tools, including scrapers, choppers, hammerstones, and exhausted core fragments, also indicated that at least some processing activities took place at both of these sites.

# Chapter 11: Ground Stone Analysis

By Aaron A. Jordan

A total of 27 ground stone artifacts were identified from sites 42KA3077 and 42KA3097 during the Tier I mitigation of the NPLA. The collection consists of four metate fragments, five mano fragments, and 18 undetermined ground stone fragments (Table 11.1).

**Table 11.1. Ground stone from sites 42KA3077 & 42KA3097**

| Artifact Type | Quartzite | Sandstone | Total |
|---|---|---|---|
| Single Hand Mano Fragment | 2 | - | **2** |
| Undetermined Mano Fragment | 3 | - | **3** |
| Undetermined Metate Fragment | 1 | 3 | **4** |
| Undetermined Ground Stone Fragment | 11 | 7 | **18** |
| **Total** | **18** | **10** | **27** |

## Analytical Methods

Analysis of ground stone was conducted using the *Groundstone Analysis: A Technological Approach to Groundstone Analysis 2nd Edition* by Jenny L. Adams (2014). Using Adam's approach, ground stone was generally determined according to the type, design, manufacturing, and number of grinding surfaces present of each artifact. Other identifiable data analyzed and considered for the ground stone artifacts in this analysis included material type, completeness, texture of material (i.e. fine, medium, coarse, conglomerate), surface morphology, grinding wear (i.e. light, moderate, heavy), grinding wear type (i.e. ground, pecked, polished, incised), and stroke (i.e. flat, rocking, chopping, pecking, scraping). All artifacts were measured and their length, width, and thickness recorded. The two types of ground stone considered here are manos and metates.

Manos are generally understood to be stone objects that are held and utilized during a grinding or milling process (Lister et al. 1960: 100; Adams 2014). In this analysis, manos were divided into two basic morphological categories: single hand and two hand. Two hand manos were further divided into smaller categories based upon the number of grinding surfaces (1, 2, or 3) that they possessed. Single hand manos were recorded as having either one or two grinding surfaces.

Metates are generally large slabs of stone to which the manos are applied during the milling process (Lister et al. 1960: 98; Adams 2014). In this analysis, metates were here divided into four morphological categories: basin metates, slab metates, trough metates, and trough metates without a secondary shelf (i.e. Utah Metates).

## Results

As stated above, 27 pieces of ground stone were identified and analyzed on sites 42KA3077 and 42KA3097 (42KA3077 n=15, 42KA3097 n=12) during the Tier I mitigation of the NPLA. Of these, five were typed as mano fragments, four as metate fragments, and 18 ground stone fragments for which a type could not be accurately identified. All 27 fragments were located on

the surface of the sites and made from either quartzite or sandstone material. Analysis of ground stone was performed by Samira Z. Hall of Bighorn.

***42KA3077***

Surface collection and testing on site 42KA3077 resulted in the identification and subsequent analysis of 15 pieces of ground stone (Table 11.2).

**Table 11.2. Ground stone from site 42KA3077**

| Artifact Type | Quartzite | Sandstone | Total |
|---|---|---|---|
| Undetermined Mano Fragment | 1 | 2 | **3** |
| Undetermined Metate Fragment | 1 | 2 | **3** |
| Undetermined Ground Stone Fragment | 9 | - | **9** |
| **Total** | **11** | **4** | **15** |

Of the 15 pieces of ground stone, three were mano fragments, three were metate fragments, and nine were undetermined ground stone fragments (Table 11.2). One of the three mano fragments was made from fine textured, red quartzite while the other two were made from a dense, coarse textured tan sandstone material. All three mano fragments exhibited grinding ware on only one surface. None of the three mano fragment's morphological category could be accurately determined due to the way in which each was fragmented. Two of the three metate fragments were made from a dense, fine grained tannish-red sandstone material, while the third fragment was made from a dense, medium grained gray quartzite material. One of the two sandstone metate fragments and the quartzite metate fragment exhibited grinding wear on two surfaces while the remaining fragment only had grinding ware on one surface. Much like the mano fragments on this site, none of the three metate fragments could be identified as to type (i.e. trough or slab) due to their extremely fragmented state. The nine remaining ground stone fragments, whose type could not be accurately identified due to the severity of their fracturing, were all made from quartzite material of varying color and texture. Two of the nine fragments exhibited grinding wear on two surfaces, while the remaining seven contained grinding wear on only one surface (Figures 11.1-11.9).

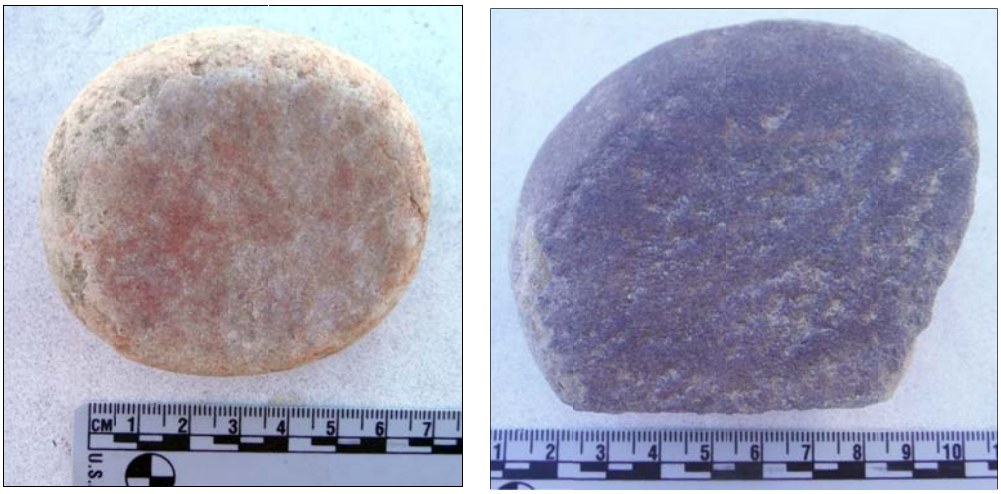


**Figure 11.1. Quartzite mano & sandstone mano fragment**

**Figure 11.2. Sandstone mano fragment & sandstone metate fragment**

**Figure 11.3. Quartzite metate fragment**

**Figure 11.4. Quartzite metate fragment**

**Figure 11.5. Quartzite ground stone fragments**

**Figure 11.6. Quartzite ground stone fragments**

**Figure 11.7. Quartzite ground stone fragments**

**Figure 11.8. Quartzite ground stone fragments**

**Figure 11.9. Quartzite ground stone fragment**

***42KA3097***

Surface collection and testing on site 42KA3097 resulted in the identification and subsequent analysis of 12 pieces of ground stone (Table 11.3).

**Table 11.3. Ground stone from site 42KA3097**

| Artifact Type | Quartzite | Sandstone | Total |
|---|---|---|---|
| Single hand Mano Fragment | 2 | - | **2** |
| Undetermined Metate Fragment | - | 1 | **1** |
| Undetermined Ground Stone Fragment | 2 | 7 | **9** |
| **Total** | **4** | **8** | **12** |

Of the 12 pieces of ground stone two were single hand mano fragments, one was a metate fragment, and nine were undetermined ground stone fragments (Table 11.3, Figures 11.10-11.13). Both single hand mano fragments were made from fine grained, tan quartzite and exhibited grinding ware on only one surface. The only metate fragment identified was made

from a dense, fine grained tan sandstone material. This fragment exhibited grinding wear on two surfaces. The exact metate type (i.e. trough or slab) could not be determined due to the fragmented state in which it was in. The nine remaining ground stone fragments, whose type could not be accurately identified due to the severity of their fracturing, were all made from either sandstone or quartzite material (seven sandstone and two quartzite) of varying color and texture. All nine of the undetermined ground stone fragments exhibited grinding wear on only one surface.

**Figure 11.10. Quartzite mano fragments**

**Figure 11.11. Sandstone metate fragment & quartzite ground stone fragment**

## Summary

A total of 27 ground stone artifacts were identified and analyzed from sites 42KA3077 and 42KA3097 during the Tier I mitigation of the NPLA. Of these artifacts, four were typed as metate fragments, five as mano fragments, and 18 were typed as undetermined ground stone fragments due to the way in which each had fragmented. The presence of ground stone material in the form of both manos and metates on sites 42KA3077 and 42KA3097 suggests that processing activities took place on both sites. It can be further inferred that most likely gathering

activities of the readily available natural resources nearby also took place here, resulting in the need for ground stone material on both sites. This extrapolation may help in better understating the site as a whole and adding to the interpretation of the sites overall function.

**Figure 11.12. Sandstone ground stone fragments**

**Figure 11.13. Ground stone fragments**

# Chapter 12: Historic Artifacts

A number of historic artifacts were encountered during the Tier I mitigation within the NPLA and are discussed below (see Figures 13.1-13.2 for locations).

***42KA3077***

The intensive surface inventory across site 42KA3077 within the NPLA resulted in the identification of a small clear glass medicinal(?) bottle with T.C. Wheaton, Co. trademark consisting of a "W" within a circle (Toulouse 1972; since 1946). No additional historic artifacts were encountered in the vicinity of this site.

**Figure 12.1. Clear glass medicinal(?) bottle from 42KA3077**

***42KA3097***

The intensive surface inventory across site 42KA3097 identified three loci of historic artifacts to the west of the historic county road alignment. The northern loci consisted of a loose grouping of four amethyst, three aqua, and five clear bottle glass fragments. All of the fragments were body shards. The second loci included a single white opal glass jar body fragment. Finally, the southern loci was composed of a loose grouping of three aqua, two cobalt blue, four clear, and one seafoam green opal glass fragment. All of these glass fragments were again body shards from bottles, with the exception of the seafoam green, which appeared to be from a decorative container. Both the northern and southern loci appear to represent small dumping episodes off of the county road by local residents of Alton, and both have been disturbed by agricultural plowing as the artifacts were scattered. The presence of the amethyst and aqua bottle glass suggests dating prior to 1924 while the clear glass is associated with use after that time frame.

# Chapter 13: Discussion & Conclusions

The Tier I investigations on sites 42KA3077 and 42KA3097 were designed to answer questions posited in the research design that deal with the themes of chronology and cultural affiliation, subsistence, site function and organization, and seasonality and mobility as they pertain to these site's prehistoric occupants. The Tier I mitigation at these sites provided some answers to the research questions, adding information to the database of tested archaeological sites in Kane County, Utah.

Bighorn completed the Tier I mitigation for the NPLA on behalf of Alton Coal. This mitigation included a surface inventory for the two prehistoric eligible sites 42KA3097 and 42KA3077, the placement of shovel probes in both sites and a test unit in 42KA3077. The remaining eligible site 42KA6081 was barricaded and monitored during construction activities.

The testing revealed little subsurface cultural material and no intact subsurface features. The possible structure identified on 42KA3077 was mapped and tested. The feature was deflated and with no floor zone and only one artifact recovered. It had also been severely impacted by cattle. The structure appeared to be a small wickup or pithouse with an ancillary storage cist.

The historic utilization of the area is represented by the presence of the historic county road alignment that linked the community of Alton to Kanab as well as several glass artifacts associated with farming and ranching that has taken place in the area over the years.

No further mitigation work was conducted nor is recommended for sites 42KA3077 and 42KA3097 beyond monitoring of initial ground disturbing activities.

**Research Themes**

***Chronology & Cultural Affiliation***

Chronologies of the sites were established using radiocarbon samples, obsidian hydration analysis, and cross dating of diagnostic artifacts. These dating methods indicated occupation of the sites during the Archaic, Formative, and Late Prehistoric periods.

*42KA3077*

<u>Obsidian Hydration</u>

xxxxxx

<u>Cross-Dating</u>

The projectile points collected from site 42KA3077 include a complete Desert Side-notched point, two Elko Corner-notched, and a Gypsum Contracting Stem point fragment. These point types indicate utilization of the site during both the Archaic and Late Prehistoric periods.

Ceramic shreds collected from the site include Southern Paiute Brown Ware, which further supports a Late Prehistoric use for the site.

*42KA3097*

Obsidian Hydration

xxxxxx

Cross-Dating

The projectile points collected from site 42KA3097 include an Elko Eared point fragment, two Elko Corner-notched point fragments, an Elko Side-notched point fragment, two Northern Side-notched point fragments, a Sudden Side-notched point fragment, a Gatecliff Contracting Stem point fragment, a Rose Spring Corner-notched point fragment, and an unclassified point fragment. These projectile point types indicate utilization of the site during both the Archaic and Formative periods. Ceramic shreds collected from the site include Southern Paiute Brown Ware and Snake Valley Grayware, which further supports a Southern Paiute a Late Prehistoric use of the site.

***Subsistence***

No intact features were encountered during the Tier I mitigation of sites 42KA3077 and 42KA3097 within the NPLA, thus no flotation or pollen samples were processed for subsistence data and no faunal remains were recovered. However, the recovery of lithic tools from both sites suggests the inhabitants of the sites were likely involved in hunting of local game as well as processing of locally available wild plant resources in the area.

**Site Extent, Function & Organization**

*42KA3077*

An intensive surface examination of site 42KA3077 found that it has been impacted over the years by ranching and tree removal activities which have likely altered the distribution of artifacts somewhat as well as the integrity of any shallow cultural features. This intensive survey across site within the NPLA found that the majority of artifacts were present along a ridgeline and off its southern slope. The site boundary established in 2005 encompassed the heart of the site, however some material was present extending to the south along the ridge and along its slopes, including the location of Features 1 and 2, as well as to the northeast, and a few artifacts off the western ridgeline slope (Figure 13.1).

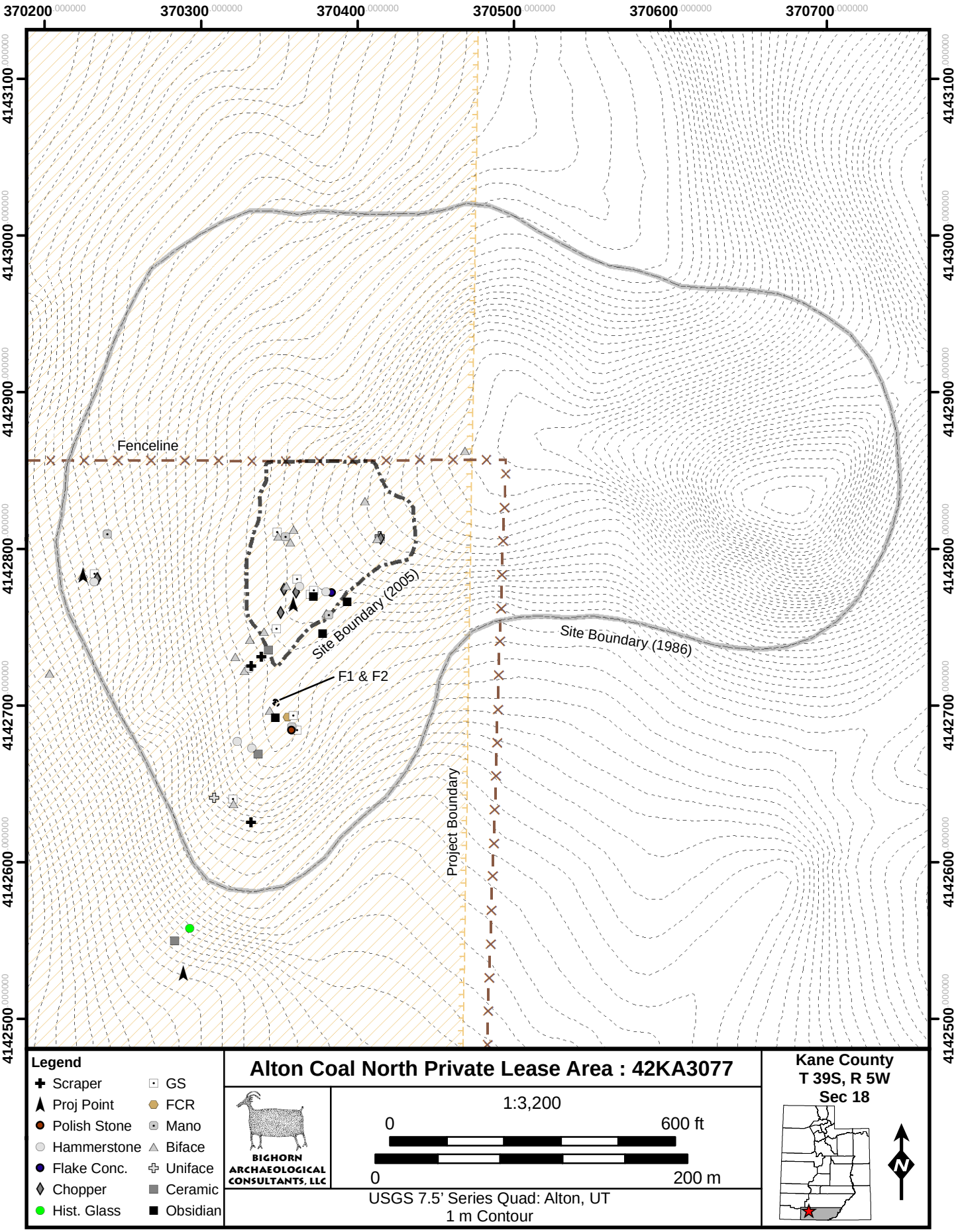



Figure 13.1. Significant artifact distribution across site 42KA3077

Testing of the site suggested that cultural materials were relegated primarily to the surface of the site, with only nine STPs indicating shallow subsurface materials that were limited to the upper 20 cm of soil. Three of these STPs indicated possible deflated thermal features that were limited to a few FCR fragments only, while a grouping of three STPs showed evidence of shallow soil staining that may represent another deflated thermal feature or use surface. Test Unit 1 indicated that Features 1 and 2 represented the shallow, deflated remains of what appeared to be a rock lined pithouse or wickiup with internal rock lined storage cist. These features were also relegated to the upper 20 cm of soil and have been severely impacted by cattle.

The discovery of a deflated wickiup or pithouse feature on the edge of the ridgeline suggests that at least some longer term occupation occurred on the site. Some evidence of deflated hearth features was also encountered suggesting possible shorter duration camping as well. The types of artifacts recovered indicate that final production of tools and/or retooling occurred onsite, and that hunting and processing of locally available plant materials were also likely important activities. Diagnostic artifacts collected suggest utilization during the Archaic and Late Prehistoric periods.

*42KA3097*

An intensive surface examination of site 42KA3097 within and around the NPLA found it to have been impacted by agricultural use over the years to include plowing and tree removal Activities that have altered the distribution and presence of artifacts, as well as the integrity of any cultural features that may have originally be present. Results of the surface examination found the site boundaries established in 2005 to be fairly accurate, with only a few artifacts identified beyond that boundary (Figure 13.2).

Testing revealed that the plow zone across the site extended to a depth of about 10 cm below the surface. Of the 62 STPs excavated across the site area, none resulted in materials recovered subsurface. The types of artifacts recovered from the surface indicate that final production of tools and/or retooling occurred onsite, and that hunting and processing of locally available plant materials were also likely important activities. Diagnostic artifacts collected suggest utilization during the Archaic, Formative, and Late Prehistoric periods.

***Seasonality & Mobility***

No information can be inferred about seasonality of use for the sites as indicators for such were not recovered.

Obsidian sourcing revealed that the groups utilizing the sites obtained the resource from the Panaca Summit and Wild Horse Canyon source areas, as well as an unknown source area. The two known sources are located approximately 70 and 100 miles to the west-northwest, suggesting either fairly long distance trade with other groups direct resource exploitation. No other exotic materials were recovered from the sites, with ceramic vessels all being local varieties.

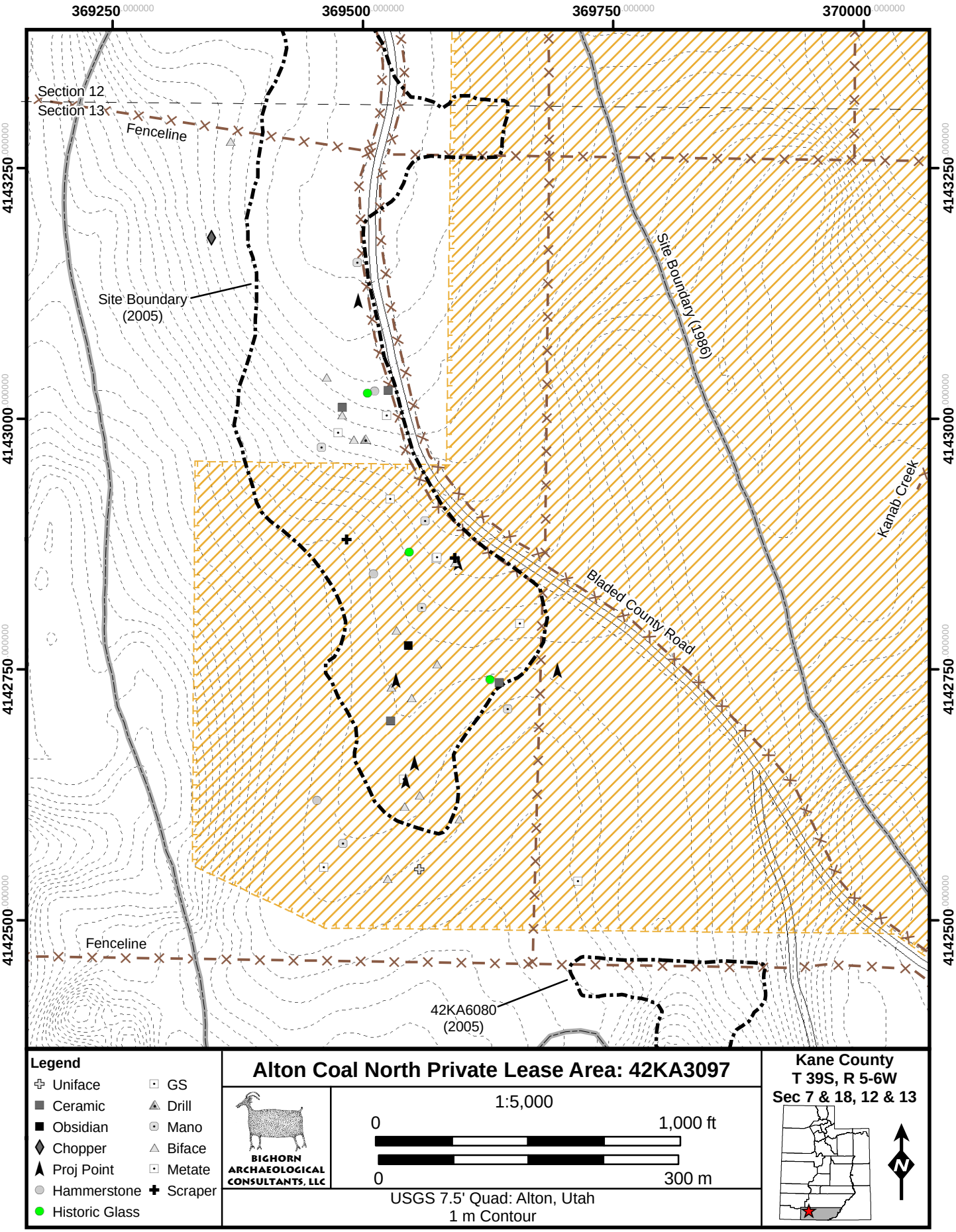



Figure 13.2. Significant artifact distribution across site 42KA3097

# References Cited

Adams, Jenny, L
1996 *Manual for a Technological Approach to Ground Stone Analysis.* Center for Desert Archaeology, Tucson, Arizona.

Agenbroad, L. D., J. I. Mead, E. D. Mead, and D. Elder
1989 Archaeology, Alluvium, and Cave Stratigraphy: The Record from Bechan Cave, Utah. *Kiva* 54:335-351.

Ahlstrom, Richard V. N. (editor)
2000 *Pithouse Excavations at the Park Wash Site (42KA4280) Grand Staircase-Escalante National Monument South Central Utah*. HRA Papers in Archaeology No. 1., HRA, Inc., Las Vegas, Nevada.

Aikens, C. M.
1965 *Excavations in Southwest Utah.* Anthropological Papers No. 76, University of Utah, Salt Lake City, Utah.

1966 *Virgin-Kayenta Cultural Relationships*. Anthropological Papers No. 79. University of Utah, Salt Lake City, Utah.

1970 *Hogup Cave.* Anthropological Papers No. 93, University of Utah, Salt Lake City, Utah.

Alder, Douglas D., and Karl F. Brooks
1996 *A History of Washington County*. Utah Centennial County History Series. Utah State Historical Society, Salt Lake City, Utah.

Allison, James R.
1988a *The Archaeology of Yellowstone Mesa, Mohave County, Arizona.* Museum of Peoples and Cultures, Technical Series No. 88-24, Brigham Young University, Provo, Utah.

1988b *Late Prehistoric Subsistence Practices in the Virgin River Drainage*. Paper Presented at the Great Basin Anthropological Conference, Park City, Utah.

Altschul, Jeffrey H., and Helen C. Fairley
1989 *Man, Models, and Management: An Overview of the Archaeology of the Arizona Strip and the Management of its Resources*. Report submitted to the USDA Forest Service and the USDI Bureau of Land Management by Statistical Research, Plateau Archaeology, and Dames and Moore, Salt Lake City, Utah.

Ambler, J. R.
1996 Dust Devil Cave and Archaic Complexes of the Glen Canyon Area. In *Glen Canyon Revisited.* Edited by P. R. Geib, p. 40-52, Anthropological Paper No. 119, University of Utah, Salt Lake City, Utah.

Andresfsky, William
1998 *Lithics, Macroscopic Approaches to Analysis.* Cambridge University Press, Cambridge.

Antevs., E.
1948 Climatic Changes and Pre-White Man. In *The Great Basin: With Emphasis on Glacial and Post Glacial Times.* Bulletin of the University of Utah Vol.38, No. 20 Biological Series 10(7):168-191, Salt Lake City, Utah.

Baldwin, Gordon C.
1950 The Pottery of the Southern Paiute. In *American Antiquity* 16:50-56.

Berry, C. F. and M. S. Berry
1986 Chronological and Conceptual Models of the Southwestern Archaic. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings.* Edited by C. J. Condie and Donald D. Fowler, p. 252-327, Anthropological Papers No. 110. University of Utah Press, Salt Lake City, Utah.

Billat, Lorna B., James D. Wilde, and Richard K. Talbot
1992 *Archaeological Testing and Excavation of Five Western Anasazi Sites along State Route 9, East of Virgin City, Utah.* Museum of Peoples and Cultures Technical Series 90-20, Office of Public Archaeology, Brigham Young University, Provo, Utah.

Bradley, Martha Sonntag
1999 *A History of Kane County*. Utah Centennial County History Series. Utah State Historical Society, Salt Lake City, Utah.

Buck, Paul E., and Laureen Perry
1999 *A Late Basketmaker III Storage and Habitation Site near Hurricane, Utah. Kiva* 64(4):471–494.

Cody, B. P.
1942 Simply Strung on a Single Strand. *Masterkey* 16:175-176.

Copeland , J. M., and R. E. Fike
1988 Fluted Projectile Points in Utah. *Utah Archaeology* 1(1):5-28.

Dalley, Gardiner F., and Douglas A. McFadden
1985 *The Archaeology of the Red Cliffs Site.* Cultural Resource Series No. 17, Utah State Office, Bureau of Land Management, Department of the Interior, Washington D. C.

1988 *The Little Man Sites: Excavations on the Virgin River Near Hurricane, Utah.* Cultural Resource Series No.23, Utah State Office, Bureau of Land Management, Washington D.C.

Davis, William E.
1985 The Montgomery Folsom Site. *Current Research in the Pleistocene* 2:11-12.

1989 The Lime Ridge Clovis Site. *Utah Archaeology* 2(1):66-76.

Davis, William E., D. Sack, and N. Shearin
1996 The Hell'n Moriah Clovis Site. *Utah Archaeology* 9(1):55-70.

Davis, William E., Mark C. Bond, J. D. Till, and D. A. Westfall
1998 *Archaeological Investigations in the DTX Tract 10 Project Area, Washington County, Utah.* Abajo Archaeology, Bluff, Utah.

Edgar, Heather Joy Hecht
1994 *Osteology and Odontology of Basketmaker II Virgin Anasazi from Kane County, Utah*. Unpublished Master's Thesis, Arizona State University, Tempe, Arizona.

Effland, Richard W., Jr., A. Trinkle Jones, and Robert C. Euler
1981 *The Archaeology of Powell Plateau: Regional Interaction at Grand Canyon*. Monograph No. 3. Grand Canyon Natural History Association, Grand Canyon, Arizona.

Elson, Mark D., and Jeffery J. Clark (Editors)
1995 *The Roosevelt Community Development Study, Vol 1: Stone and Shell Artifacts*. Anthropological Papers 14(1). Center for Desert Archaeology, Tucson, Arizona.

Euler, Robert C., and Susan Chandler
1978 Aspects of Prehistoric Settlement Patterns in Grand Canyon. In *Investigations of the Southwestern Anthropological Research Group: An Experiment in Archaeological Cooperation*, edited by Robert C. Euler and George J. Gumerman, pp. 73–86. Museum of Northern Arizona, Flagstaff, Arizona.

Euler, Robert C., A. Trinkle Jones, Richard W. Effland, and Susan M. Chandler
1979 The Colorado Plateaus: Cultural Dynamics and Paleoenvironment. *Science* 205:1089–1101.

Fiedel, S. J.
1999 Older than We Thought: Implications of Corrected Dates for Paleoindians. *American Antiquity* 64(1):95-115.

Fowler, Donald D., David B. Madsen, and E. M. Hattori
1973 *Prehistory of Southeastern Nevada.* Publications in the Social Sciences No. 6, Desert Research Institute, University of Nevada, Reno, Nevada.

General Land Office (GLO)
1877a *Survey plat of Township 39 South, Range 5 West, Salt Lake Meridian*, prepared by J. G. Burril. US Surveyor General's Office, Salt Lake City, Utah. US Department of the Interior, Bureau of Land Management, Utah Land Records.

1877b *Survey plat of Township 41 South, Range 4.5 West, Salt Lake Meridian*, prepared by J. G. Burril. US Surveyor General's Office, Salt Lake City, Utah. US Department of the Interior, Bureau of Land Management, Utah Land Records.

1885 *Survey plat of Township 41 South, Range 5 West, Salt Lake Meridian*, prepared by Shadrach M. Richardson. US Surveyor General's Office, Salt Lake City, Utah. US Department of the Interior, Bureau of Land Management, Utah Land Records

Geib, Phil R.
1996 *Glen Canyon Revisited.* Anthropological Paper No. 119, University of Utah, Salt Lake City, Utah.

Geib, Phil R., and D. Davidson
1993 Anasazi Origins: A Perspective from Preliminary Work at Old Man Cave. *Kiva* 60:191-202.

Geib, Phil R., N. J. Coulam, K. A. Hays-Gilpin, and V. H. Clark
1996 *Atlatl Rock Cave*. Manuscript On file, Navajo Nation Archaeology Department, Northern Arizona University Branch Office, Flagstaff, Arizona.

Geib, Phil R., Jim H. Collette, and Kimberly Spurr
2001 *Kaibabitsinungwu: An Archaeological Sample Survey of the Kaiparowits Plateau*. Cultural Resource Series No. 25. Grand Staircase-Escalante National Monument Special Publication No. 1. Bureau of Land Management, Salt Lake City, Utah.

Gourley, Dale R.
2003 *A Cultural Resource Inventory of the Proposed Leucadia Access Road Corridor in Washington County, Utah.* Research Report No. 03-34, Baseline Data, Inc. American Fork, Utah.

2016a *Archaeological Monitoring & Historic Properties Treatment Plan for the Alton Coal North Private Lease Area, Kane County, Utah.* Report Number 15-44. Bighorn Archaeological Consultants, LLC, Santa Clara, Utah.

2016b *Preliminary Report on the Tier I Testing of Site 42KA3097 & Historic Road Reconnaissance within the Alton Coal North Private Lease Area, Kane County, Utah*. Bighorn Archaeological Consultants, LLC, Santa Clara, Utah.

2017 *Preliminary Report on the Tier I Testing of Site 42KA3077 within the Alton Coal North Private Lease Area, Kane County, Utah*. Bighorn Archaeological Consultants, LLC, Santa Clara, Utah.

Gourley, Dale R., and Robert B. Nash
2013 *Archaeological Testing & Data Recovery on the Washington Fault Site (42WS5277) for the Southern Parkway, Phase 3 Geotechnical Testing Project in Washington County, Utah*. Report Number 10-71. Bighorn Archaeological Consultants, LLC, Santa Clara, Utah.

Gourley, Dale R., Zachary T. Revene, and Robert B. Nash
2009 *Results of the Phase I Site Testing at 42WS479 along the Rio Virgin Bloomington to Beaver Dam Fiber-optic Corridor, Washington County, Utah*. Report Number 08-45. Bighorn Archaeological Consultants, LLC, Santa Clara, Utah.

Gourley, Dale R., Robert B. Nash, Jim Christensen, and Syanna Tefteller (Editors)
2010 *Data Recovery Investigations on Six Archaeological Sites along Fort Pearce Wash, Washington County, Utah* . Report Number 05-25. Bighorn Archaeological Consultants, LLC, Santa Clara, Utah.

Gregg, Susan A.
1988 *Foragers and Farmers: Population Interaction and Agricultural Expansion in Prehistoric Europe*. University of Chicago Press, Chicago, Illinois.

Gumerman, George J.
1965 *Highway Salvage Job 1964-9, 1965-23,28*. Museum of Northern Arizona, Flagstaff, Arizona.

Gunnerson, J. H.
1956 A Fluted Point Site in Utah. *American Antiquity* 21(4):412-414.

Halbirt, Carl D. and C. A. Gualtieri
1981 *Archaeological Investigations Utah International, Inc., San Francisco, Alton Coal Field Survey, Federal, State, and Private Lands, Kane County, Utah*. U81-NI-0254. Museum of Northern Arizona, Department of Archaeology, Flagstaff, Arizona.

Harrington, M. R.
1937 Some Early Pit Dwellings in Nevada. *Masterkey* 11:122-124.

1942 Black Dog Cave. *Masterkey* 16:173-174.

Heid, James L.
1982 *Settlement Patterns on Little Creek Mountain, Utah*. University of Nevada, Las Vegas, Nevada.

Heizer, R.F., and T.R. Hester
1978 Great Basin. In *Chronologies in New World Archaeology*. Edited by R.E. Taylor and C.W. Meighan, pp. 147-199. Academic Press, New York, New York.

Holmer, Richard N.
1978 *Mathmatical Typology for Archaic Projectile Points of the Eastern Great Basin*. Ph.D. dissertation, Department of Anthropology, University of Utah, Salt Lake City, Utah.

Holmer, Richard N., and Dennis G. Weder
1980 Common Post-Archaic Projectile Points of the Fremont Area. In *Fremont Perspectives*, edited by David B. Madsen, pp. 55-68. Antiquities Section Selected Papers No. 16. Utah State Historical Society, Salt Lake City, Utah.

Janetski, Joel C.
2001 Late Paleoindian Artifacts from Utah Valley. *Utah Archaeology* 14(1):15-26.

Janetski, Joel C., and James D. Wilde
1989 A Preliminary Report of Archaeological Excavations at Antelope Cave and Rock Canyon Shelter, Northwestern Arizona. *Utah Archaeology* 1989 2(1):88–106.

Janetski, Joel C., and M. J. Hall
1983 *An Archaeological and Geological Assessment of Antelope Cave (NA5507), Mohave County, Northwestern Arizona.* Cultural Resource Management Services, Department of Anthropology, Brigham Young University, Provo, Utah.

Jennings, Jesse D.
1957 *Danger Cave.* Anthropological Paper No. 27, University of Utah, Salt Lake City, Utah.

1980 *Cowboy Cave.* Anthropological Paper No. 104, University of Utah, Salt Lake City, Utah.

Jones, Anne Trinkle
1986 *A Cross Section of Grand Canyon Archaeology: Excavations at Five Sites along the Colorado River*. Western Archaeological and Conservation Center Publications in Anthropology No. 28. Tucson, Arizona.

Jones, Kevin T., and James F. O'Connell
1981 *Preliminary Report: Archaeological Research at Nawthis Village, 1980*. University of Utah Archaeological Center Reports of Investigations No. 81-4. Salt Lake City, Utah.

Judd, N. M.
1926 *Archaeological Observations North of the Rio Colorado.* Bureau of American Ethnology, Bulletin No. 82, Washington D. C.

Justice, Noel
2002a *Stone Age Spear and Arrow Points of the Southwestern United States.* Indiana University Press, Indiana.

2002b *Stone Age Spear and Arrow Points of California and the Great Basin.* Indiana University Press, Indiana.

Keller, D.R.
1987 *A Report of Archaeological Resources on the Alton Coal Project*. Museum of Northern Arizona, Flagstaff, Arizona.

Kelly, I. T.
*1964* *Southern Paiute Ethnography*. University of Utah Anthropological Papers No. 69, Glen Canyon Series No. 21. University of Utah Press, Salt Lake City, Utah.

Kohl, R. B.
1991 Fluted Projectile Points in Southwestern Utah. *Utah Archaeology* 4(1):79-83.

Lamb, S. M.
1958 Linguistic Prehistory in the Great Basin. *International Journal of American Linguistics* 24(2):95-100.

Lister, R.H., J.R. Amblin, and F.C. Lister
1960 *The Coombs Site, Part II*. Anthropological Papers No. 41. University of Utah Press, Salt Lake City, Utah.

Lyneis, Margaret M.
1992 *The Main Ridge Community at Lost City: Virgin Anasazi Architecture, Ceramics and Burials.* Anthropological Papers No. 117, University of Utah, Salt Lake City, Utah.

1994 Ceramics. In *Kern River Pipeline Cultural Resources Data Recovery Report: Utah, Vol. 1, Research Context and Data Analysis*. Dames and Moore, Las Vegas, Nevada.

1995 The Virgin Anasazi, Far Western Puebloans. *Journal of World Prehistory* 9(2):199-241.

Madsen, David B.
1980 *Fremont Perspectives*. Antiquities Section Selected Papers 7(16). Utah Division of State History, Salt Lake City, Utah.

1986 Prehistoric Ceramics. In *Great Basin*, edited by Warren d'Azevedo, pp. 206-214. Handbook of North American Indians, vol. 11, William C. Sturtevant, general editor. Smithsonian Institution, Washington D.C.

1989 *Exploring the Fremont*. Utah Museum of Natural History, Salt Lake City, Utah.

Madsen, David B., and LaMar Lindsay
1977 *Backhoe Village*. Antiquities Section Selected Papers No. 12. Utah Division of State History, Salt Lake City, Utah.

Madsen, David B., and Steven R. Simms
1998 *The Fremont Complex: A Behavioral Perspective*. Journal of World Prehistory, 12(3): 255-336.

Madsen, Rex E.
1977 Prehistoric Ceramics of the Fremont. In *Museum of Northern Arizona Ceramic Series 6*. Flagstaff, Arizona.

Marwitt, John P.
1968 *Pharo Village*. University of Utah Anthropological Papers No. 91, Salt Lake City, Utah.

McAvoy, J. M., and L. D. McAvoy
1997 *Archaeological Investigations of Site 44SX202, Cactus Hill, Sussex County, Virginia.* Research Report Series No. 8, Virginia Department of Historic Resources, Richmond, Virginia.

McDonald, Elizabeth Kae
1994 *A Spatial and Temporal Examination of Prehistoric Interaction in the Eastern Great Basin and on the Northern Colorado Plateau*. Unpublished PhD dissertation, University of Colorado, Boulder, Colorado.

McFadden, Douglas A.
1994 *Virgin Anasazi Settlement on the Grand Staircase.* Paper presented at the Western Anasazi Symposium, Utah Professional Archaeological Council, Cedar City, Utah.

2000 *Formative Chronology and Site Distribution on the Grand Staircase-Escalante National Monument* (DRAFT). Manuscript on file, Grand Staircase-Escalante National Monument, Bureau of Land Management, Kanab, Utah.

Metcalfe, Duncan
1981 Charles B. Hunt Site. In *Bull Creek*, by Jesse D. Jennings and Dorothy Sammons-Lohse, pp. 48–52. Anthropological Papers No. 105. University of Utah, Salt Lake City, Utah.

Miller, B. A.
1978 Archaeological Survey of Sullivan Canyon and Adjacent Areas, Mohave County, Arizona. *Western Anasazi Reports* 1:33-54.

Moffitt, K., S. Rayl, and M. Metcalf
1978 *Archaeological Investigations along the Navajo-McCullough Transmission Line, Southern Utah and Northern Arizona.* Museum of Northern Arizona, Flagstaff, Arizona.

Mueller, J. W., G. J. Staley, G. G. Harrison, R. W. Ralph, C. A. Sartwell and R. P. Gauthier
1968 *Paria Plateau Survey Report, 1968 Season.* Manuscript on file, Museum of Northern Arizona, Flagstaff, Arizona.

Museum of Northern Arizona (MNA)
1986a IMACS Site Form for 42KA3077. Site files, Utah Division of State History, Antiquities Section, Salt Lake City, Utah.

1986b IMACS Site Form for 42KA3097. Site files, Utah Division of State History, Antiquities Section, Salt Lake City, Utah.

Neff, H., D.O. Larson, and M.D. Glascock
1997 The Evolution of Anasazi Ceramic Production and Distribution: Compositional Evidence from a Pueblo II Site in South-Central Utah. *Journal of Field Archaeology 24:473-492.*

Nickens, Paul R,. and Kenneth L. Kvamme
1981 *Archaeological Investigations at the Kanab Site, Kane County, Utah*. Nickens and Associates, Montrose, Colorado.

Nielson, Asa S.
1978 *Proposed Subsistence Models for the Sevier Culture, Sevier River Drainage, West-Central Utah*. Unpublished Master's Thesis, Brigham Young University, Provo, Utah.

1998 *Excavation/Mitigation of Three Sites near Hildale, Utah: 42Ws2195 42Ws2196, AZ B:1:35(BLM) (Reservoir Site).* Research Report No. U98-8. Baseline Data, Inc., Orem, Utah.

Nusbaum, J. L.
1922 *A Basket Maker Cave in Kane County, Utah.* Indian Notes and Mongraphs, Miscellaneous Series No. 29, Museum of the American Indian, Heye Foundation, New York, New York.

Schleisman, Dean, and Asa S. Nielson
1988 *Archaeological Excavations at Hog Canyon Dune (Site 42Ka 2574), Hog Creek Canyon, Kane County, Utah*. Museum of Peoples and Cultures Technical Series No. 87-26. Brigham Young University, Provo, Utah.

Schroeder, A. H.
1953 A Few Sites in the Moapa Valley, Nevada. *Masterkey* 27:18-24, 62-68.

1955 *Archaeology of Zion Park.* Anthropological Papers No. 22, University of Utah, Salt Lake City, Utah.

Schwartz, Douglas W., Richard C. Chapman, and Jane Kepp
1980 *Archaeology of the Grand Canyon: Unkar Delta*. Grand Canyon Archaeology Series No. 2. School of American Research, Santa Fe, New Mexico.

Schwartz, Douglas W., Jane Kepp, and Richard C. Chapman
1981 *Archaeology of the Grand Canyon: The Walhalla Plateau*. Grand Canyon Archaeology Series No. 3. School of American Research, Santa Fe, New Mexico.

Sharrock, F. W.
1964 *1962 Excavations, Glen Canyon Area.* Anthropological Papers No. 73, University of Utah, Salt Lake City, Utah.

Shutler, R.
1961 *Lost City, Pueblo Grande de Nevada.* Nevada State Museum Anthropological Papers No. 5, Carson City, Nevada.

Simms, Steven R.
1986 New Evidence for Fremont Adaptive Diversity. *Journal of California and Great Basin Anthropology* 8:204-216.

Simms, Steven R., and L. W. Lindsay
1989 42MD300: An Early Holocene Site in the Sevier Desert. *Utah Archaeology* 2(1):56-66.

Soil Conservation Service (SCS)
1938 *Photomap_U335*, "BPI" Virgin River Area Quad 9, Johnson 2. US Department of Agriculture, Soil Conservation Service. Utah Automated Geographic Reference Center, Salt Lake City, Utah.

Soule, E. C.
1975 Lost City Revisited. *The Masterkey* 49:4-19.

Spielmann, Katherine A.
1986 Interdependence among Egalitarian Societies. *Journal of Anthropological Archaeology* 5:279-312.

1991a *Farmers, Hunters, and Colonists: Interaction Between the Southwest and the Southern Plains*. University of Arizona Press, Tucson, Arizona.

1991b *Interdependence in the Protohistoric Southwest: An Ecological Analysis of Plains-Pueblo Interaction*. Garland, New York, New York.

Spielmann, Katherine A., and James F. Eder
1994 Hunters and Farmers: Then and Now. *Annual Review of Anthropology* 23:303-323.

Stavish, Patricia
2007 *Cultural Resource Inventory of Alton Coal Development's Project Area, Kane County, Utah*. Montgomery Archaeological Consultants, Moab, Utah.

Talbot, Richard K., and James D. Wilde
1989 Giving Form to the Formative: Shifting Settlement Patterns in the Eastern Great Basin and Northern Colorado Plateau. *Utah Archaeology* 2(1):3-18.

Talbot, Richard K., and Lane D. Richens
2009 *Shifting Sands: The Archaeology of Sand Hollow*. Occasional Paper No. 13. Museum of Peoples and Cultures, Brigham Young University, Provo, Utah.

Talbot, Richard K., Lane D. Richens, James D. Wilde, Joel C. Janetski, and Deborah E. Newman
1995 *Clear Creek Archaeological Project, Volume 4: Excavations of Open Habitation Sites*. Museum of Peoples and Cultures Technical Series No. 95-8. Brigham Young University, Provo, Utah.

Talbot, Richard K., Lane D. Richens, James D. Wilde, Joel C. Janetski, and Deborah E. Newman
2000 *Excavations at Five Finger Ridge, Clear Creek Canyon, Central Utah*. Museum of Peoples and Cultures Occasional Papers No. 5, pp. 429, Brigham Young University, Provo, Utah.

Thompson, Richard A.
1971 Prehistoric Settlement in the Grand Canyon National Monument. *Plateau* 44:67-71.

Thompson, Richard A., and G. B. Thompson
1974 *A Preliminary Report of Excavations in the Grand Canyon National Monument: Sites GC 670, GC 671, GC 663*. Manuscript on file, Grand Canyon National Park and Southern Utah State College, Cedar City, Utah.

1978 *The Little Jug Site: 1976-1977*. Manuscript on file, Grand Canyon National Park and Southern Utah State College, Cedar City, Utah.

Thornton, Meg, and Keith Montgomery
2005 *Cultural Resource Inventory of the Coal Hollow Project Coal Seam Drill Sites in the Alton Amphitheater, Kane County, Utah*. Montgomery Archaeological Consultants, Moab, Utah.

Tilton, Terry L.
2001 *Geological Map of the Alton Quadrangle, Kane County, Utah*. Miscellaneous Publication 01-4. Utah Geological Survey, Utah Department of Natural Resources, Salt Lake City, Utah.

Tipps, Betsy L.
1989 *Cultural Resource Investigations near Kanab, Utah: Excavation and Structural Stabilization at Cottonwood Canyon Cliff Dwelling.* Cultural Resources Report 421-1-8821, P-III Associates, Salt Lake City, Utah.

Toulouse, Julian Harrison
1972 *Bottle Makers and Their Marks*. Thomas Nelson, Inc., New York, New York.

Utah Professional Archaeological Council
2008 *Linear Sites: Guidance for Identifying and Recording under Section 106 of the National Historic Preservation Act*. Utah Professional Archaeological Council, Salt Lake City, Utah.

Wade, William D.
1967 *Archaeological Investigations in Northwestern Arizona.* Unpublished Manuscript, Museum of Northern Arizona, Flagstaff, Arizona.

Walling-Frank, Barbara
1998 AZ B:1:35(BLM): The Carling Reservoir Site. In, *Excavation/Mitigation Report. Three Sites near Hildale, Utah: 42Ws2195, 42Ws2196, AZ B:1:35(BLM) (Reservoir Site)*, compiled by Asa S. Nielson, pp. 6.1-6.90. Research Report 98-9. Baseline Data, Inc., Orem, Utah.

Walling, Barbara A., and Richard A. Thompson
2004 *Archaeology of the Dead Raven Site*. United States Department of the Interior, Bureau of Land Management, Salt Lake City, Utah.

Walling, Barbara A., Richard A. Thompson, Gardiner F. Dalley and Dennis Weder
1986 *Excavations at Quail Creek.* Cultural Resource Series No. 20, Utah State Office, Bureau of Land Management, Salt Lake City, Utah.

Watkins, Christopher N.
2009 Type, Series, and Ware: Characterizing Variability in Fremont Ceramics Temper. In *Journal of California and Great Basin Anthropology*, vol. 29, no. 2, pp. 145–162.

Wilde, James D. and Deborah E. Newman
1989 Late Archaic Corn in the Eastern Great Basin. *American Anthropologist* 91:712-720.

Weaver, Donald E., Jr.
1986 *Archaeological Investigations, Utah International, San Francisco Alton Coal Field Project, Bureau of Land Management Land, Cedar City District, and Private Land, Kane County, Utah*. Museum of Northern Arizona, Department of Anthropology, Flagstaff, Arizona.

Westfall, Deborah A.
1987 *The Pinenut Site: Virgin Anasazi Archaeology on the Kanab Plateau of Northwestern Arizona*. Cultural Resource Series Monograph No. 4. Arizona Office of the Bureau of Land Management, Phoenix, Arizona.

Westfall, Deborah A., William E. Davis, and Eric Blinman
1987 *Green Spring: An Anasazi and Southern Paiute Encampment in the St. George Basin of Utah.*Cultural Resource Series No. 21, USDI Bureau of Land Management, Salt Lake City, Utah.

Zweifel, Matthew, Derinna V. Kopp, and Ronald Rood
2006 The Tommy Turf Site 42KA6032: A Basketmaker II Burial from Kane County, Utah. *Archaeology: Learning from the Land*. Grand Staircase-Escalante National Monument Symposium Proceedings.

# Appendix A:
## Testing Results by Unit

**Table A.1. Shovel test pit & test unit results from site 42KA3077**

| STP # | Level | Excavation Depth | Soil Type | Artifacts/Materials Present |
|---|---|---|---|---|
| 1 | Surface | 0 cm | Brown (7.5YR 5/2) silty clay, 15% gravel | Pink quartzite polishing stone |
| | 1 | 0-10 cm | Brown (7.5YR 5/2) sandy clay, 45% gravel | - |
| | 2 | 10-20 cm | Brown (7.5YR 5/4) clay loam, 40% gravel | - |
| 2 | Surface | 0 cm | Brown (7.5YR 5/2) sandy clay, 5% gravel | Possible location of 1986 hearth area |
| | 1 | 0-10 cm | Dark brown (7.5YR 3/2) silty clay, <20% gravel | 10% FCR |
| | 2 | 10-20 cm | Dark brown (7.5YR 3/2) silty clay, 45% gravel, 25% large rocks | FCR |
| 3 | Surface | 0 cm | Brown (7.5YR 5/2) sandy clay, 10% cobbles | Possible location of 1986 hearth area |
| | 1 | 0-10 cm | Brown (7.5YR 5/2) sandy clay, 15% gravel | - |
| | 2 | 10-20 cm | Brown (7.5YR 5/2) sandy clay, 30% gravel | - |
| 4 | Surface | 0 cm | Brown (7.5YR 5/2) sandy clay, 20% gravel | Ceramic sherd |
| | 1 | 0-10 cm | Dark brown (7.5YR 3/2) sandy clay, 15% gravel | - |
| | 2 | 10-20 cm | Dark brown (7.5YR 3/2) sandy clay, 5% gravel | - |
| 5 | Surface | 0 cm | Strong brown (7.5YR 5/6) sand, 30% gravel | Possible location of 1986 hearth area |
| | 1 | 0-10 cm | Brown (7.5YR 5/2) sandy clay, 30% gravel, <5% cobbles | - |
| | 2 | 10-20 cm | Brown (7.5YR 5/2) sandy clay, 20% gravel | - |
| 6 | Surface | 0 cm | Strong brown (7.5YR 5/6) sand, 15% gravel | Ground stone fragment |
| | 1 | 0-10 cm | Brown (7.5YR 5/2) sandy clay, 5% gravel | - |
| | 2 | 10-20 cm | Brown (7.5YR 5/2) sandy clay, <5% gravel | - |
| 7 | Surface | 0 cm | Grayish brown (10YR 5/2) sand, 15% gravel | Hammerstone, soil staining |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay, <5% gravel | 2% FCR |
| | 2 | 10-20 cm | Brown (10YR 4/3) sandy clay, <5% gravel | <1% FCR (small pieces) |
| 8 | Surface | 0 cm | Brown (10YR 5/3) sand, 10% gravel | Chert biface |
| | 1 | 0-10 cm | Dark brown (10YR 3/3) silty sand, 10% gravel | - |
| | 2 | 10-20 cm | Dark brown (10YR 3/3) silty sand, 20% gravel | - |

| STP # | Level | Excavation Depth | Soil Type | Artifacts/Materials Present |
|---|---|---|---|---|
| 9 | Surface | 0 cm | Very dark grayish-brown (10YR 3/2) silty sand, 15% gravel | - |
| | 1 | 0-10 cm | Very dark grayish-brown (10YR 3/2) silty sand, 20% gravel | - |
| | 2 | 10-20 cm | Dark brown (10YR 3/3) sandy clay, 15% cobbles | - |
| 10 | Surface | 0 cm | Light brown (7.5YR 6/3) sand, 15% gravel | - |
| | 1 | 0-10 cm | Brown (7.5YR 5/4) sandy clay, 10% gravel | - |
| | 2 | 10-20 cm | Brown (7.5YR 5/4) sandy clay, 10% gravel | - |
| 11 | Surface | 0 cm | Brown (7.5YR 4/2) sand, <10% gravel | Chopper, possible soil staining |
| | 1 | 0-10 cm | Black (7.5YR 2.5/1) sandy clay, 10% gravel | Mano fragment, soil staining |
| | 2 | 10-20 cm | Black (7.5YR 2.5/1) sandy clay; changed to dark brown (7.5YR 3/4) clay loam at 13 cm, <5% gravel | Soil staining |
| | 3 | 20-30 cm | Dark brown (7.5YR 3/4) clay loam, <2% gravel | - |
| 12 | Surface | 0 cm | Brown (10YR 4/3) sand, <2% gravel | Possible soil staining, FCR |
| | 1 | 0-10 cm | Dark yellowish-brown (10YR 3/4) sandy clay, <2% gravel | - |
| | 2 | 10-20 cm | Dark yellowish-brown (10YR 3/4) sandy clay, <2% gravel | - |
| 13 | Surface | 0 cm | Brown (10YR 4/3) sand, 20% gravel | Chopper |
| | 1 | 0-10 cm | Dark yellowish-brown (10YR 3/4) sandy clay, 5% gravel | - |
| | 2 | 10-20 cm | Dark yellowish-brown (10YR 3/4) clay loam, 5% gravel | - |
| 14 | Surface | 0 cm | Brown (10YR 4/3) sandy clay, 5% gravel | Mano fragment |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay, 5% gravel | Obsidian projectile point base |
| | 2 | 10-20 cm | Brown (10YR 4/3) clay loam, <2% gravel | - |
| | 3 | 20-30 cm | Very dark brown (10YR 4/3) clay loam, <2% gravel | - |
| 15 | Surface | 0 cm | Brown (10YR 4/3) sandy clay, <5% gravel | Mano fragment |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay changed to clay loam at 5 cm, 10% gravel | - |
| | 2 | 10-20 cm | Brown (10YR 4/3) clay loam, 5% gravel | - |

| STP # | Level | Excavation Depth | Soil Type | Artifacts/Materials Present |
|---|---|---|---|---|
| 16 | Surface | 0 cm | Brown (10YR 5/3) sandy clay, 5% gravel | Mano fragment, biface |
| | 1 | 0-10 cm | Brown (10YR 5/3) sandy clay, 5% gravel | 7 white chert tertiary flakes |
| | 2 | 10-20 cm | Brown (10YR 4/3) clay loam, 5% gravel mottled with dark grayish-brown (10YR 4/2) | 1 white chert tertiary flake, 1 red chert tertiary flake, coal particles |
| | 3 | 20-30 cm | Brown (10YR 4/3) clay loam, <2% gravel mottled with dark grayish-brown (10YR 4/2) | Coal particles |
| | 4 | 30-40 cm | Dark grayish-brown (10YR 4/2) clay loam, <2% gravel | - |
| 17 | Surface | 0 cm | Dark grayish-brown (10YR 4/2) sandy clay, 5% gravel | Tested cobble |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay, <2% gravel | - |
| | 2 | 10-20 cm | Brown (10YR 4/3) sandy clay, <2% gravel | - |
| 18 | Surface | 0 cm | Pale brown (10YR 6/3) sand, <2% gravel | Mano Fragment |
| | 1 | 0-10 cm | Dark grayish-brown (10YR 4/2) mottled with yellowish-brown (10YR 5/4) sandy clay, <2% gravel | - |
| | 2 | 10-20 cm | Yellowish-brown (10YR 5/4) sandy clay, <2% gravel | - |
| 19 | Surface | 0 cm | Dark grayish-brown (10YR 4/2) sand, <5% gravel | Mano fragment/hamemrstone |
| | 1 | | Dark brown (10YR 3/3) sandy clay, 5% gravel | - |
| | 2 | | Dark brown (10YR 3/3) clay loam, <2% gravel | - |
| 20 | Surface | 0 cm | Brown (10YR 4/3) silty sand, 5% gravel | Biface |
| | 1 | 0-9 cm | Brown (10YR 4/3) sandy clay, 15% gravel | - |
| | 2 | 9-18 cm | Very dark grayish-brown (10YR 4/3) with mottled yellowish-brown (10YR 5/6) sandy clay loam, <2% gravel; changed to brownish-yellow (10YR 6/8) at 15cm and then bedrock at 18 cm | - |
| 21 | Surface | 0 cm | Brown (10YR 5/3) silty sand, <5% gravel | Ground stone fragment, chopper |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay, 5% gravel | - |
| | 2 | 10-20 cm | Brown (10YR 4/3) sandy clay, 5% gravel | - |
| 22 | Surface | 0 cm | Dark grayish-brown (10YR 4/2) silty sand, 20% gravel | Ground stone fragment |
| | 1 | 0-10 cm | Very dark grayish-brown (10YR 4/3) sandy clay, 5/% gravel | - |
| | 2 | 10-20 cm | Very dark grayish-brown (10YR 4/3) sandy clay, <2/% gravel | - |

| STP # | Level | Excavation Depth | Soil Type | Artifacts/Materials Present |
|---|---|---|---|---|
| 23 | Surface | 0 cm | Grayish-brown (10YR 5/2) silty sand, <5% gravel | 2 choppers |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay, <5% gravel | Coal particles |
| | 2 | 10-20 cm | Brown (10YR 4/3) sandy clay, <2% gravel | Mottled coal discoloration |
| 24 | Surface | 0 cm | Grayish-brown (10YR 5/2) silty sand, <2% gravel | Mano Fragment |
| | 1 | 0-10 cm | Dark grayish-brown (10YR 4/2) silty sand, <2% gravel | - |
| | 2 | 10-20 cm | Grayish-brown (10YR 5/2) sandy clay, <2% gravel | - |
| 25 | Surface | 0 cm | Very pale brown (10YR 7/3) silty sand, 5% gravel | Possible location of 1986 hearth |
| | 1 | 0-10 cm | Brown (7.5YR 4/4) clay loam, <2% gravel | FCR |
| | 2 | 10-20 cm | Brown (7.5YR 4/4) clay loam, <2% gravel | - |
| 26 | Surface | 0 cm | Yellowish-brown (10YR 5/4) silty sand, <2% gravel | Possible location of 1986 hearth, biface |
| | 1 | 0-10 cm | Brown (7.5YR 4/4) silty sand, 15% gravel | Mottled decomposing coal discoloration |
| | 2 | 10-20 cm | Dark yellowish-brown (10YR 4/6) silty sand, 15% gravel, 5% cobbles | Mottled decomposing coal discoloration |
| 27 | Surface | 0 cm | Very dark brown (10YR 2/2) silty clay, <2% gravel | Possible location of 1986 hearth area |
| | 1 | 0-10 cm | Very dark brown (10YR 2/2) silty clay, <2% gravel | - |
| | 2 | 10-20 cm | Very dark brown (10YR 2/2) silty clay, <2% gravel, large rocks, 5+ small cobbles | - |
| 28 | Surface | 0 cm | Brown (10YR 5/3) silty sand, <2% gravel | Ground stone fragment |
| | 1 | 0-10 cm | Very dark gray-brown (10YR 3/2) silty sand, <2% gravel | Red chert shatter fragment |
| | 2 | 10-20 cm | Very dark gray-brown (10YR 3/2) sandy clay, <2% gravel | - |
| | 3 | 20-30 cm | Very dark gray-brown (10YR 3/2) sandy clay, <2% gravel | - |
| 29 | Surface | 0 cm | Brown (10YR 5/3) silty sand, <2% gravel | Ground stone fragment |
| | 1 | 0-10 cm | Brown (10YR 4/3) sandy clay, <2% gravel | - |
| | 2 | 10-20 cm | Dark yellowish-brown (10YR 4/4) sandy clay, <2% gravel | - |
| 30 | Surface | 0 cm | Pale brown (10YR 6/3) silty sand, <2% gravel | Ceramic shred |
| | 1 | | Pale brown (10YR 6/3) silty sand, <2% gravel | - |
| | 2 | | Brown (10YR 5/3) sandy clay, <2% gravel | - |

| STP # | Level | Excavation Depth | Soil Type | Artifacts/Materials Present |
|---|---|---|---|---|
| 31 | Surface | 0 cm | Brown (10YR 4/3) sandy clay | - |
| | 1 | 0-10 cm | Brown (10YR 4/3) silty clay changed to mottled black (7.5YR 2.5/1) silty clay at 4 cm | Soil staining |
| | 2 | 10-20 cm | Mottled black (7.5YR 2.5/1) silty clay changed to dark yellowish-brown (10YR 4/4) silty clay at 15 cm | Soil staining |
| | 3 | 20-30 cm | Strong brown (7.5YR 4/6) sandy clay | - |
| 32 | Surface | 0 cm | Brown (10YR 5/3) silty sand | - |
| | 1 | 0-10 cm | Brown (10YR 5/3) silty sand changed to black (7.5YR 2.5/1) silty sand at 2 cm | Soil staining |
| | 2 | 10-20 cm | Black (7.5YR 2.5/1) silty sand changed to mottled strong brown (7.5YR 4/6) sandy clay at 11 cm | Soil staining |
| | 3 | 20-30 cm | Strong brown (7.5YR 4/6) sandy clay | - |
| TU1 | 1 | 0-10 cm | Brown (10YR 4/3) silty sand with organic debris | Structural stone |
| | 2 | 3-17 cm | Very dark brown (10YR 2/2) sandy clay, <20% gravel, 5% small cobbles | 1 white chert tertiary flake, structural stone |
| | 3 | 9-30 cm | Dark brown (10YR 3/3) silty clay, 20% gravel; changed to compact decomposing bedrock at 30 cm | - |

**Table A.2. Shovel test pit results from site 42KA3097**

| STP # | Levels | Excavation Depth | Artifacts/Materials Present | Depth Recovered |
|---|---|---|---|---|
| 1 | 2 | 21 cm | - | - |
| 2 | 2 | 20 cm | - | - |
| 3 | 2 | 20 cm | - | - |
| 4 | 2 | 20 cm | - | - |
| 5 | 2 | 22 cm | - | - |
| 6 | 2 | 20 cm | - | - |
| 7 | 2 | 20 cm | - | - |
| 8 | 2 | 20 cm | - | - |
| 9 | 2 | 20 cm | - | - |
| 10 | 2 | 24 cm | - | - |
| 11 | 2 | 20 cm | - | - |
| 12 | 2 | 20 cm | - | - |
| 13 | 2 | 20 cm | White/red chert uniface | Surface |
| 14 | 2 | 20 cm | - | - |
| 15 | 2 | 22 cm | - | - |
| 16 | 2 | 20 cm | - | - |
| 17 | 2 | 20 cm | - | - |
| 18 | 2 | 20 cm | - | - |
| 19 | 2 | 20 cm | - | - |
| 20 | 2 | 20 cm | - | - |
| 21 | 2 | 20 cm | - | - |
| 22 | 2 | 20 cm | - | - |
| 23 | 2 | 21 cm | - | - |
| 24 | 2 | 20 cm | - | - |
| 25 | 2 | 25 cm | - | - |
| 26 | 2 | 20 cm | Possible depression | Negative |
| 27 | 2 | 20 cm | Ground stone fragment | Surface |
| 28 | 2 | 20 cm | - | - |
| 29 | 2 | 20 cm | Gray ware ceramic sherd | Surface |
| 30 | 2 | 20 cm | Red quartzite mano fragment | Surface |
| 31 | 2 | 20 cm | White chert projectile point basal fragment | Surface |
| 32 | 2 | 20 cm | Red quartzite mano fragment | Surface |
| 33 | 2 | 20 cm | - | - |
| 34 | 2 | 20 cm | - | - |
| 35 | 2 | 20 cm | Mottled chert chopper/hammerstone | Surface |
| 36 | 2 | 20 cm | Red quartzite mano fragment | Surface |
| 37 | 2 | 21 cm | Five red sandstone ground stone fragments, red quartzite hammerstone & one white/gray chert flake | Surface |
| 38 | 2 | 20 cm | Tan quartzite hammerstone & one red chert flake | Surface |
| 39 | 2 | 22 cm | Yellow sandstone metate & one tan/white chert flake | Surface |
| 40 | 2 | 20 cm | Gray ware ceramic sherd | Surface |
| 41 | 2 | 20 cm | Obsidian projectile point basal fragment & red quartzite mano fragment | Surface |
| 42 | 2 | 20 cm | - | - |
| 43 | 2 | 20 cm | - | - |
| 44 | 2 | 20 cm | Possible depression adjacent to black chert biface basal fragment | Surface/Negative |

| STP # | Levels | Excavation Depth | Artifacts/Materials Present | Depth Recovered |
|---|---|---|---|---|
| 45 | 2 | 20 cm | Three chert flakes | Surface |
| 46 | 2 | 20 cm | One white chert flake | Surface |
| 47 | 2 | 20 cm | White chert projectile point basal fragment & 2 flakes | Surface |
| 48 | 2 | 20 cm | - | - |
| 49 | 2 | 20 cm | - | - |
| 50 | 2 | 20 cm | - | - |
| 51 | 2 | 20 cm | - | - |
| 52 | 2 | 20 cm | - | - |
| 53 | 2 | 20 cm | - | - |
| 54 | 2 | 20 cm | - | - |
| 55 | 2 | 20 cm | - | - |
| 56 | 2 | 20 cm | - | - |
| 57 | 2 | 20 cm | One flake in vehicle track | Surface |
| 58 | 2 | 20 cm | Projectile point basal fragment 1 m west in sagebrush | Surface |
| 59 | 2 | 20 cm | - | - |
| 60 | 2 | 20 cm | - | - |
| 61 | 2 | 20 cm | - | - |
| 62 | 2 | 20 cm | - | - |

# Appendix B:
## Chipped Stone Analysis

**Table B.1. Chipped stone debitage analysis from site 42KA3077**

| FS # | STP # | Level | easting | northing | Material Type | Color | Shatter | Flake Frag | Prim Flk | Sec Flk | ICR Flk | Tert Flk | BTF Flk | Press Flk | Core | Weight | Total | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | surface | 370331 | 4142726 | quartzite | tan | - | - | - | - | 1 | - | - | - | - | 29 | 1 | |
| 6 | - | surface | 370394 | 4142766 | obsidian | opaque black | 1 | - | - | - | - | - | - | - | - | 2 | 1 | |
| 8 | 16 | 0-10 | 370363 | 4142777 | chert | opaque white/grey mottled | - | - | - | - | - | 1 | - | - | - | 1 | 1 | submit for hydration and sourcing |
| 10 | 16 | 10 to 20 | 370363 | 4142777 | chert | opaque red | - | - | - | - | - | - | - | 1 | - | <1 | 1 | |
| 10 | 16 | 10 to 20 | 370363 | 4142777 | chert | translucent white | - | - | - | - | - | 1 | - | - | - | <1 | 1 | |
| 16 | - | surface | 370377 | 4142746 | obsidian | translucent black banded | - | - | - | - | 1 | - | - | - | - | 1 | 1 | |
| 17 | - | surface | 370372 | 4142770 | obsidian | translucent clear/black banded | - | - | - | - | - | 1 | - | - | - | <1 | 1 | submit for hydration and sourcing |
| 29 | F4 in F2 | 10 to 20 | | | chert | opaque white | - | - | - | - | - | 1 | - | - | - | <1 | 1 | may be too small & thin for sourcing (?) |
| 31 | - | surface | 370347 | 4142692 | obsidian | translucent black | - | - | - | - | - | 1 | - | - | - | <1 | 1 | |
| 36 | - | surface | 370343 | 4142697 | chert | translucent white | - | - | - | - | - | 1 | - | - | - | <1 | 1 | submit for hydration and sourcing |
| 38 | 28 | 0-10 | 370347 | 4142811 | chert | opaque red/black mottled | 1 | - | - | - | - | - | - | - | - | - | - | minor use-ware along one convex edge, utilized flake |
| 1 | - | surface | 370331 | 4142726 | quartzite | tan | - | - | - | - | 1 | - | - | - | - | 29 | 1 | |

| FS # | STP # | Level | easting | northing | Material Type | Color | Shatter | Flake Frag | Prim Flk | Sec Flk | ICR Flk | Tert Flk | BTF Flk | Press Flk | Core | Weight | Total | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | - | surface | 370394 | 4142766 | obsidian | opaque black | 1 | - | - | - | - | - | - | - | - | 2 | 1 | |
| 8 | 16 | 0-10 | 370363 | 4142777 | chert | opaque white/grey mottled | - | - | - | - | - | 1 | - | - | - | 1 | 1 | submit for hydration and sourcing |
| 10 | 16 | 10 to 20 | 370363 | 4142777 | chert | opaque red | - | - | - | - | - | - | - | 1 | - | <1 | 1 | |
| 10 | 16 | 10 to 20 | 370363 | 4142777 | chert | translucent white | - | - | - | - | - | 1 | - | - | - | <1 | 1 | |
| 16 | - | surface | 370377 | 4142746 | obsidian | translucent black banded | - | - | - | - | 1 | - | - | - | - | 1 | 1 | |
| 17 | - | surface | 370372 | 4142770 | obsidian | translucent clear/black banded | - | - | - | - | - | 1 | - | - | - | <1 | 1 | submit for hydration and sourcing |
| 29 | F4 in F2 | 10 to 20 | | | chert | opaque white | - | - | - | - | - | 1 | - | - | - | <1 | 1 | may be too small & thin for sourcing (?) |
| 31 | - | surface | 370347 | 4142692 | obsidian | translucent black | - | - | - | - | - | 1 | - | - | - | <1 | 1 | |
| 36 | - | surface | 370343 | 4142697 | chert | translucent white | - | - | - | - | - | 1 | - | - | - | <1 | 1 | submit for hydration and sourcing |
| 38 | 28 | 0-10 | 370347 | 4142811 | chert | opaque red/black mottled | 1 | - | - | - | - | - | - | - | - | - | - | minor use-ware along one convex edge, utilized flake |
| 1 | - | surface | 370331 | 4142726 | quartzite | tan | - | - | - | - | 1 | - | - | - | - | 29 | 1 | |

**Table B.2. Chipped stone tools analysis from site 42KA3077**

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | - | surface | 370351 | 4142776 | quartzite | red | chopper | 55.4 | 91.3 | 29.8 | complete | 157 | large primary flake, heavy battering/crushing -ware present along entire convex edge |
| 3 | - | surface | 370337 | 4142733 | chert | opaque red/white banded | scraper/ chopper | 42.6 | 51.8 | 17.2 | complete | 49 | both crushing and scraping-ware present along 80% of the tools edges; all edges utilized except platform area of flake. |
| 4 | - | surface | 370358 | 4142766 | chert | translucent white/purple mottled | biface | 11.5 | 15 | 3.9 | fragment | 1 | late stage basal fragment, possible notch present near one corner - but not enough present to determine type. |
| 5 | - | surface | 370358 | 4142812 | chert | translucent white/red mottled | biface | 24.8 | 32.1 | 6.9 | fragment | 4 | late stage large biface tip |
| 7 | 14 | 0-10 | 370352 | 4142809 | obsidian | translucent black | proj point | 8.2 | 16.8 | 3.7 | fragment | 1 | Elko Corner-notched basal fragment, base with both tangs; may be too small to submit for hydration and sourcing (?) |
| 9 | 16 | surface | 370363 | 4142777 | chert | opaque grey | biface | 19.7 | 29.7 | 13.4 | fragment | 7 | mid-stage basal fragment, thick, chunky, not refined yet |

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | - | surface | 370358 | 4142766 | chert | translucent red/yellow/ red mottled | proj point | 33.8 | 22.7 | 4.5 | complete | 4 | Elko Corner-notched, reworked |
| 12 | - | surface | 370348 | 4142808 | chert | opaque white/grey mottled | biface | 23.4 | 17.6 | 4.4 | fragment | 2 | late stage tip fragment |
| 13 | - | surface | 370413 | 4142308 | chert | translucent white | biface | 28.8 | 28.7 | 5.6 | fragment | 3 | mid-stage mid-section fragment |
| 14 | - | surface | 370367 | 4142642 | chert | opaque white/grey mottled | uniface | 30.4 | 15.7 | 4.6 | fragment | 2 | unifacially flake, made from large blade flake |
| 15 | - | surface | 370224 | 4142784 | chert | opaque gray | biface | 25.8 | 22.8 | 7.2 | fragment | 3 | mid-stage mid-section fragment |
| 18 | - | surface | 370320 | 4142623 7 | chert | opaque white | biface | 23.3 | 27.3 | 7.2 | fragment | 5 | mid-stage mid-section fragment |
| 19 | - | surface | 370357 | 4142805 | chert | translucent white | biface | 13.7 | 18.2 | 4.8 | fragment | 1 | mid-stage tip fragment |
| 20 | - | surface | 370321 | 4142732 | chert | opaque cream/gray mottled | biface | 42.6 | 28.7 | 11 | fragment | 9 | mid-stage blade edge fragment |
| 21 | - | surface | 370412 | 4142807 | chert | opaque white | biface | 19.3 | 18.6 | 5.4 | fragment | 1 | mid-stage tip fragment |
| 22 | - | surface | 370413 | 4142808 | chert | opaque white/grey mottled | uniface/ graver | 20.7 | 33.6 | 3.7 | fragment | 1 | large ICR flake fragment unifacially flaked, burin/graver tip present/placed along uniface edge |
| 23 | - | surface | 370330 | 4142743 | chert | opaque white/grey mottled | biface | 14.8 | 20.3 | 4.5 | fragment | 1 | late-stage mid-section |
| 24 | - | surface | 370402 | 4142832 | chert | opaque brown | biface | 16.6 | 13.6 | 4.5 | fragment | <1 | late-stage blade edge fragment |
| 26 | - | surface | 370339 | 4142748 | chert | opaque white/grey mottled | biface | 34.7 | 21.2 | 6.3 | fragment | 4 | late-stage mid-section |

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | - | surface | 370353 | 4142778 | chert | translucent red | biface | 18.4 | 16.4 | 4 | fragment | 1 | late-stage blade edge fragment |
| 28 | - | surface | 370224 | 4142784 | chert | opaque white | proj point | 20.9 | 19.4 | 5.6 | fragment | 2 | Gatecliff/Gypsum basal fragment |
| 30 | - | surface | 370327 | 4142724 | chert | opaque white/red mottled | biface | 21 | 25.3 | 8 | fragment | 7 | early stage basal fragment |
| 33 | - | surface | 370468 | 4142864 | chert | translucent white/tan mottled | biface | 37 | 38.4 | 6.5 | complete | 7 | made from large ICR flake, possibly forming a tip at one end |
| 34 | - | surface | 370287 | 4142529 | chert | translucent white | proj point | 20.3 | 13 | 2.6 | complete | <1 | Desert Side-notched, text book example |
| 35 | - | surface | 370203 | 4142720 | chert | opaque cream/gray mottled | biface | 43.6 | 38.3 | 16.6 | fragment | 26 | mid-stage basal fragment |
| 37 | - | surface | 370380 | 4142739 | chert | translucent white/cream mottled | biface | 24.5 | 30.9 | 6.3 | fragment | 5 | late stage basal fragment |

**Table B.3. Chipped stone debitage analysis from site 42KA3097**

| FS # | STP # | Level | easting | northing | Material Type | Color | Shatter | Flake Frag | Prim Flk | Sec Flk | ICR Flk | Tert Flk | BTF Flk | Press Flk | Core | Weight | Total | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 28 | surface | 369324 | 4142937 | Obsidian | translucent black banded | - | - | - | - | 1 | - | - | - | - | 5 | 1 | submit for hydration and sourcing |
| 45 | - | surface | 369545 | 4142773 | Obsidian | translucent banded black | - | - | - | - | - | - | 1 | - | - | 2 | 1 | submit for hydration and sourcing |

**Table B.4. Chipped stone tools analysis from site 42KA3097**

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | surface | 369495 | 4143117 | chert | opaque white | proj point | 17.3 | 20.9 | 5.9 | fragment | 3 | One barb and one tang present. Corner-notched; Elko Corner-notched |
| 2 | | surface | 369556 | 4142551 | chert | opaque pink/white banded | biface | 37.5 | 15.3 | 8.2 | fragment | 6 | late stage, convex blade edge fragment |
| 3 | | surface | 369540 | 4142639 | obsidian | opaque black | proj point | 24.1 | 22.1 | 4.3 | fragment | 2 | both side-notches placed 6.3mm above proximal end; Northern Side-notched |
| 4 | | surface | 369592 | 4142860 | chert | opaque mottled brown/cream | core/scraper | 59.6 | 32.1 | 21.3 | complete | 36 | scraper made from exhausted core frag, one scraping edge along slightly convex edge |
| 5 | | surface | 369542 | 4142611 | chert | opaque brownish-yellow | biface | 24.6 | 21.8 | 6.8 | fragment | 5 | late stage, mid-section |
| 6 | | surface | 369548 | 4142721 | chert | opaque white | biface | 16.4 | 14.5 | 5.1 | fragment | 2 | late stage, basal fragment |
| 7 | | surface | 369571 | 4142753 | chert | opaque white | biface | 29.1 | 24.3 | 5.9 | fragment | 3 | lanceolate, late stage, reworked |
| 8 | | surface | 369591 | 4142855 | chert | translucent red/white banded | proj point | 21.6 | 14 | 4.5 | fragment | 2 | corner notched, stemmed, convex blade edge |
| 9 | | surface | 369556 | 4142624 | chert | opaque pink/white banded | biface | 20.5 | 17.5 | 4.6 | fragment | 3 | late stage tip |
| 10 | | surface | 369596 | 4142601 | chert | mottled yellow/pink/gray | biface | 34.5 | 20 | 7.2 | fragment | 5 | mid stage tip |

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 21 | surface | 369346 | 4143037 | chert | opaque mottled orange/gray | proj point | 25.8 | 26.9 | 5 | fragment | 4 | Elko corner-notched |
| 38 | | surface | 369490 | 4142979 | chert | opaque red | biface | 21.2 | 20.2 | 3.9 | fragment | 2 | late stage basal fragment |
| 42 | | surface | 369528 | 4142732 | chert | opaque mottled pink/white | biface | 23.4 | 18.8 | 4.9 | fragment | 2 | late stage mid-section, lanceolate blade edges |
| 43 | | surface | 369367 | 4143278 | chert | translucent burgundy/cr eam | biface | 25 | 31.6 | 7.9 | fragment | 7 | mid stage basal fragment |
| 44 | | surface | 369531 | 4142738 | chert | opaque white | proj point | 19.4 | 21.3 | 6.5 | fragment | 3 | both side-notches placed 12.8mm above proximal end; Sudden Side-notched |
| 46 | | surface | 369573 | 4142861 | quartzite | red | hammerstone | 67.8 | 51.3 | 42 | complete | 202 | hammerstone made from river cobble |
| 47 | | surface | 369346 | 4143181 | chert | mottled yellow/pink/ gray | chopper/ hammerstone | 57.8 | 55.7 | 30.5 | complete | 101 | circular shape with both battering and crushing ware edges |
| 48 | | surface | 369510 | 4142845 | quartzite | pink | hammerstone | 84.8 | 51.1 | 43.3 | complete | 254 | hammerstone made from river cobble |
| 49 | | surface | 369478 | 4143003 | chert | opaque black | biface | 24.1 | 18 | 6 | fragment | 2 | late stage tip |
| 50 | | surface | 369463 | 4143041 | chert | translucent red | biface | 17.6 | 17.7 | 3.5 | fragment | 2 | late stage mid-section, coarse grained |
| 51 | | surface | 369453 | 4142619 | quartzite | cream | hammerstone | 66 | 45.2 | 48.1 | complete | 225 | hammerstone made from river cobble |

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | | surface | 369511 | 4143029 | quartzite | mottled red/yellow | chopper/ hammerstone | 92.6 | 87.3 | 67.3 | complete | 720 | hammerstone made from river cobble; circular shape with both battering and crushing ware edges |
| 62 | | surface | 370129 | 4142544 | chert | opaque white | proj point | 15.5 | 14.1 | 2.5 | fragment | 1 | Rosegate Series, made from small tertiary flake, unifacially flaked, flake-point. |
| 63 | | surface | 369496 | 4142877 | chert | opaque white | proj point | 12.5 | 20.4 | 5 | fragment | 2 | Elko Side-notched basal fragment, base with both tangs |
| 64 | | surface | 369501 | 4142981 | chert | mottled red/white | drill | 23.5 | 20.4 | 5.5 | fragment | 2 | drill fragment |
| 66 | | surface | 369550 | 4142658 | chert | opaque white/grey mottled | proj point | 19.2 | 19.3 | 5.2 | fragment | 3 | Elko Eared basal fragment |
| 67 | | surface | 369532 | 4142788 | chert | translucent white | biface | 24.6 | 16.7 | 3.9 | fragment | 1 | late stage tip fragment |
| 68 | | surface | 369388 | 4143103 | chert | translucent yellow | biface | 35.5 | 34.5 | 8 | fragment | 11 | late stage basal fragment, rounded 'circular" base constricts where blade begins; possible Codie knife |
| 69 | | 0-8cm | 369321 | 4142981 | chert | translucent white/yello w mottled | core | 31.2 | 46.1 | 18.9 | fragment | 29 | exhausted core fragment, flakes take from all surfaces, no cortex present |
| 70 | | surface | 369695 | 4142743 | chert | white | proj point | 14 | 16 | 6 | fragment | | Northern Side-notched |

| FS# | STP# | Level | East | North | Material Type | Color | Artifact Type | Length (mm) | Width (mm) | Thickness (mm) | Completeness | Weight (g) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | | Surface | 369597 | 4142858 | chert | white/gray mottled chert | proj point | 15 | 18 | 6 | fragment | | Gatecliff Contracting Stem |

# Appendix C:
## Obsidian Sourcing & Hydration Analysis

**Geochemical Research Laboratory Letter Report 2017-20**

*Energy Dispersive X-ray Fluorescence Analysis of Obsidian Artifacts from 42KA3077 and 42KA3097, Kane County, Utah*

March 16, 2017

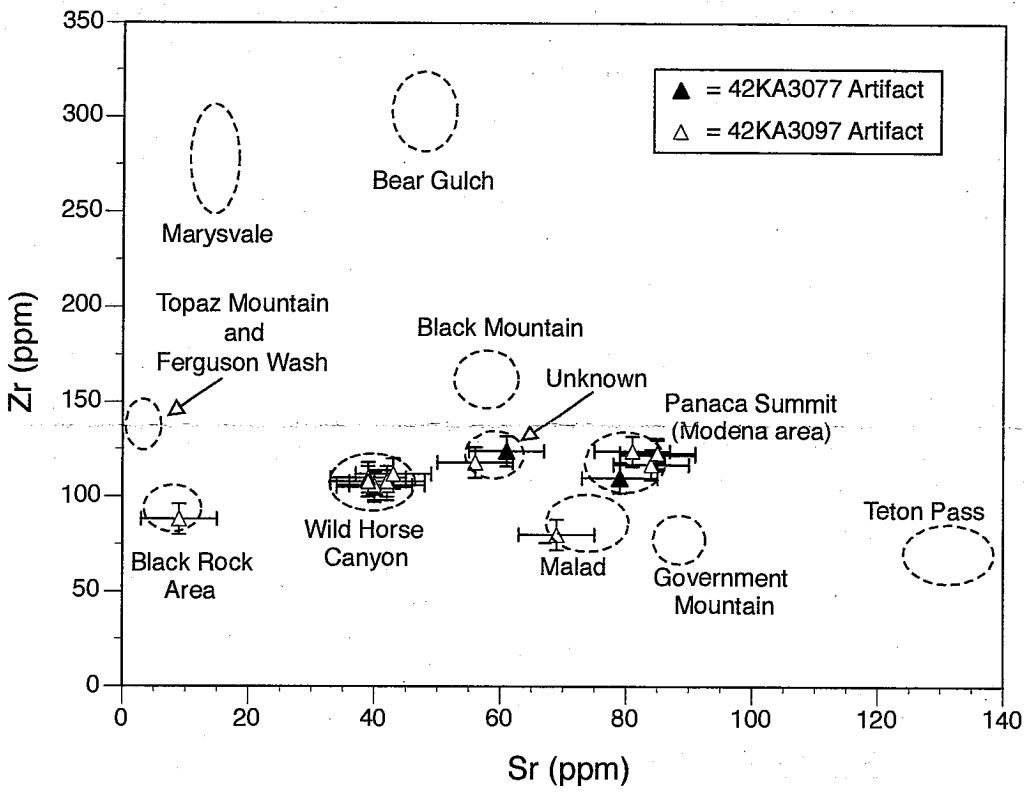
Mr. Dale R. Gourley
Bighorn Archaeological Consultants, LLC
3790 Nicholas Drive
Santa Clara, UT 84765

Dear Mr. Gourley:

This letter contains tables and figures presenting energy dispersive x-ray fluorescence (edxrf) data generated from the analysis of 23 obsidian artifacts from two archaeological sites (42KA3077, n= 5; 42KA3097, n= 18), located south of Alton in Kane County, Utah. The research reported here was completed pursuant to your letter request of February 15, 2017. Laboratory equipment and instrumentation, and artifact-to-source (geochemical type) attribution procedures, measurement resolution limits for each element, and literature references, except as indicated, are the same as reported for sites from the Fort Pearce area (Hughes 2007) and 42SW479 (Hughes 2009).

**Figure 1**

Zr vs. Sr Composition of Artifacts from 42KA3077 and 42KA3097, Utah



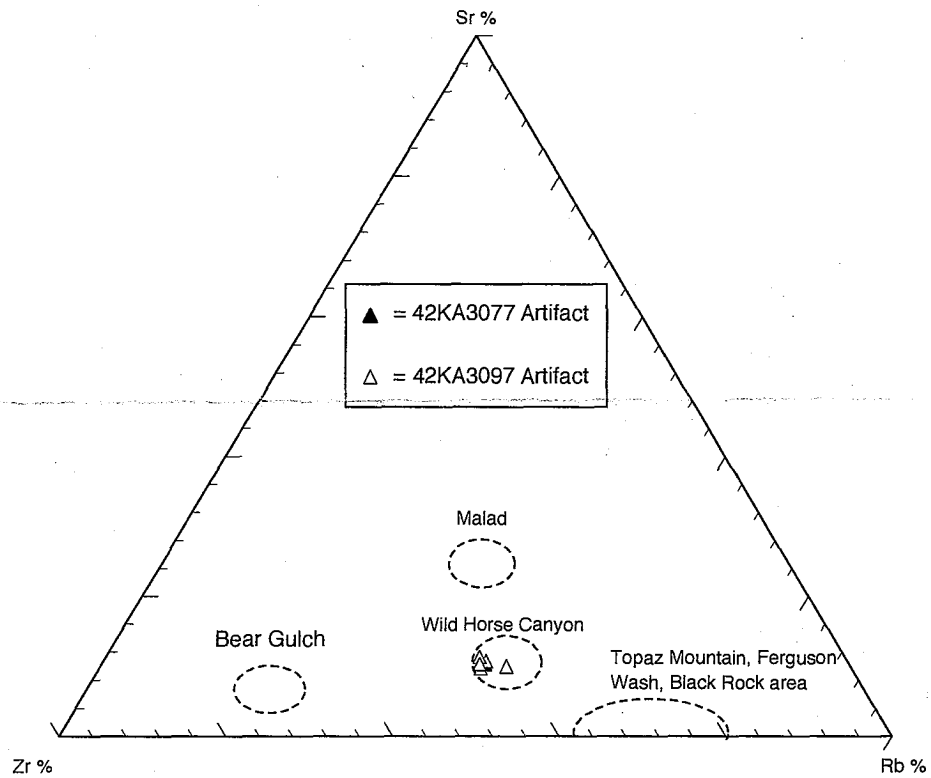

Dashed lines represent range of variation measured in archaeologically significant geologic obsidian source samples. Triangles plot values for specimens in Table 1. Error bars are two-sigma (95% confidence interval) composition estimates for each artifact. *Note*: values for artifact FS # 17 from 42KA3097 plot off the chart at this scale.

Seventeen of the artifacts you sent were large enough to generate reliable quantitative composition estimates (i.e., ppm values)Table 1 and Figure 1 present trace element data indicating that seven artifacts conform to the trace element profile of Wild Horse Canyon volcanic glass, that five match the trace element profile of obsidian of the Panaca Summit (Modena area) chemical type, while single specimens conform to the trace element signature of Black Rock area, Malad, and Brown's Bench area obsidians. Two artifacts—one each from 42KA3077 and 42KA3097— share the fingerprint of a geographically unknown obsidian.

Whenever possible I report trace element measurements in quantitative units (i.e. ppm) and make artifact-to-source attributions on the basis of correspondences in diagnostic trace element concentration values (e.g. those presented in Table 1), but six of the obsidian artifacts you sent were too small (i.e. < 9-10 mm diameter) and/or thin (i.e. < ca. 1.5 mm thick) to generate x-ray counting statistics adequate for proper conversion from background-corrected intensities to quantitative concentration estimates (i.e., ppm) so I applied the same laboratory analysis protocol (described in detail in Hughes 2010) to generate integrated net count (intensity) data for the elements Rb, Sr, Y, Zr, Nb, Fe, and Mn. After background subtraction, the intensities (counts per second with peaks stripped of overlapping Kα and Kβ line contributions from adjacent elements) were converted to percentages. The counting data and derived ratios appear in Table 2, and the plotted values appear in Figure 2. Source assignment was made by comparing the plots for artifacts against the parameters of geological sources (including specimens representing the Wild Horse Canyon, Topaz Mountain, Ferguson Wash, Black Rock area chemical types), along with specimens from Malad, Idaho, known to be significant in Utah prehistory. Integrated net peak intensity data (see Table 2 and Figure 2) indicate that all six small artifacts were made from Wild Horse Canyon obsidian.

**Figure 2**

Ternary Diagram Plots for Small Obsidian Artifacts from 42KA3077 and 42KA3097, Utah




Dashed lines represent range of variation in geological obsidian source samples. Dots plot data for the specimens in Table 2.

**Table 2**

Integrated Net Count Rate Data for Small Obsidian Artifacts from 42KA3077 and 42KA3097

| | Element Intensities | | | | | | | Intensity Ratios | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cat. no. | Rb | Sr | Zr | Σ Rb,Sr,Zr | Rb% | Sr% | Zr% | Fe/Mn | Rb/Sr | Zr/Y | Y/Nb | Zr/Nb | Sr/Y | Obsidian Source (Chemical Type) |
| KA3077, 17 | 422 | 95 | 402 | 919 | .459 | .103 | .437 | 20.9 | 4.4 | 7.1 | .5 | 3.8 | 1.7 | Wild Horse Canyon |
| KA3097, 25 | 416 | 97 | 393 | 906 | .459 | .107 | .434 | 21.5 | 4.3 | 6.4 | .7 | 4.5 | 1.6 | Wild Horse Canyon |
| KA3097, 26 | 394 | 83 | 383 | 860 | .458 | .097 | .445 | 21.9 | 4.8 | 6.4 | .6 | 4.0 | 1.4 | Wild Horse Canyon |
| KA3097, 30a | 405 | 102 | 396 | 903 | .449 | .113 | .439 | 21.7 | 4.0 | 6.8 | .7 | 4.6 | 1.8 | Wild Horse Canyon |
| KA3097, 30b | 352 | 78 | 326 | 756 | .466 | .103 | .431 | 21.2 | 4.5 | 6.8 | .6 | 4.3 | 1.6 | Wild Horse Canyon |
| KA3097, 34b | 398 | 90 | 389 | 877 | .454 | .103 | .444 | 21.0 | 4.4 | 6.3 | .7 | 4.6 | 1.5 | Wild Horse Canyon |

Elemental intensities (peak counts/second above background) generated at 40 seconds livetime

In summary, of the five artifacts analyzed from 42KA3077, two each were made from Wild Horse Canyon and from Panaca Summit (Modena area) obsidian, and one was made from an unknown obsidian source. Eleven of the 18 artifacts analyzed from 42KA3097 were made from Wild Horse Canyon glass, three were fashioned from Panaca Summit (Modena area) obsidian, with single specimens manufactured from Black Rock area, Brown's Bench area, Malad, and a geographically unknown obsidian.

I hope this information will help in your analysis and interpretation of other cultural material from these sites. Please contact me at my laboratory (phone [650] 851-1410, via e-mail: rehughes@silcon.com, or at my web site: www.geochemicalresearch.com) if I can provide any further assistance or information. As you requested, I have forwarded the specimens to Tom Origer for obsidian hydration analysis.

Sincerely,

Richard E. Hughes

Richard E. Hughes, Ph.D., RPA
Director, Geochemical Research Laboratory

## REFERENCES

Hughes, Richard E.

2007 Energy Dispersive X-ray Fluorescence Analysis of Obsidian Artifacts from the Fort Pearce Wash area of Washington County, Southwestern Utah. Geochemical Research Laboratory Letter Report 2007-21 submitted to Jon R. Baxter, Bighorn Archaeological Consultants, April 5, 2007.

2009 Energy Dispersive X-ray Fluorescence Analysis of Obsidian Artifacts from Archaeological Site 42WS479, Located Within the Beaver Mountains of Washington County, Utah. Geochemical Research Laboratory Letter Report 2009-27 submitted to Dale R. Gourley, Bighorn Archaeological Consultants, March 12, 2009.

2010 Determining the Geologic Provenance of Tiny Obsidian Flakes in Archaeology Using Nondestructive EDXRF. **American Laboratory** 42 (7): 27-31.

Table 1

Quantitative Composition Estimates for Obsidian Artifacts from 42KA3077 and 42KA3097, Utah

| Site / FS Number | Zn | Ga | Rb | Sr | Y | Zr | Nb | Ba | Ti | Mn | $Fe_2O_3^T$ | Fe/Mn | Obsidian Source (Chemical Type) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Trace and Selected Minor Element Concentrations** | | | | | | | | | | | **Ratio** | |
| 42KA3077, 6 | nm | nm | 206 ±5 | 85 ±3 | 34 ±3 | 122 ±4 | 24 ±3 | 503 ±21 | nm | nm | nm | 30 | Panaca Summit (Modena area) |
| 42KA3077, 7 | nm | nm | 174 ±4 | 61 ±3 | 21 ±3 | 124 ±4 | 22 ±3 | 293 ±22 | nm | nm | .91 ±.02 | 25 | Unknown |
| 42KA3077, 16 | nm | nm | 186 ±4 | 79 ±3 | 31 ±3 | 110 ±4 | 22 ±3 | 501 ±21 | nm | nm | nm | 30 | Panaca Summit (Modena area) |
| 42KA3077, 31 | nm | nm | 185 ±4 | 40 ±3 | 23 ±3 | 105 ±4 | 28 ±3 | 140 ±18 | nm | nm | .81 ±.02 | 22 | Wild Horse Canyon |
| 42KA3097, 3 | nm | nm | 195 ±4 | 40 ±3 | 25 ±3 | 106 ±4 | 27 ±3 | 157 ±18 | nm | nm | .93 ±.02 | 21 | Wild Horse Canyon |
| 42KA3097, 13 | nm | nm | 198 ±4 | 42 ±3 | 26 ±3 | 106 ±4 | 25 ±3 | 138 ±20 | nm | nm | .91 ±.02 | 22 | Wild Horse Canyon |
| 42KA3097, 14 | nm | nm | 206 ±4 | 84 ±3 | 34 ±3 | 117 ±4 | 21 ±3 | 476 ±22 | nm | nm | nm | 31 | Panaca Summit (Modena area) |
| 42KA3097, 16 | nm | nm | 160 ±4 | 56 ±3 | 26 ±3 | 118 ±4 | 27 ±3 | 302 ±20 | nm | nm | .84 ±.02 | 25 | Unknown |
| 42KA3097, 17 | nm | nm | 225 ±5 | 30 ±3 | 68 ±3 | 381 ±6 | 54 ±3 | 603 ±26 | nm | nm | 2.31 ±.04 | 95 | Brown's Bench area? |
| 42KA3097, 18 | nm | nm | 191 ±4 | 39 ±3 | 27 ±3 | 110 ±4 | 28 ±3 | 191 ±20 | nm | nm | .98 ±.02 | 24 | Wild Horse Canyon |
| 42KA3097, 19a | nm | nm | 258 ±4 | 9 ±2 | 61 ±4 | 88 ±4 | 34 ±3 | nm | nm | nm | .91 ±.02 | 20 | Black Rock area |
| 42KA3097, 19b | nm | nm | 194 ±4 | 39 ±3 | 25 ±3 | 108 ±4 | 25 ±3 | 135 ±19 | nm | nm | .82 ±.02 | 22 | Wild Horse Canyon |
| 42KA3097, 21 | nm | nm | 188 ±4 | 81 ±3 | 29 ±3 | 124 ±4 | 19 ±2 | 528 ±22 | nm | nm | .99 ±.02 | 34 | Panaca Summit (Modena area) |
| 42KA3097, 23 | nm | nm | 204 ±4 | 85 ±3 | 32 ±3 | 123 ±4 | 21 ±3 | 465 ±20 | nm | nm | 1.12 ±.02 | 32 | Panaca Summit (Modena area) |
| 42KA3097, 34a | nm | nm | 195 ±4 | 42 ±3 | 22 ±3 | 108 ±4 | 27 ±3 | 162 ±26 | nm | nm | .90 ±.02 | 22 | Wild Horse Canyon |
| 42KA3097, 45 | nm | nm | 207 ±5 | 43 ±3 | 24 ±3 | 112 ±4 | 31 ±3 | 144 ±18 | nm | nm | nm | 22 | Wild Horse Canyon |
| 42KA3097, 57 | nm | nm | 118 ±4 | 69 ±3 | 31 ±3 | 80 ±4 | 16 ±3 | 1549 ±26 | nm | nm | .95 ±.02 | 42 | Malad |
| *U.S. Geological Survey Reference Standard* | | | | | | | | | | | | | |
| RGM-1 (measured) | nm | nm | 150 ±4 | 111 ±3 | 26 ±3 | 220 ±4 | 8 ±3 | 827 ±30 | nm | nm | 1.86 ±.02 | 65 | Glass Mtn., CA |
| RGM-1 (recommended) | nm | nm | 149 | 108 | 25 | 219 | 9 | 807 | 1600 | 279 | 1.86 | nr | Glass Mtn., CA |

Values in parts per million (ppm) except total iron (in weight percent) and Fe/Mn intensity ratios; ± = 2 σ estimate of x-ray counting uncertainty and regression fitting error at 120-360 seconds livetime; nm = not measured; nr = not reported.

# Appendix D:
## Ground Stone & Hammerstone Analysis

**Table D.1. Ground stone & hammerstone analysis from site 42KA3077**

| Material | Color | Burn | L (cm) | W (cm) | Th (cm) | Type | Comp | Texture | Design | Manuf | # Surfaces | S. Texture | Morph | Wear | W. Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QT | RED | N | 6.30 | 5.80 | 3.10 | MNF | 1 | FN | ST | GR | 1 | FN | FL | H | PL |
| QT | TAN | N | 6.40 | 5.00 | 3.30 | HMS | 1 | MD | ST | PK | 2 | FN | IR | L | PK |
| QT | BRW | N | 6.40 | 5.60 | 4.50 | UGS | 3 | FN | IN | PK | 2 | FN | IR | L | PK |
| SN | RED | N | 14.70 | 4.60 | 2.50 | MTF | 3 | FN | ST | PK | 2 | FN | CC | H | PK |
| SN | TAN | ? | 9.00 | 6.80 | 2.30 | MNF | 2 | CS | ST | PK | 1 | CS | FL | H | PK |
| QT | RED | N | 4.60 | 5.60 | 4.00 | UGS | 4 | FN | ID | PK | 1 | FN | IR | L | PK |
| QT | GRY | N | 4.00 | 2.70 | 2.80 | UGS | 3 | FN | ST | PK | 1 | FN | IR | L | PK |
| QT | GRY | N | 6.00 | 4.00 | 5.00 | HMS | 3 | FN | IC | ID | 1 | FN | IR | L | PK |
| QT | TAN | N | 7.70 | 5.30 | 3.00 | HMS | 3 | FN | ID | ID | 1 | FN | IR | M | GR |
| QT | RED | N | 6.20 | 6.20 | 6.00 | HMS | 3 | FN | ST | PK | 2 | UN | IR | M | PK |
| QT | RED | N | 7.30 | 5.50 | 5.90 | UGS | 2 | FN | ST | GR | 1 | FN | CC | H | GR |
| QT | RED | N | 7.10 | 5.40 | 2.20 | HMS | 3 | FN | ID | ID | 1 | FN | FL | L | GR |
| QT | RED | N | 6.00 | 6.20 | 2.00 | UGS | 3 | FN | ID | ID | 1 | FN | FL | L | GR |
| QT | BLK | N | 4.80 | 5.10 | 3.30 | UGS | 3 | CS | ID | ID | | CS | IR | L | ID |
| QT | TAN | N | 6.50 | 6.70 | 3.00 | UGS | 3 | FN | ST | PK | 1 | FN | CC | H | PK |
| SN | TAN | N | 13.30 | 12.90 | 3.00 | MTF | 3 | FN | ST | PK | 1 | FN | CC | H | PK |
| QT | TAN | N | 5.00 | 5.30 | 2.70 | HMS | 3 | FN | ST | PK | 1 | FN | FL | L | PK |
| QT | TAN | N | 6.50 | 5.70 | 4.10 | HMS | 3 | FN | ST | PK | 1 | FN | CC | H | PK |
| SN | TAN | N | 12.40 | 9.50 | 6.10 | MNF | 2 | CS | ST | PK | 1 | CS | ID | H | PK |
| QT | GRY | N | 8.80 | 6.70 | 3.00 | UGS | 3 | MD | ST | PK | 1 | MD | PK | M | PK |
| QT | RED | N | 6.90 | 5.50 | 4.30 | UGS | 3 | FN | IN | PK | 2 | MD | PK | L | PK |
| QT | GRY | N | 18.70 | 10.50 | 5.80 | MTF | 3 | MD | ST | PK | 2 | MD | PK | M | PK |

**Table D.2. Ground stone & hammerstone analysis from site 42KA3097**

| Material | Color | Burn | L (cm) | W (cm) | Th (cm) | Type | Comp | Texture | Design | Manuf | # Surfaces | S. Texture | Morph | Wear | W. Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QT | RED | N | 7.10 | 4.60 | 2.60 | UGS | 3 | FN | ID | IC | 1 | FN | IR | L | IC |
| SN | TAN | N | 5.00 | 4.20 | 4.00 | UGS | 3 | CS | IN | IN | 1 | CR | IR | UN | UN |
| SN | RED | N | 5.20 | 4.40 | 4.00 | UGS | 3 | MD | IN | IN | 1 | CR | IR | UN | UN |
| QT | RED | N | 6.20 | 4.10 | 3.80 | UGS | 3 | FN | IN | PK | 1 | FN | IR | UN | UN |
| QT | TAN | N | 7.10 | 5.30 | 5.00 | SMN | 3 | FN | IN | PK | 1 | FN | IR | PK | UN |
| QT | TAN | N | 6.00 | 5.20 | 4.40 | SMN | 3 | MD | IN | PK | 1 | CR | IR | PK | UN |
| un | UN | N | 11.70 | 8.60 | 3.10 | UGS | IND | FN | IN | IC | 1 | FN | IR | UN | UN |
| UN | UN | N | 7.30 | 6.80 | 4.20 | UGS | IND | MD | ST | PK | 1 | UN | UN | UN | UN |
| UN | UN | N | 10.60 | 7.30 | 3.00 | UGS | IND | CS | ID | PK | 1 | UN | UN | UN | UN |
| UN | UN | N | 9.60 | 9.00 | 5.10 | UGS | IND | MD | ID | PK | 1 | UN | UN | UN | UN |
| UN | UN | N | 11.50 | 6.90 | 11.40 | UGS | IND | MD | ID | PK | 1 | UN | UN | UN | UN |
| SN | TAN | N | 12.70 | 6.30 | 3.60 | MTF | 2 | FN | ID | GR | 2 | UN | UN | UN | UN |