UtahStateUniversity

Future Moab Campus

Moab, Utah

30-Year Campus Master Plan

March 2012

Contents

Consultant Team

Planner: DESIGNWORKSHOP

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Executive Summary

The Utah State University future Moab campus master plan is a comprehensive assessment of the property and vision for the campus.

During an initial visioning session, the project stakeholders and design team collectively decided that the future Moab campus will have regionally appropriate architectural character and will let the site qualities define the character of the development. The native character of the land will be maintained to the greatest extent possible and the plan will leverage the best attributes of the property including its views, topographic features, colors and textures.

During the analysis phase, access from Highway 191, future adjacent developments, power lines and pipelines were identified as the major constraints on the property. Opportunities include incredible views, a large, flat portion of the University parcel, trail connection possibilities and cooperation with The State of Utah School and Institutional Trust Lands Administration (SITLA), who is the owner of most surrounding properties.

A joint planning process with SITLA was initiated to develop integrated land use, transportation and utility systems with the intent of creating an integrated master plan that has complimentary uses.

The resulting land use plan for the area includes close to 11 acres of land for student housing that could yield up to 270 units, 26 acres of land for multi-family housing that could yield up to 510 units and 24 acres of land for single-family housing that could yield up to 95 units. The campus plan includes 426,000 gross square feet (gsf) of buildings including 60,000 gsf of federal agency space, a central plant, a student union and a small amount of retail space. The plan also includes two three-story parking garages with a total of 1080 stalls.

The plan is linear in nature and organized along a central pedestrian spine in order to take advantage of a flat portion of the site. The pedestrian spine also acts as a campus utility and emergency vehicle corridor. An access road divides the core of the academic campus from the parking side to create a pedestrian friendly experience and a series of campus pods organize buildings around central courtyard spaces, which define where designed and programmed exterior spaces will be developed. The remainder of the landscape will be native.

The utilities and systems for the campus have been planned in conjunction with the SITLA properties. The systems include the road network, power access, sewer connection, water demand and connections, storm water system, fiber optic connection, gas connection, other dry utilities, bicycle lanes and a trail network.

A vision for the first phase building is included in the master plan to create a foundation for fund raising and to capture the imagination of the University, Moab residents and future students at Utah State University, Moab.

View of the La Sal Mountains from the USU Future Moab Campus site

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Background

Context Map

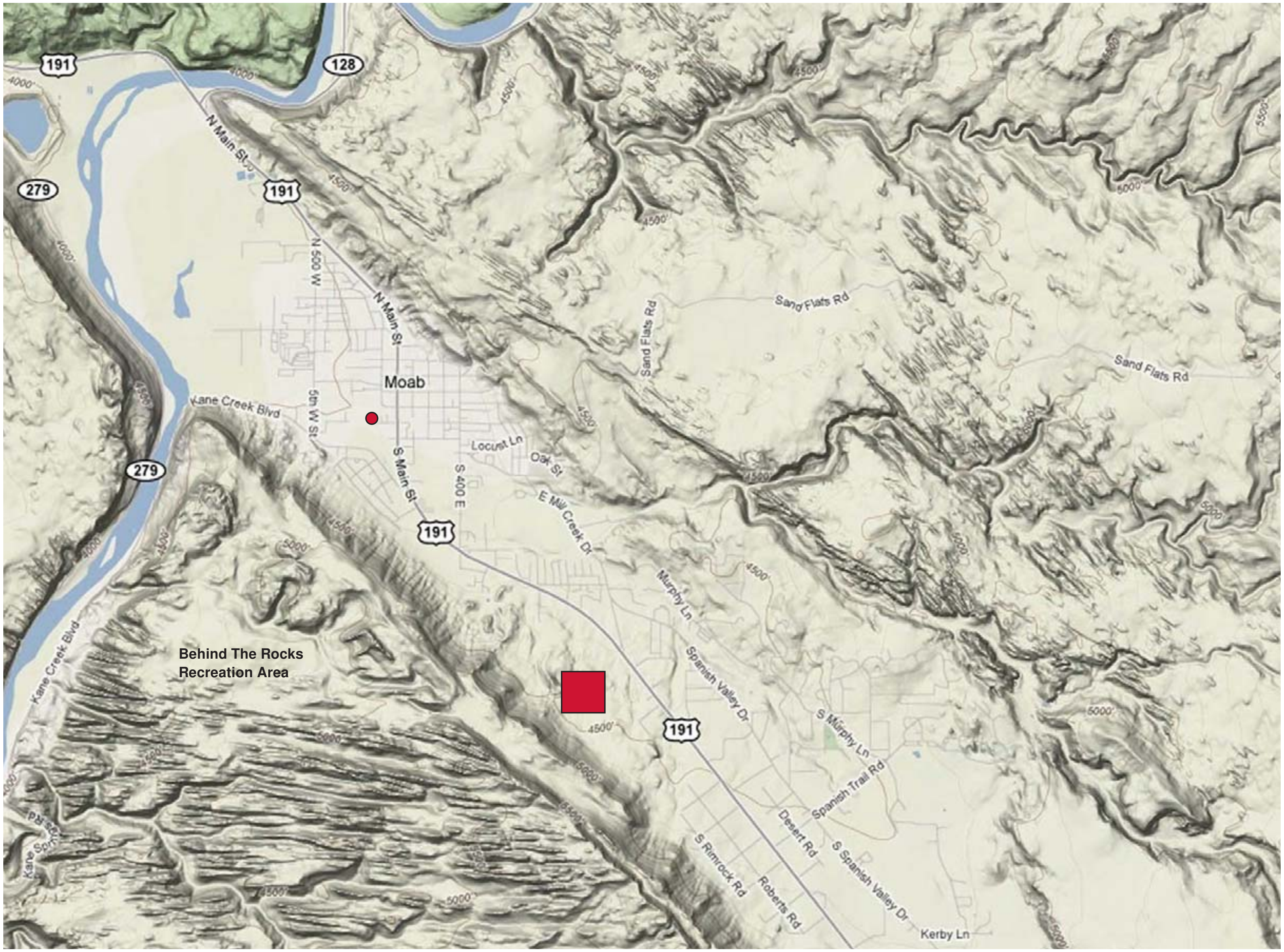
The location of the Utah State University Future Moab Campus is on a 40-acre site that is approximately 3 miles from the center of Moab City.

Vehicular access to the campus is primarily via Highway 191. A new road is planned to access the property from the highway.

The site (red box) is located on an elevated piece of property next to a cliff band below the “Behind The Rocks” recreation area.

There is a prominent view of the La Sal Mountain range from the property in addition to views north towards Moab City and the cliffs adjacent to the property.

The existing Utah State University Moab Education Center is located at 125 W 200 S. (red dot).



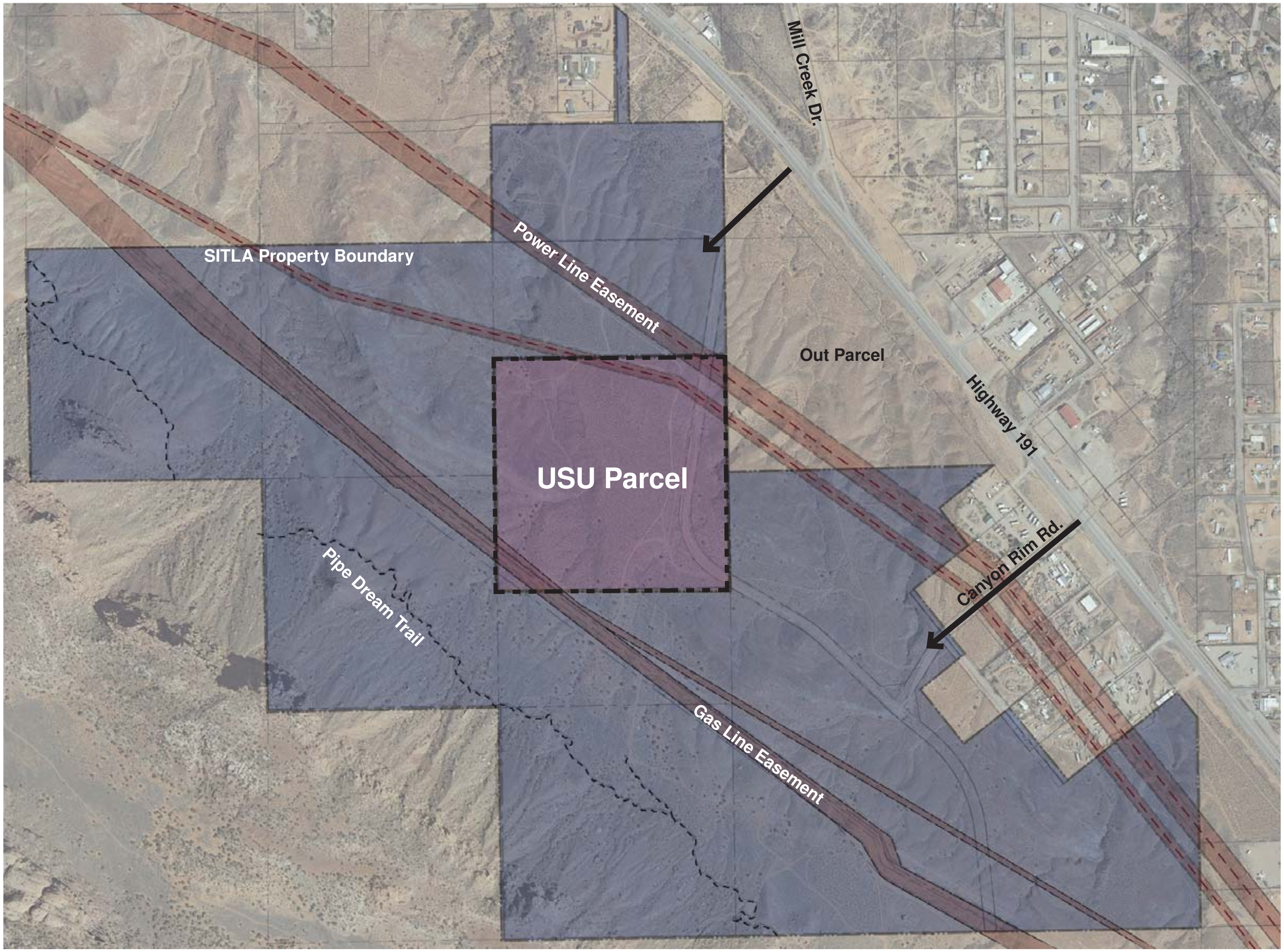
Site Map

The 40-acre parcel of land allocated for the future Moab Campus is positioned within 326 acres of land owned by SITLA. SITLA is collaborating with USU and the planning team to develop a plan with integrated infrastructure and land use for this area.

An additional piece of land labelled "out parcel" is not owned by the University or SITLA. There are preliminary plans by the owner to develop the property as a large-scale retail center.

The main access points to the property are identified by the red arrows. The most desirable location is across Highway 191 from Mill Creek Dr. There are plans to reconfigure the intersection of Mill Creek Dr. with Highway 191 and the entrance road to campus would be located at this new intersection. The second location is along Canyon Rim Rd. The properties along that road are unkempt and therefore not suitable for a primary entrance to the University campus.

The primary constraints to development on the property are power and gas easements that run through the site and the undulating topographic conditions.



USU Moab and the creation of a future Moab campus

In 1969, the Utah State Legislature established the USU Southeast Center for Continuing Education. Professors flew down from Logan three days per week to teach classes.

In the 1980's, USU began offering electronic class delivery.

In 1995, the Ron and Katherine Holyoak family donated 20 acres of land dedicated to the development of a future Moab campus.

In 1997, USU partnered with the Utah Education Network (UEN) to deliver classes through a statewide satellite system.

In 2005, Utah State University initiated the Moab Education Center. The center currently has nine distance education classrooms, approximately 115 enrolled students and a capacity for 200.

In 2007, UEN and USU partnered to develop the video conferencing system used today for face-to-face interactive distance education.

Plans for a future campus have been underway for several years. A planned land swap with SITLA expanded the campus site from a 20 acre parcel into a 40 acre parcel.

The initiation of the annexation process to transfer jurisdiction of this property from Grand County to the City of Moab is also under way. All of these actions have paved the way for the University to begin a master planning process for the future campus.

Following an initial visioning process that produced renderings for the first facility planned for the campus, the Wendy Walker-Tibbetts family gifted $15 million towards the construction of a future Moab campus facility.

This master planning document envisions what the campus will be in 30-years.

Existing USU Moab Education Center

Vision For the Future campus

A vision for the campus was developed and documented through discussions about environmental, economic, community, and aesthetic attributes the plan should have. Design Workshop calls this comprehensive sustainable approach, DW Legacy Design®. The following is a brief description of those categories.

Environment. Human existence depends on recognizing the value of natural systems and organizing its own activities to protect them. Design should fit the purpose to the conditions of the land in ways that support future generations, driving value long-term.

Economics. Projects must be financially sustainable to last multiple generations. Projects that are socially and environmentally responsive are, in the long term, the most economically successful.

Community. Projects must contribute to the quality of life of the people who use them and who are affected by them. They shall be regenerative, seeking to repair damage to the community fabric where it exists and lifting up the lives of those who are influenced. The design of the built environment should foster connections and interaction among families, groups, towns, cities and nations.

Art/aesthetics. Beauty is a timeless quality. It boosts economic value, supports viability, attracts capital and contributes to a project's longevity. Our design process seeks new aesthetic solutions, while at the same time producing works that are not merely provocative or sensational. Timeless works provide meaning and enjoyment for passing generations and endure temporary styles or shifting fads.

Environment

Buildings

All buildings on campus will be certified to a minimum LEED Silver level with potential for gold or platinum certification.

Buildings will be oriented to enhance their energy efficiency by controlling solar heat gain and utilizing relatively narrow floors to provide maximum daylight distribution to all spaces.

The campus buildings and infrastructure will contribute to the Utah State University net zero 2050 goal.

Appropriate alternative energy sources will be researched and utilized to heat water and power campus facilities.

Campus facilities will minimize water use through efficient fixtures and re-use harvested water for non-potable purposes and in the landscape.

The facilities will be constructed using materials sourced locally and within 500 miles of the site.

Landscape Character

The campus will be positioned in the natural landscape with the intent of preserving all major natural topographic features and the native landscape character.

Existing drainage systems will be preserved to ensure natural patterns are not disturbed and to act as wildlife corridors through the site.

The planting strategy for areas of the site that are disturbed will be to revegetate areas that will remain native and to utilize xeric, water conserving species within the campus itself.

All lighting systems will recognize dark sky protocols.

Storm Water

The campus will detain up to the 100 year 24-hour storm on-site to ensure there is no net gain of storm water run-off in volume over pre-development conditions.

Surface detention strategies in addition to subgrade storm water detention vaults will be considered during the planning process.

Multiple strategies to reduce the volume of runoff will also be considered including green roofs and permeable paving.

Art / Aesthetics

Landscape Aesthetics

The natural character of the site will be the defining character of the campus and the campus will blend with the environment.

The master plan will minimize the visual impact of parking lots.

Architectural Aesthetics

The architecture will be a modern Southwest style that is influenced by local materials and the Colorado Plateau landscape.

The architectural language should be able to transfer to the rest of the campus and context.

Campus Identity

A landmark will be located on Highway 191 to mark the University campus entry drive.

A signature architectural component will be created within the campus to signify higher education and Utah State University in Moab.

Community

Trails

Local and regional destinations will be linked together through a comprehensive trail network.

A pedestrian under-pass will cross Highway 191 to safely connect the University campus with downtown Moab and the surrounding residential communities.

The trail network will provide a strong link to SITLA properties and future student / residential housing communities on that land.

Through the trails network, the campus will be walkable and bikeable and will reduce single-occupancy vehicle trips.

Civic Life

The campus will be a venue for arts and culture.

The campus will be a place of community interaction for all age groups and all walks of life.

The campus will contain an amphitheater and a potential conference center facility that can be used by the greater community.

Community Impact

The campus will increase local employment opportunities and will create a more educated local community populace.

The campus students will increase local tax revenue to the City through housing demand and retail patronage.

The University will be an asset that strengthens the community.

The campus will increase the demand for daily commercial needs in the community and on the campus.

Economics

Funding Mechanisms

USU will apply for CIB funding to finance infrastructure including roads, utilities and storm water system projects.

USU will utilize private funding like the Wendy Walker-Tibbetts gift to build facilities.

USU will utilize dedicated Moab City campus funds to finance portions of the project.

USU will target sustainability funds and incentives to reduce overall hard costs.

USU will seek to partner with Federal agencies to lease lab and office space to help finance facilities.

Growth Projections

Precedent

Recorded data on the six year growth trend of the USU Moab Education Center indicates a linear 17.5% annual growth rate when calculating head count and a linear 14.6% annual growth rate for Full Time Equivalent (FTE) students.

The growth of the center actually started off slow with some slight declines for the first three years but has realized 18% to 45% growth over the last three years in both head count and FTE.

Projections

For the purpose of projecting growth for the future Moab Campus, this study projects FTE growth at 11%, 13% and 15% with Head count growth at 10%, 12% and 14%. The intent is to show a range of possible trajectories.

The head count growth will likely slow in relation to FTE over time as the student body transitions to a higher number of traditional vs. Non-traditional students over time.

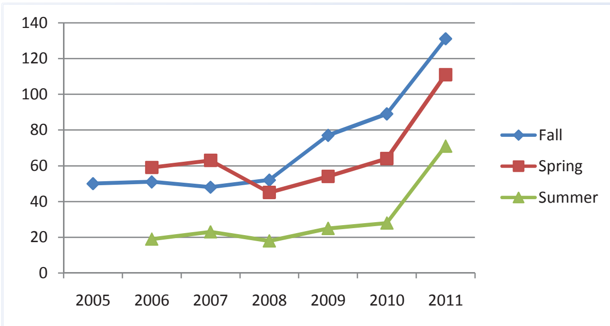
There will likely be years of rapid growth as has occurred recently. A growth spurt may also occur for several years after the first new facility is built.

There may also be a levelling off at some point in the future, which will likely correspond to absorption of the local market and the growth rates of Moab and Grand County.

Precedent Growth Data

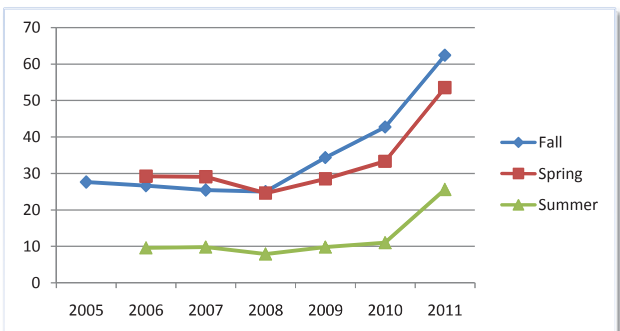
HEAD COUNT

	2005	2006	2007	2008	2009	2010	2011
Fall	50	51	48	52	77	89	131
Spring		59	63	45	54	64	111
Summer		19	23	18	25	28	71



FTE

	2005	2006	2007	2008	2009	2010	2011
Fall	27.6	26.6	25.4	25	34.3	42.7	62.4
Spring		29.2	29.1	24.6	28.5	33.3	53.5
Summer		9.6	9.8	7.9	9.8	11	25.6



30-Year FTE Projections

Annual Growth over 6 years

FTE Precedent **14.6%**

	2005	2006	2007	2008	2009	2010	2011
Actual	27.6	26.6	25.4	25	34.3	42.7	62.4
Straight		31.6	36.2	41.5	47.6	54.6	62.5

FTE

11.0% Growth Rate

	2016	2021	2026	2031	2036	2041
Students	105	177	299	503	848	1428
Faculty / Staff	9	15	25	42	71	119
Total:	114	192	323	545	918	1548

13.0% Growth Rate

	2016	2021	2026	2031	2036	2041
Students	115	212	390	719	1325	2441
Faculty / Staff	10	18	33	60	110	203
Total:	125	229	423	779	1435	2644

15.0% Growth Rate

	2016	2021	2026	2031	2036	2041
Students	126	252	508	1021	2054	4132
Faculty / Staff	10	21	42	85	171	344
Total:	136	273	550	1106	2225	4476

Staff / Faculty ratio based on the Uinta Basin, Tooele and Brigham City averages
1:12

Growth Projections (Cont.)

30-Year Head count Projections

Annual Growth over 6 years

Head Count Precedent 17.5%

	2005	2006	2007	2008	2009	2010	2011
Actual	50	51	48	52	77	89	131
Straight		58.8	69.0	81.1	95.3	112.0	131.6

Head Count

10.0% Growth Rate

	2016	2021	2026	2031	2036	2041
Students	211	340	547	881	1419	2286
Total:	211	340	547	881	1419	2286

12.0% Growth Rate

	2016	2021	2026	2031	2036	2041
Students	231	407	717	1264	2227	3925
Total:	231	407	717	1264	2227	3925

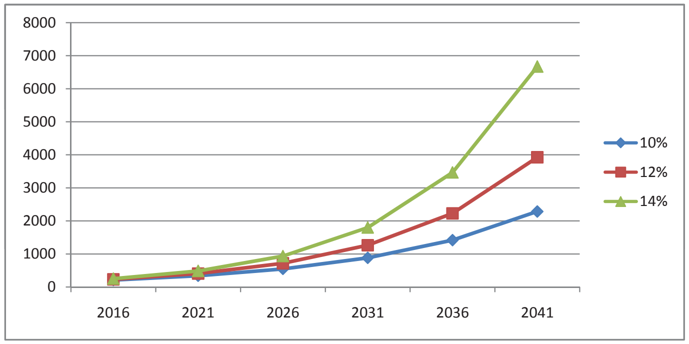
14.0% Growth Rate

	2016	2021	2026	2031	2036	2041
Students	252	486	935	1800	3467	6674
Total:	252	486	935	1800	3467	6674

30-Year Projection Charts

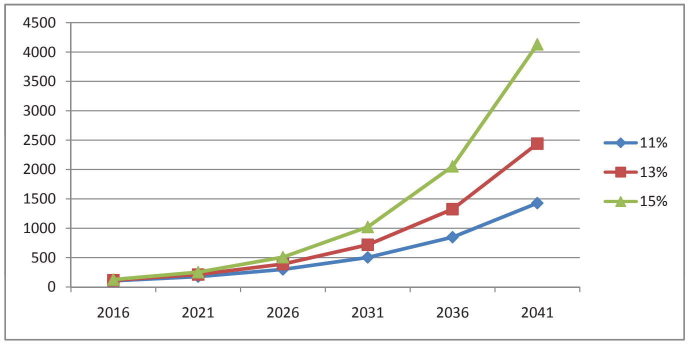
Head Count Projection

	2016	2021	2026	2031	2036	2041
10%	211	340	547	881	1419	2286
12%	231	407	717	1264	2227	3925
14%	252	486	935	1800	3467	6674



FTE Growth Projection

	2016	2021	2026	2031	2036	2041
11%	105	177	299	503	848	1428
13%	115	212	390	719	1325	2441
15%	126	252	508	1021	2054	4132



Campus Building / Parking Capacity

It is envisioned that the future Moab Campus will start out as a non-traditional student campus and evolve into a more traditional destination campus over time.

Many attributes of the Moab region draw prospective students nationally and internationally and those attributes are the foundation for future USU Moab degree programs.

The following analysis projects building square footage on an area per student ratio (sf/FTE column). That ratio is different depending on the type of student. The ratios were determined based on current USU master planning processes and conditions at USU Toole, Uinta Basin and Brigham City.

The head count and FTE projections are based on the mid-range growth model illustrated on previous pages.

Parking assumptions are based on a residential campus ratio of .25 stalls per student and assume proximate student housing, walkability, bikeability and future transit will reduce the overall parking demand.

The building program also assumes that 60,000 square feet of leasable space will be developed by potential partners of the University including federal agencies that can share lab space and educational resources.

In order to accommodate 3500 students and provide space for future partners, the campus will need a build-out of 430,000 gross square feet (gsf) of building space and provide a total of 1032 required parking stalls.

Building Capacity

Total Square Footage by Student Population	Headcount	FTE %	FTE	Faculty/Staff (1:12 FTE)	sf/FTE	Total SF	Notes
Traditional Student (on-the-ground teaching)	1000	75%	750	63	150	112,500	Assuming 2000 students in On-the ground programs and 50% of courses on-the-ground (1000)
Traditional Student (remote teaching)	2200	75%	1650	138	150	247,500	Assuming 1200 students in remote programs and 50% of courses for on-the-ground programs taught remotely (1000)
Non-traditional Student (remote teaching)	300	50%	150	13	80	12,000	Assuming 300 student ceiling for non-traditional students
Federal Agencies						60,000	
Totals	**3500**		**2550**	**213**		**429,600**	

Parking

Total Parking Stalls needed	Headcount	Stalls per headcount	Stalls needed		Notes
Traditional Student	3200	0.25	800		
Faculty and Staff	213	0.5	106		
Non-traditional Students	300	0.5	150		
Federal Agencies			180		Assuming 3 cars per 1000/SF for 60,000 SF of space
Subtotal:	**3713**		**1236**		
Shared Parking Reduction			150		Non-traditional students will use traditional student spaces in the evening time
Subtota:l			**1086**		
5% Transit Reduction			54		
Total Recommended Stalls:			**1032**		

Educational Programming

Current USU Moab Programs

Masters Degrees
- Agricultural Systems Technology, MS
- Applied Environmental Geoscience
- Computer Science, MS
- Elementary Education, MEd
- English–Technical Writing, MS
- Health, Physical Education, & Recreation, MEd
- Human Resources, MS
- Instructional Technology & Learning Sciences, MS
- Instructional Technology, MEd
- Natural Resources, MNR
- Psychology - School Counseling, MS
- Rehabilitation Counseling, MRC
- Secondary Education, MEd
- Social Work, MSW
- Special Education, MEd, MS

Bachelors Degrees
- Accounting, BS
- Agribusiness, BS
- Business, BS
- Communicative Disorders, 2nd BS
- Communicative Disorders & Deaf Education, BS
- Early Childhood Education (K-3), BS
- Economics, BS
- Elementary Education (K-6), BS
- English Teaching, BS
- Entrepreneurship, BS
- Family Life Studies, BS
- History, BS
- Interdisciplinary Studies, BS

Bachelors Degrees (continued)
- Management Information Systems, BS
- Mathematics Education, BS
- Psychology, BS
- Recreation Resource Management, BS
- Social Work, BS
- Special Education, BS

Associates Degrees
- Criminal Justice, AS
- General Studies, AS
- General Technology, AAS
- Office Systems Support, AAS

Minors
- Anthropology
- History
- Sociology
- Spanish

Certificates
- Deafblindness - Preservice Training
- Museum Studies
- Native American Studies Program
- Personal Financial Planning

Licensures
- Administrative / Supervisory
- Alternative Route to Licensure, MEd
- Early Childhood-Alternative Teacher . Preparation

Licensures (continued)
- Secondary Teacher Education Program (S.T.E.P.)

Endorsements
- Distance Learning
- Elementary Mathematics
- English as a Second Language
- Gifted and Talented
- Reading
- School Library Media
- Utah Mathematics

USU Moab Programs In Development

- Geology
- Digital Media and Post-Production Film
- Tourism Management
- Natural Resources
- Geology and Geo Science
- Allied Health
- Visual Arts / Fine Arts
- Hospitality
- Alternative Energy Systems
- Nursing

View of the Cliff Band and Character of the Site Topography

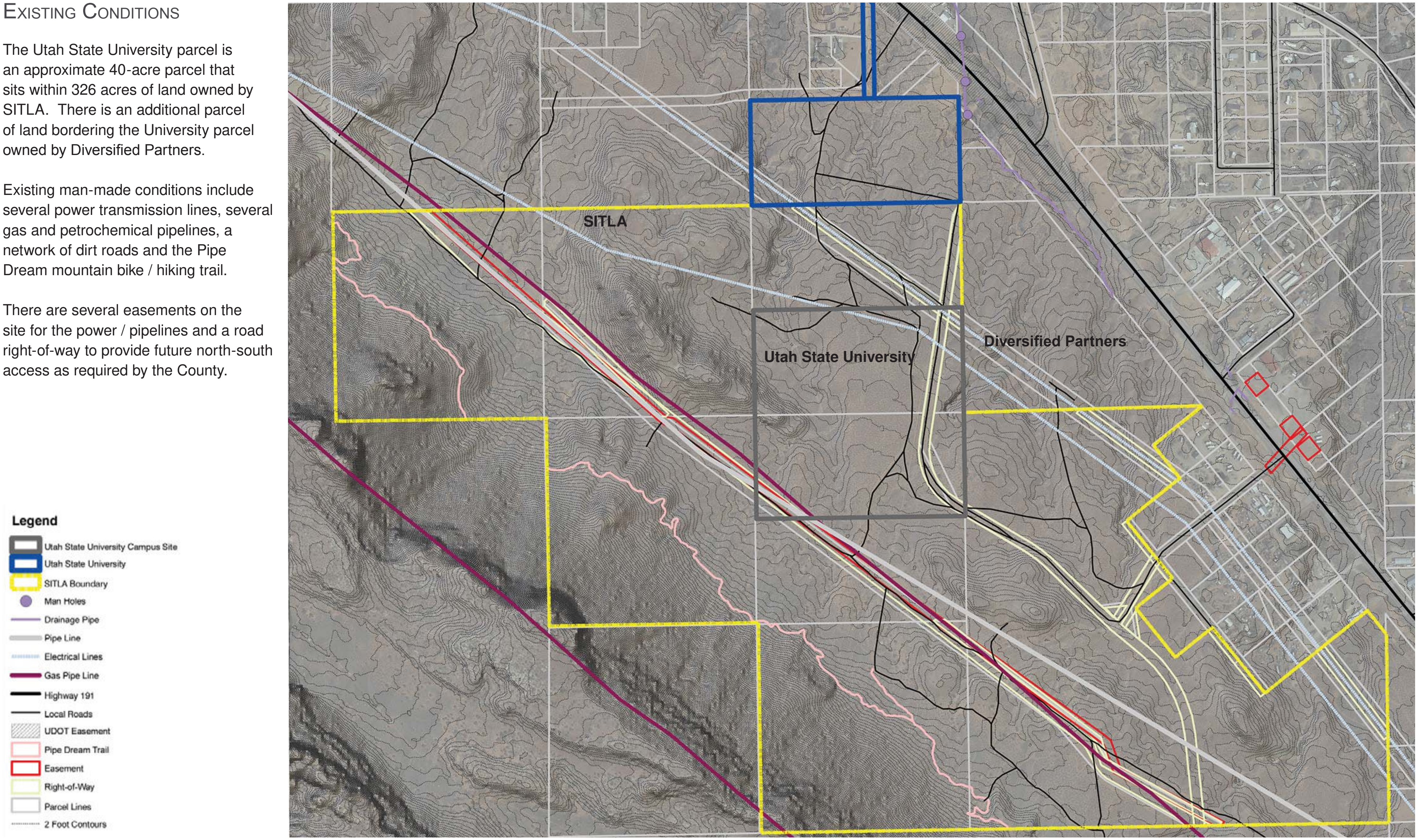
Analysis

Existing Conditions

The Utah State University parcel is an approximate 40-acre parcel that sits within 326 acres of land owned by SITLA. There is an additional parcel of land bordering the University parcel owned by Diversified Partners.

Existing man-made conditions include several power transmission lines, several gas and petrochemical pipelines, a network of dirt roads and the Pipe Dream mountain bike / hiking trail.

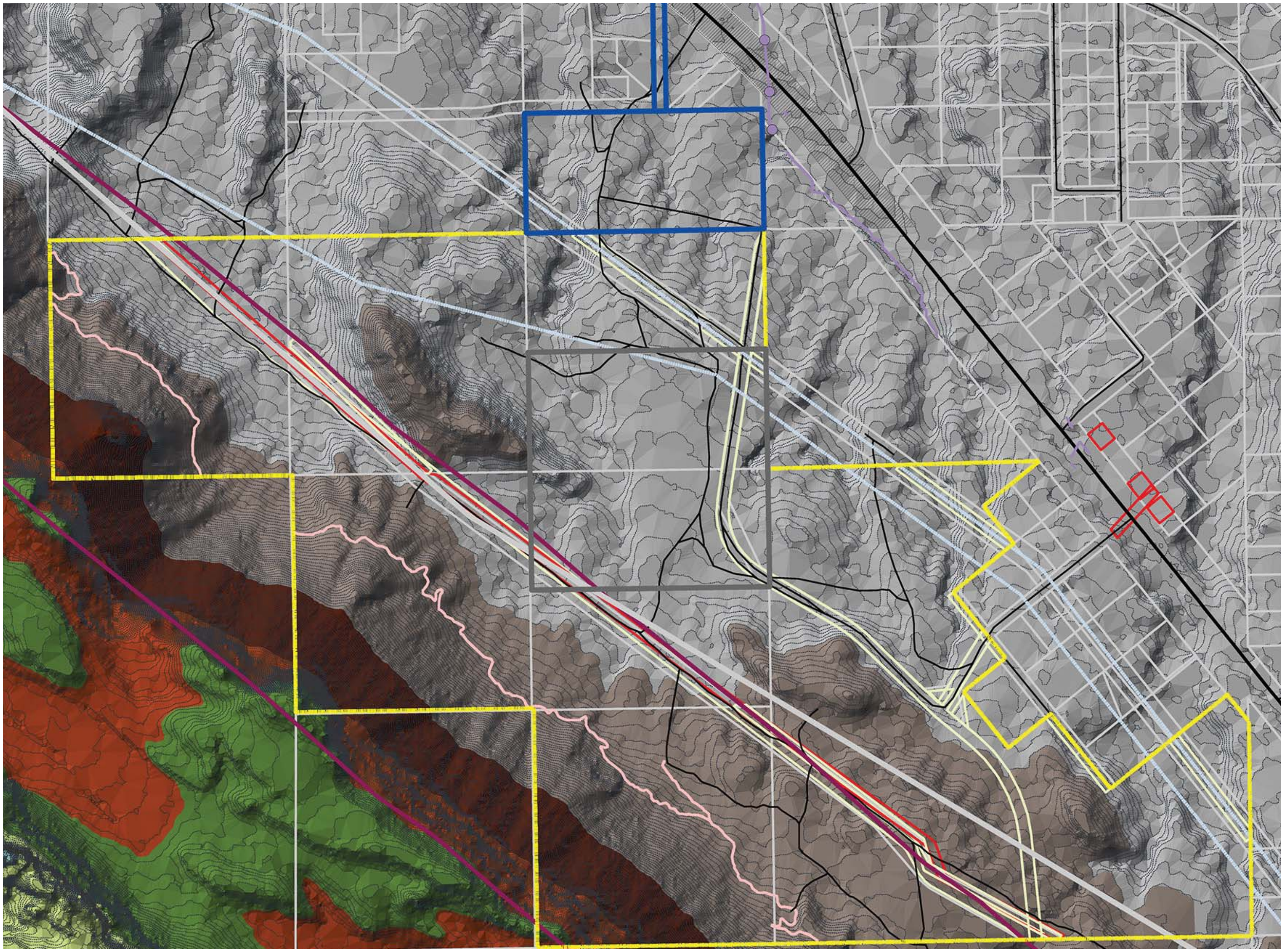
There are several easements on the site for the power / pipelines and a road right-of-way to provide future north-south access as required by the County.



Elevation - Context

The cliff band is the most prominent topographic feature near the site. These cliffs rise to over 6,000 feet in elevation. The road elevation near the Mill Creek intersection with Highway 191 is at 4,257 feet.

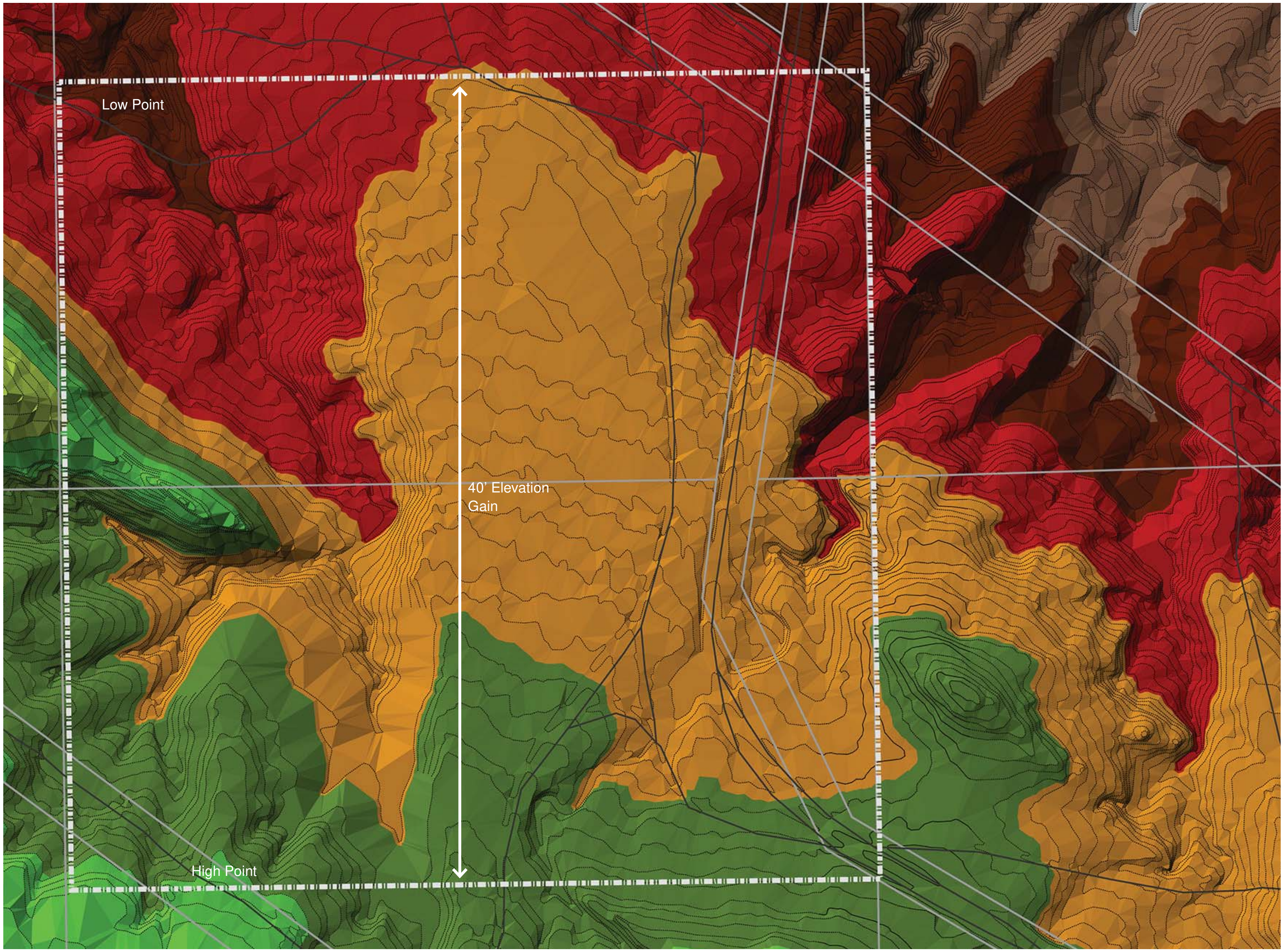
The center of the Utah State University site is at 4,356 feet. The project site is over one hundred feet above Highway 191 and over 1,600 feet below the top of the cliffs.



Elevation - Site

The high point of the site is on the south west corner of the site and is 4,454 in elevation. The low point is 4329 in elevation located in the drainage on the north west side of the site.

There is a 40' rise in elevation from the north side of the site to the south measured across the most developable land of the campus site.



Legend

- Utah State University Campus Site
- Highway 191
- Local Roads
- Parcel Lines
- 2 Foot Contours

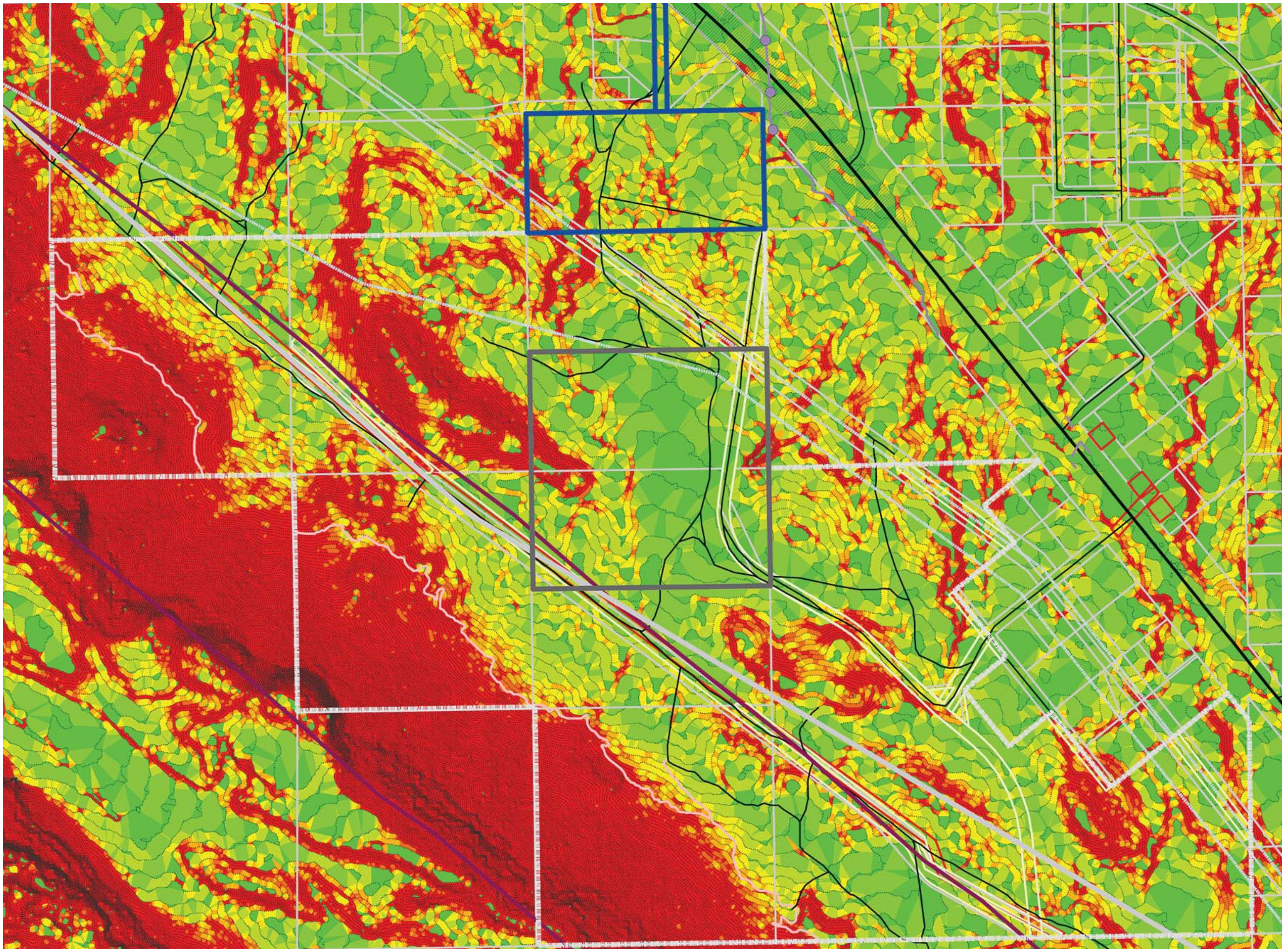
Elevation Model (in feet)

- 4,550 and higher
- 4,525 - 4,550
- 4,500 - 4,525
- 4,475 - 4,500
- 4,450 - 4,475
- 4,425 - 4,450
- 4,000 - 4,425
- 4,375 - 4,000
- 4,350 - 4,375
- 4,325 - 4,350

Slope - Context

The contextual slope map illustrates a generally undulating topography with many drainages, sub-drainages and mound features. The cliff band is the steepest area on site and is near vertical in many locations.

The broad green swath in the center of the 40-acre site is the most suitable for development.



Legend

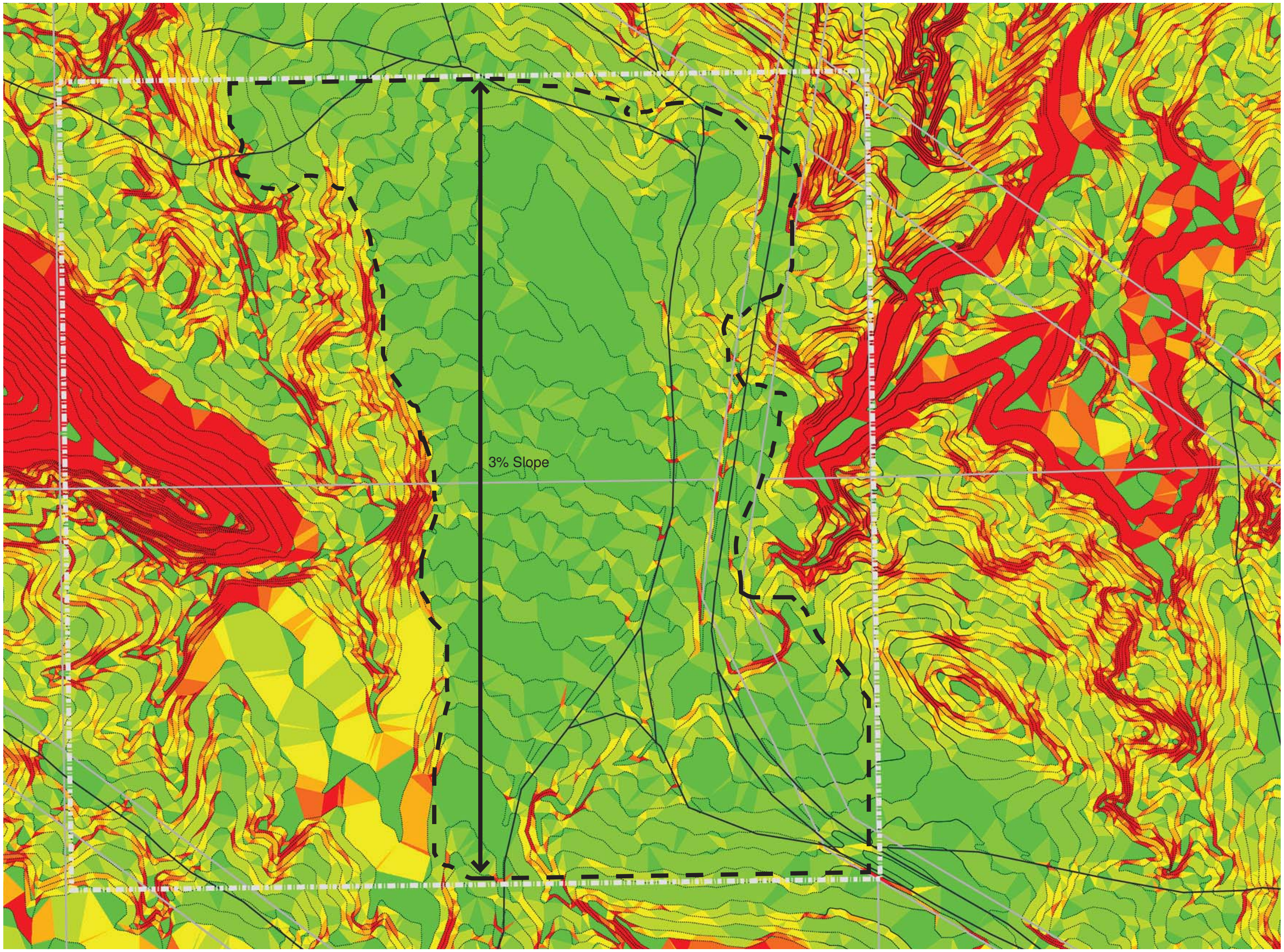
- Utah State University Campus Site
- Utah State University
- SITLA Boundary
- Man Holes
- Drainage Pipe
- Pipe Line
- Electrical Lines
- Gas Pipe Line
- Highway 191
- Local Roads
- UDOT Easement
- Pipe Dream Trail
- Easement
- Right-of-Way
- Parcel Lines
- 2 Foot Contours
- 0-5%
- 5-10%
- 10-15%
- 15-20%
- 20-25%
- 25-30%
- 30% and greater

Slope - Site

The slope in the center of the Utah State University parcel is an average of 3% from north to south measured in the center of the site and is therefore, highly developable.

This developable area (dashed outline) is approximately 25 acres in size - juts over 50% of the parcel. Development should be contained within this zone to protect the natural topographic features on the site.

Slopes increase considerably within the two drainages on either side of the developable pad.



Legend

- Utah State University Campus Site
- Highway 191
- Local Roads
- Parcel Lines
- 2 Foot Contours
- 0-5%
- 5-10%
- 10-15%
- 15-20%
- 20-25%
- 25-30%
- 30% and greater

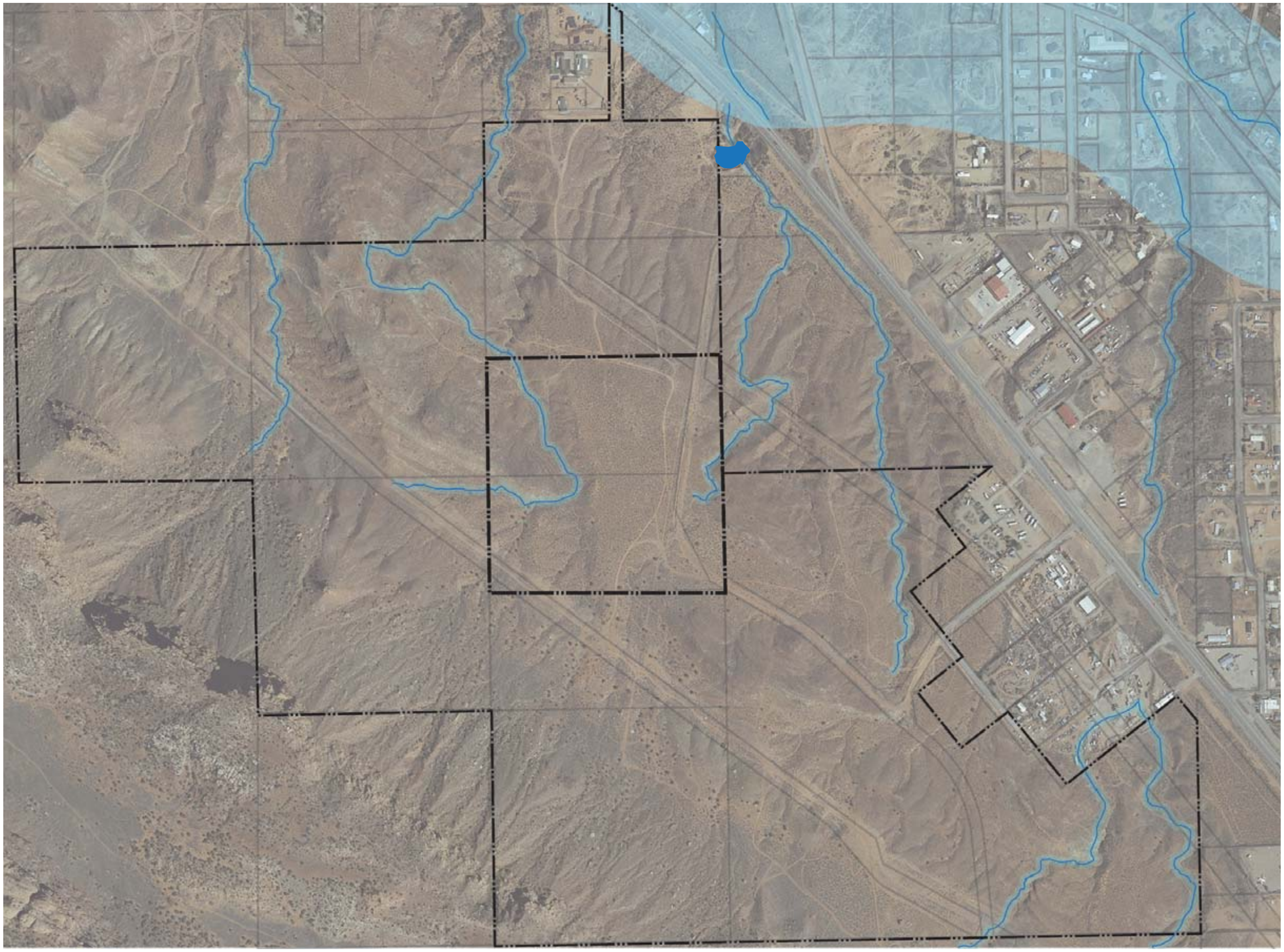
Hydrology - Context

The site lies within the lower Pack Creek watershed area. The six primary drainages / streams illustrated within the SITLA and USU property are perennial streams that see water only during storm events. These drainages empty into Pack Creek, which runs parallel to Highway 191 on the north side until it crosses the highway just south of town and empties into Mill Creek. Mill Creek drains into the Colorado River.

Shallow ground water is evident near Highway 191 and the bottom of the valley but should not be an issue on this site.

An existing detention basin and related improvements exist north of the site next to Highway 191.

Development within the greater property will seek to detain all storm water on site and limit post development storm water run-off to pre-development levels.



Legend

Primary Drainages / Streams

Shallow Ground Water

Detention Basin

Wildlife - Site

Ring-necked Pheasant
Conditions on the northern portion of the site are suitable for Ring-Necked Pheasant Habitat. This species prefers fields and farmland with brushy cover for nesting and foraging. They are a ground dwelling species but will fly when needed. This species is a sought after game bird for hunters but population levels remain steady due to stocking. Ring-Necked Pheasant are not endangered or protected.

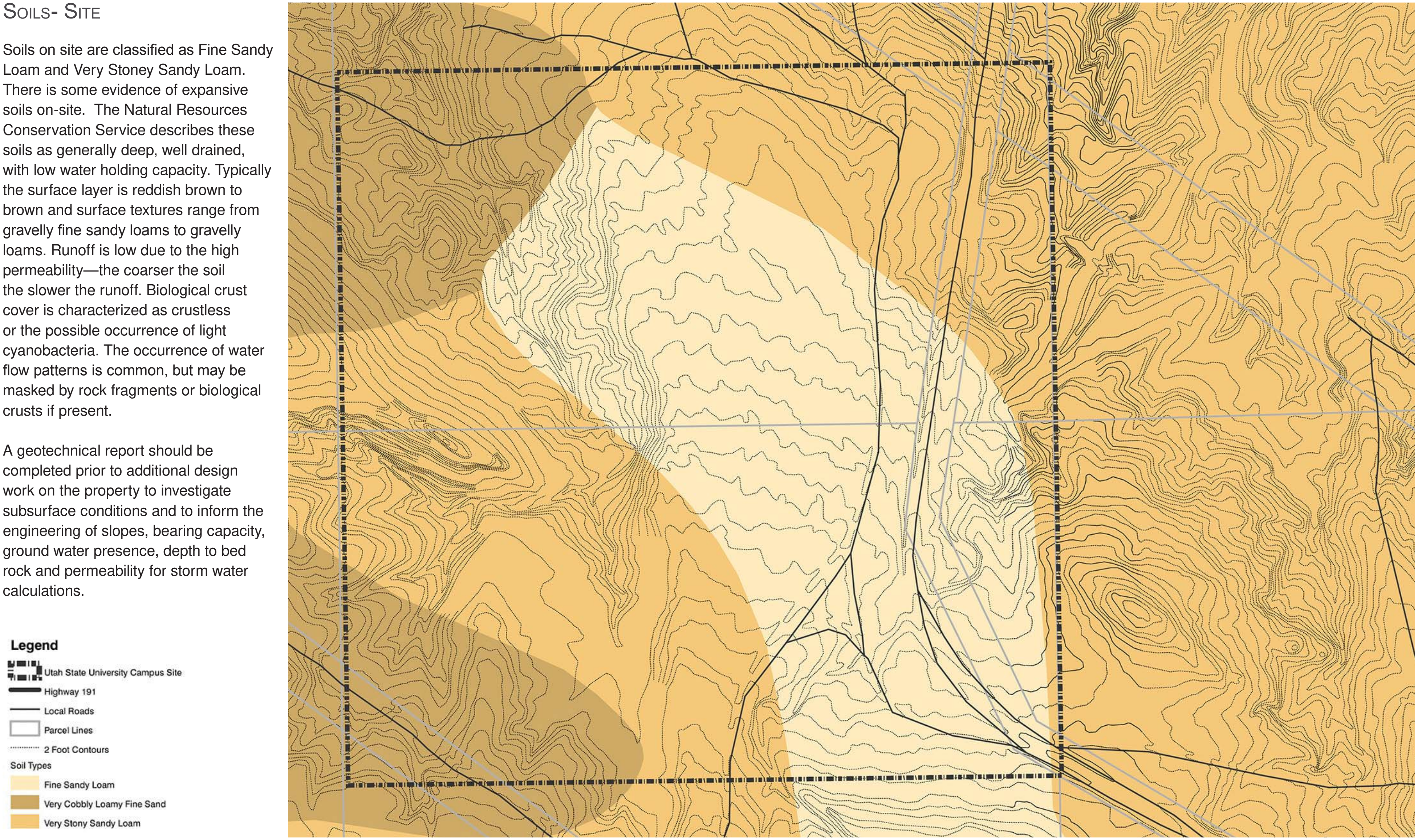
Chukar Partridge
Chukar prefer talus or rocky slopes above streams. The upper portions of the site on the south side have some characteristics of the preferred habitat for this species but they would be more likely found on the steeper slopes. Habitat for this species is generally uncontested from development because they prefer remote, rugged areas. Chukar are not endangered or protected.

There is some evidence of Mule Deer on site but this area is not believed to be prime habitat for them.

Soils- Site

Soils on site are classified as Fine Sandy Loam and Very Stoney Sandy Loam. There is some evidence of expansive soils on-site. The Natural Resources Conservation Service describes these soils as generally deep, well drained, with low water holding capacity. Typically the surface layer is reddish brown to brown and surface textures range from gravelly fine sandy loams to gravelly loams. Runoff is low due to the high permeability—the coarser the soil the slower the runoff. Biological crust cover is characterized as crustless or the possible occurrence of light cyanobacteria. The occurrence of water flow patterns is common, but may be masked by rock fragments or biological crusts if present.

A geotechnical report should be completed prior to additional design work on the property to investigate subsurface conditions and to inform the engineering of slopes, bearing capacity, ground water presence, depth to bed rock and permeability for storm water calculations.



Rock Fall Hazard - Context

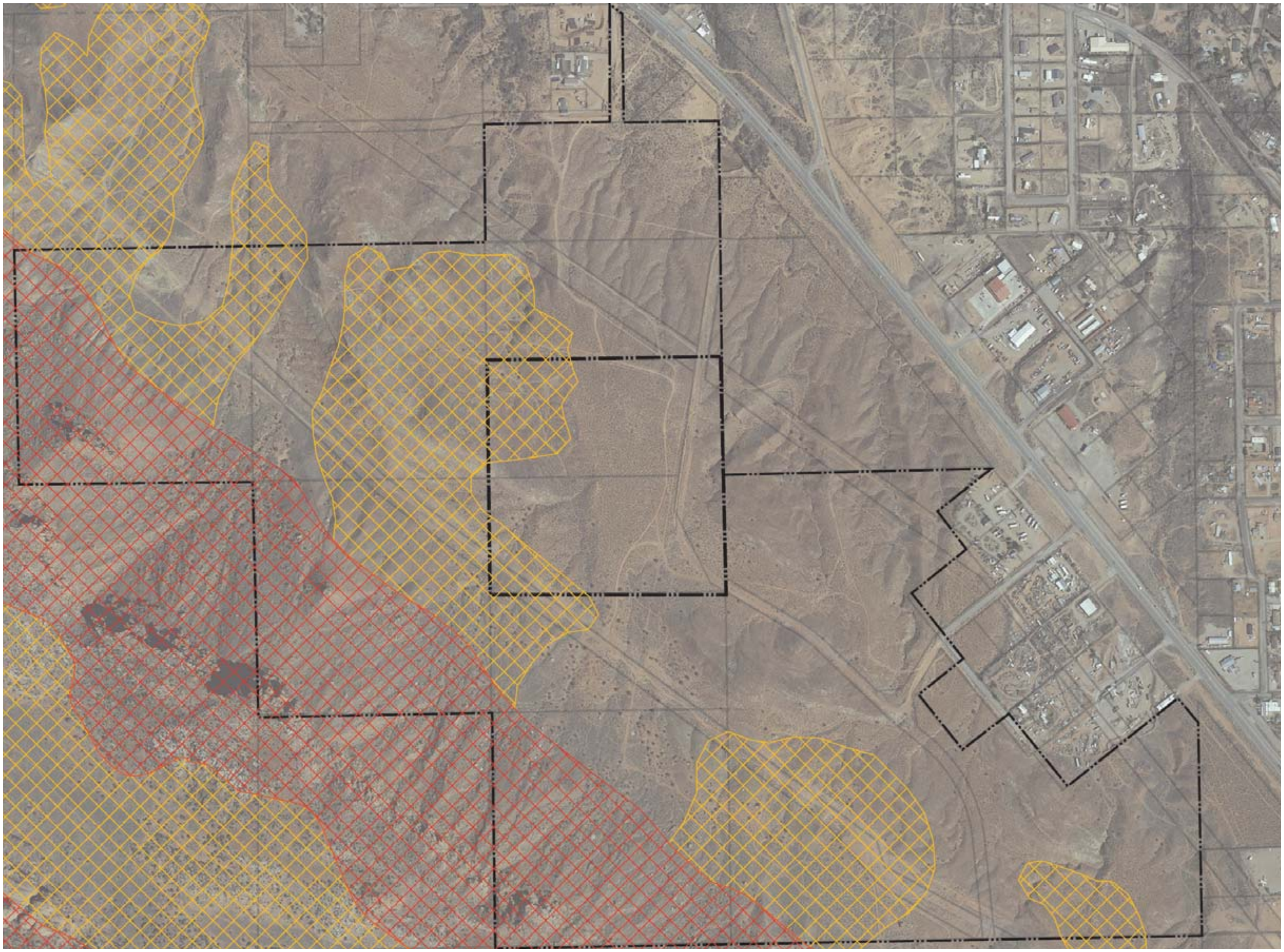
A study published in 2003 by the Utah Geological Survey named: "Geologic Hazards of Moab-Spanish Valley, Grand County, Utah", identifies moderate and high risk rock fall zones on and around the vicinity of the project site.

The high rock fall hazard areas are characterized by cliff areas of high relief with steep slopes below cliffs. Boulders falling from these areas can have a high velocity and travel upwards of 1,000 feet in the run-out zone.

The moderate rock fall hazard zones are low relief upland areas underlain with bedrock. Dislodged rocks in these areas are not likely to gain significant velocity or travel more than a few tens of feet.

It is recommended that a geologist specializing in rock fall hazards assess and map this area for specific and local hazards to identify actual conditions on the site. The study cited above was conducted at a regional scale and may not be accurate at a site scale.

A copy of the regional map and study is included in the appendix.



Legend

- Moderate Rock Fall Hazard
- High Rock Fall Hazard

State of Utah
School and Institutional
TRUST LANDS ADMINISTRATION

Michael O. Leavitt
Governor
David T. Terry
Director

675 East 500 South, Suite 500
Salt Lake City, Utah 84102-2818
801-538-5100
801-355-0922 (Fax)
http://www.trustlands.com

March 1, 1999

Mr. James L. Dykmann,
Compliance Archaeologist
State Historic Preservation Office
300 Rio Grande
Salt Lake City, Utah 84101

RE: USU/CEU Moab Branch Campus Development Parcel, Grand County (No SHPO case no. as yet); finding of ***No Historic Properties***

Dear Jim:

This letter is in regard to the subject action by the School and Institutional Trust Lands Administration, in compliance with accordance with *U.C.A.* 9-8-404 and *U.A.C. R850-60*. The subject action is a proposed development of 375.5 acres of trust land located on the south side of Moab in southern Grand County. Please note the attached report (Wolfe and Montgomery 1999) and IMACS site forms for newly-recorded sites 42Gr2916 through Gr2920 with attached SHPO Cover Page. Please be aware that I am submitting these data both on behalf of Montgomery Archaeological Consultants (in fulfillment of their permit responsibility) and to aid in consultation with your office regarding this case. Please respond to my attention at your convenience.

The subject project is depicted in Figure 1 of the attached report, and described elsewhere in that report. All five of the sites they identified (and recorded for the first time) have been recommended to me as *not eligible* for the National Register, and I concur. Accordingly, the School and Institutional Trust Lands Administration has determined that archaeological sites 42Gr2916, 2917, 2918, 2919 and 2930 are *not eligible*; further, this agency finds that since no other potential historic properties are located in the subject project's area of potential effects, that the proposed university branch campus development will effect ***No Historic Properties***. Please concur at your earliest convenience. Thanks very much in advance for your time in reviewing this matter. Please contact me at 538-5168 should you need additional information or assistance regarding this case.

Sincerely,

Kenny Wintch

Kenneth L. Wintch
Staff Archaeologist

State of Utah
Department of Community and Economic Development
Division of State History
Utah State Historical Society

UTAH STATE HISTORICAL SOCIETY

Michael O. Leavitt
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300 Rio Grande
Salt Lake City, Utah 84101-1182
(801) 533-3500 FAX: 533-3503 TDD: 533-3502
ushs@history.state.ut.us http://history.utah.org

March 25, 1999

Kenneth L. Wintch, Staff Archaeologist
Utah School and Institutional State Trust
Lands Administration
675 East 500 South, Suite 500
Salt Lake City UT 84102

RE: USU/CEU Moab Branch Campus Development Parcel, Grand County

In Reply Please Refer to Case No. 99-0314

Dear Kenny:

The Utah State Historic Preservation Office received the above referenced report on March 3, 1999. After consideration of the report, the USHPO concurs with the determination that sites; [42GR 2916-19 and 2930] are not eligible for the National Register of Historic Places. We, therefore, also concur with the TLA's determination of **No Historic Property**.

This information is provided on request to assist Trust Lands with its state law responsibilities as specified in U.A.C. 9-8-404. If you have questions, please contact me at (801) 533-3555. My email address is: jdykman@state.ut.us

As ever,

James L. Dykmann
Compliance Archaeologist

JLD:99-0314 Lands/NPx5/NEx5

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Existing Transportation System Assessment

Existing Conditions

Roadway Network

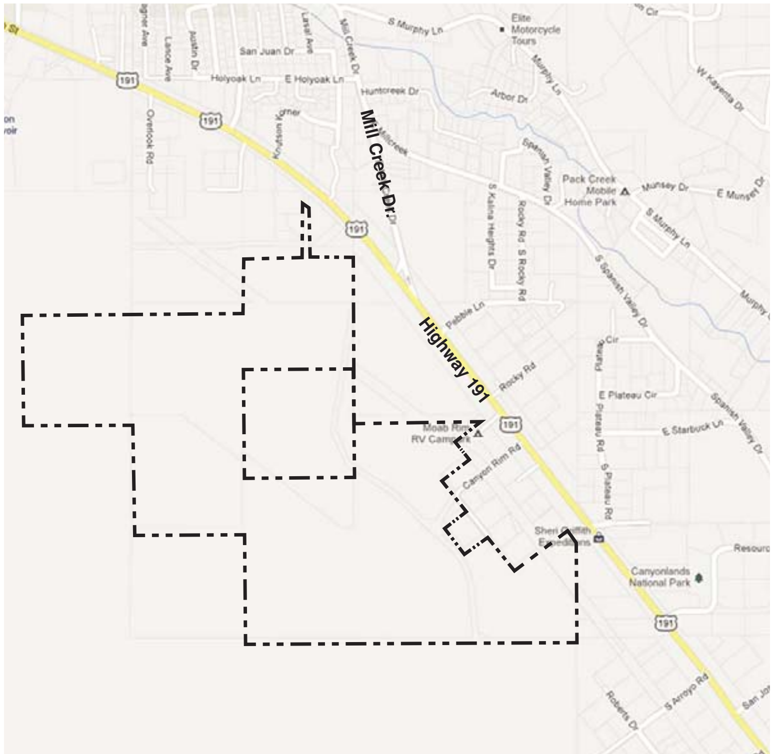
US-191 is a state-operated highway with an access category of "Regional Rural" (access category 4). US-191 is composed of a four-lane cross section with two southbound lanes, one northbound lane, and a center two-way left-turn lane (TWLTL) median. Fairly wide shoulders (approximately 12 feet wide) are located on each side of the road. The posted speed limit in this area is 55 mph.

Mill Creek Drive is a two-lane Moab City road. It intersects US-191 at a fairly sharp angle. The posted speed limit on Mill Creek Drive is 30 mph. This intersection is stop-controlled for Mill Creek Drive. A plan has been developed to re-align Mill Creek Drive as illustrated to the right. Construction of the re-alignment is pending funding.

Several other minor intersections exist near the proposed site that provide access to businesses and small residential subdivisions.

Data Collection

Hales Engineering collected afternoon peak period turning movement volumes at the intersection of Mill Creek Drive and US-191 on Tuesday, July 12, 2011.



Existing Road Network

Mill Creek Re-Alignment Plan (By Others)

The counts were conducted between 4:00 and 6:00 p.m. The peak hour was determined to be between 4:30 and 5:30 p.m. Vehicles were classified during the peak period count. Approximately six percent were combination trucks, three percent single-unit trucks, and five percent recreational vehicles. No pedestrians or cyclists were observed during the count period. Detailed count information can be found in the Appendix.

According to data obtained from UDOT (Traffic on Utah Highways, 2010), the average daily traffic (ADT) on US-191 is approximately 10,100 vehicles per day (vpd). Truck traffic on a daily basis was estimated by UDOT (Truck Traffic on Utah Highways, 2010) to be significantly higher than the observed peak period truck traffic (24 percent combination trucks and nine percent single-unit trucks).

Opportunities/Constraints

Access

US-191 is classified by UDOT as an access category 4 roadway, which stipulates the following spacing requirements: for traffic signals, streets and driveways:

- Minimum signal spacing: 2,640 feet (one-half mile)
- Minimum street spacing: 660 feet
- Minimum access spacing: 500 feet

A realignment of Mill Creek Drive at an angle closer to 90 degrees with US-191 would increase safety at the intersection.

This intersection has also been identified as a location for future signalization. The distance between Mill Creek Drive and the nearest traffic signal north of this location is over one mile and therefore meets the UDOT signal spacing requirements for a new signalized intersection in that location.

This proposed new intersection has been identified as the preferred location for primary access to the project site. Alternative access at Skyline Drive would be difficult due to terrain issues. Access could also be obtained at Canyon Rim Rd. However, because of the adjacent land use, this road is not a preferred gateway to the campus and community.

Existing Transportation System Assessment

Pedestrian/Cycle Issues
It is anticipated that a significant portion of the student body, staff, and faculty could commute to the University using bicycles.

A pedestrian/cyclist tunnel is proposed in this master plan to connect the University and downtown Moab by routing a trail under US-191. During a meeting with UDOT representatives on July 12, 2011, Dale Stapley (Region 4, East ROW Coordinator) indicated that a pedestrian tunnel could be feasible as long as it was long enough to facilitate future widening of US-191 to a five-lane cross section.

Public Transit
Currently, there is no public transit in Moab. Several private organizations (hotels, outfitters, etc.) have shuttles for their patrons. City-wide public transportation including coverage of the USU campus would assist in reducing vehicle trips thereby potentially reducing needed infrastructure capacity (roadways and parking lots). Public transit would provide viable alternatives for both students and staff that live in Moab.

Adjacent Land Use
Adjacent land use plays a critical role in the transportation system for this project. For example, intense land use will consume available capacity at intersections serving this project thereby decreasing the level of service, and possibly limiting the intensity of this project or requiring additional roadway infrastructure. However, a significant number of trips to US-191 could be reduced during peak periods of the day if there are complimentary uses close by as is shown in the plan.

Adjacent land use also provides the opportunity for shared parking agreements that create a net decrease in parking required due to non-overlapping uses. For example, peak residential parking occurs at night while peak college/university parking occurs during the day.

Existing Utility System Assessment

To support the USU Moab master plan project, Stantec completed a preliminary review of the existing utilities required to service the site. Meetings and teleconferences were held with utility providers to discuss the proximity of existing facilities as well as available capacities. The following is a summary of the existing utility systems and the current plan for connection to each utility. *Figure UT-1* illustrates the existing utilities in the project area.

Water

Utility Agency: Grand Water and Sewer Service Agency
Key Contact: Mark Sovine, Manager
Telephone: (435) 259-8121
E-mail: Mark@grandwater.org

Existing System
There are two existing water systems in the general vicinity of the proposed USU Campus. The Moab City water system is constrained to properties north of the site. Connection to this system is not considered feasible due to the distance of existing infrastructure from the USU / SITLA site and the low elevation of existing storage.

The Grand Water and Sewer Service Agency (GWSSA) maintains a 12”-diameter water line in the US 191 right of way. The GWSSA water system serves Spanish Valley and is comprised of seven pressure zones. The USU / SITLA site is located near the lower end of that water system. This location, relative to the GWSSA water system will allow the USU Campus access to water at pressures high enough to service the site. GWSSA has annexed the 326-acre SITLA parcel into its service area, and should have adequate source water and storage to serve the project.

Sewer

Utility Agency: Grand Water and Sewer Service Agency
Key Contact: Mark Sovine, Manager
Telephone: (435) 259-8121
E-mail: Mark@grandwater.org

Existing System
The existing sewer in the area is operated and maintained by GWSSA. There is an 8”-diameter sanitary sewer main in the US 191 right of way. The line ends at the approximate location of the access for the existing 20 acre USU parcel.

Based on conversations with GWSSA, there is capacity in the line to serve the 40 acre USU Campus and SITLA properties.

The GWSSA sewer system connects to the Moab City sewer system via two metered connections. the USU / SITLA properties would likely connect to the GWSSA system. The inter-connectedness of these systems means that existing Moab City sewer system capacities and future demands could affect GWSSA’s ability to provide sewer service to the USU / SITLA properties but currently, there is enough capacity.

Power

Utility Agency: Rocky Mountain Power
Key Contact: Jesse Barker
Telephone: (435) 259-3203
E-mail: Jesse.Barker@PacifiCorp.com

Existing System
The existing Rocky Mountain Power (RMP) distribution system is comprised of 12 kV power lines located within a 2,000-ft radius of the site. Additionally, there are three transmission lines that cross the northeast corner of the Campus site.

The transmission lines are 69 kV, 138 kV, and 345 kV. There is 1 MW available in the area based on current substation capacities.

Natural Gas

Utility Agency: Questar
Key Contact: Dennis Thompson
Telephone: (801) 324-3643

E-mail: dennis.thompson@questar.com

Existing System
Questar purchased the natural gas system for Moab City and Spanish Valley in 2001. The system is comprised of intermediate high pressure (IHP) distribution lines located along public streets. Based on discussions with Questar, the nearest available natural gas line with appreciable capacity is the existing 4"-diameter line in Spanish Valley Drive.

Questar is currently in the process of upgrading the natural gas distribution system. These upgrades are part of a five year capital improvement plan for Questar. The plan includes the construction of a new 6" diameter IHP main in the USU 191 corridor. The main is scheduled for installation in US 191 in 2015.

Storm water

Agency: Moab City
Key Contacts/telephone: Jeff Foster, Public Works Director (435) 259-7485
E-mail: jfoster@moabcity.org

Existing System
Existing storm water runs overland and concentrates in rills and drainages throughout the surrounding area. On the USU site, there is a primary natural swale west of the proposed campus that collects storm water and conveys it north toward US 191, and a second major drainage course crosses the south east portion of the campus site.

The desert environment presents several challenges associated with storm water management including intense rainfall events, sediment transport, and sanding of pipelines and ponds. Given that the site is currently undeveloped, there is limited existing storm water infrastructure available for the USU campus and SITLA properties. There is an existing storm water detention pond located on the west side of the US 191 across from the Millcreek Drive intersection. Storm water management was identified as a constant challenge by City officials and has been planned for in this master plan.

Fiber Optics

Agency: Frontier Communications
Key Contacts/telephone: Kim Healy. 435) 257-8125
E-mail: kim.healey@ftr.com

Existing System
Frontier operates and maintains a 96 strand fiber optic line in the US 191 right-of-way. Additionally, Frontier serves the telephone and high speed data needs of Moab and Spanish Valley.

Based on conversations with Frontier's engineer, 70 of the 96 strands are available to support new development.

Other Utilities

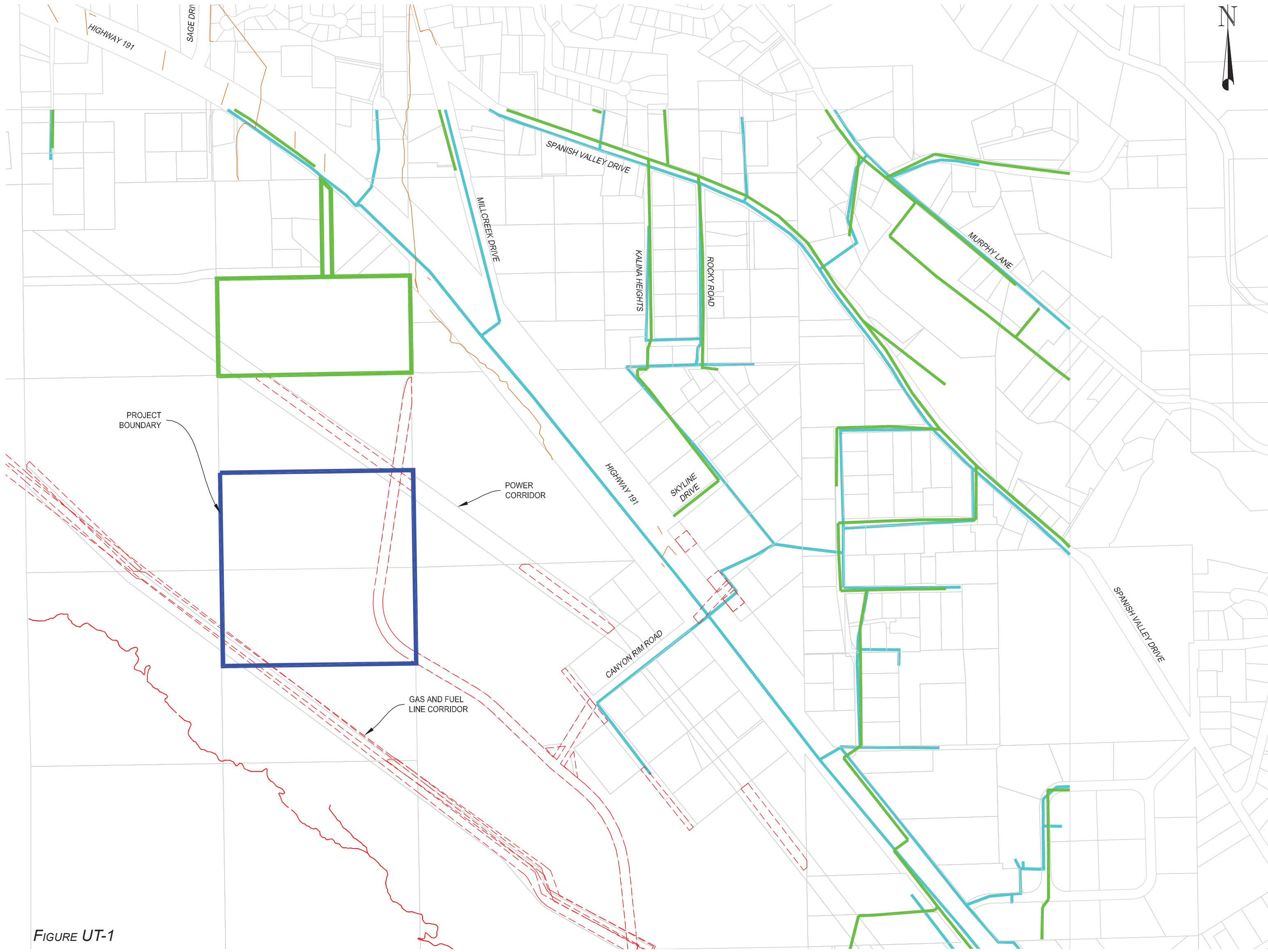
Agency: Frontier Communications
Key Contacts/telephone: Todd Phnister, MAPCO, (435) 260-1280; and Chad Shepherd, Williams, (435) 220-0139.
E-mail: kim.healey@ftr.com

The southwest corner of the site is crossed by three pipelines. Williams Northwest Pipeline operates a 26"-diameter high pressure natural gas line, and the Mid-American Pipeline Company (MAPCO) operates the other two lines. The MAPCO pipelines are 10" and 16"-diameter and are used for transmission of natural gas liquid (NGL) such as propane and butane.

Based on the master plan, Campus development does not infringe upon these facilities. Portions of the proposed SITLA development do parallel and cross the Williams/MAPCO corridor. These areas will require close coordination with the pipeline owners throughout the design process.

Changes to the campus master plan that include roadway or utility crossings should be coordinated with Williams and MAPCO to confirm crossing requirements of their existing easements.

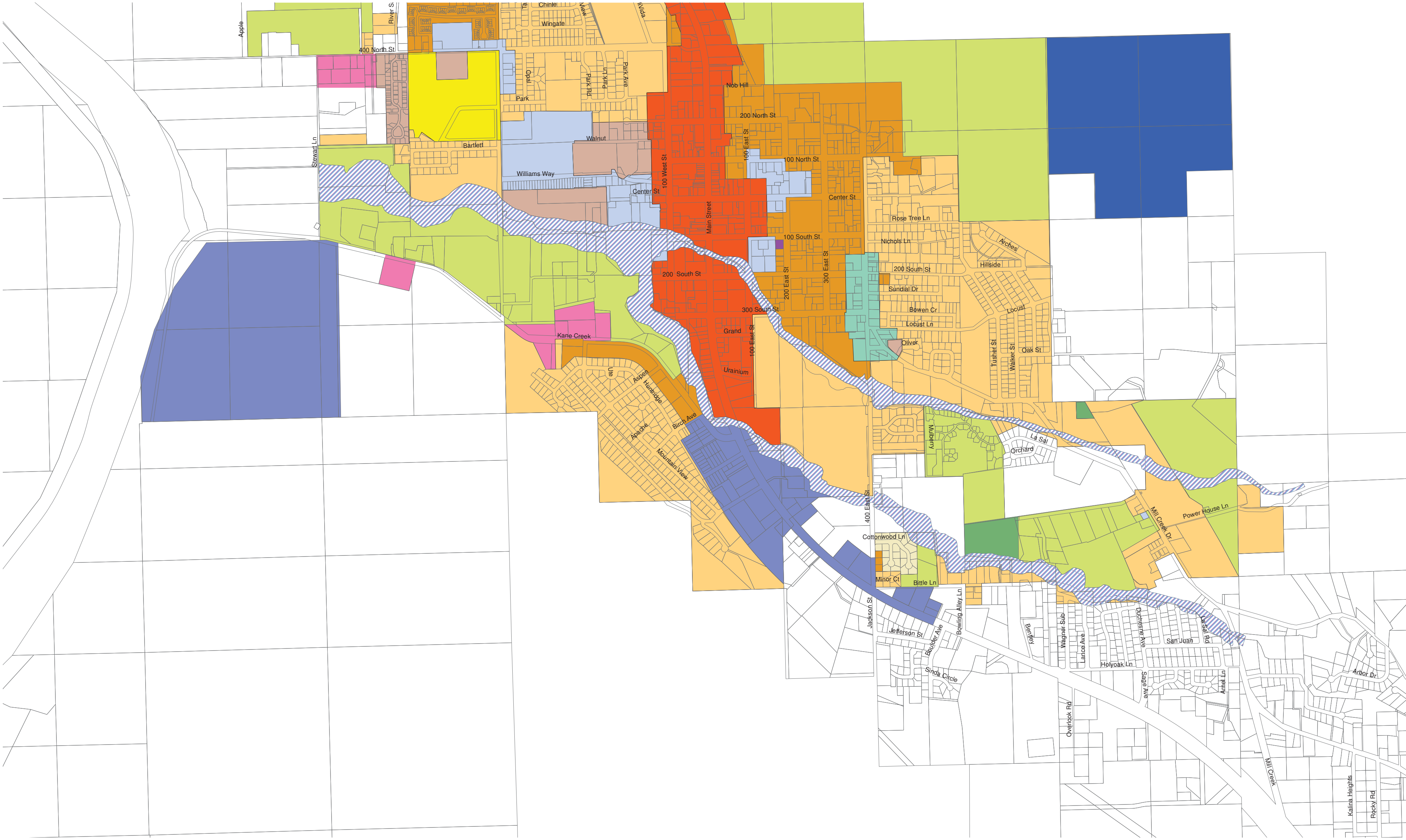
Existing Utility System Assessment



Legend

- PARCEL LINE
- EXISTING EASEMENT
- EXISTING WATER LINE
- EXISTING SEWER LINE
- EXISTING STORM DRAIN
- EXISTING USU PARCEL
- PROPOSED USU EXCHANGE PARCEL (PROJECT AREA)

Figure UT-1



Moab City Zoning

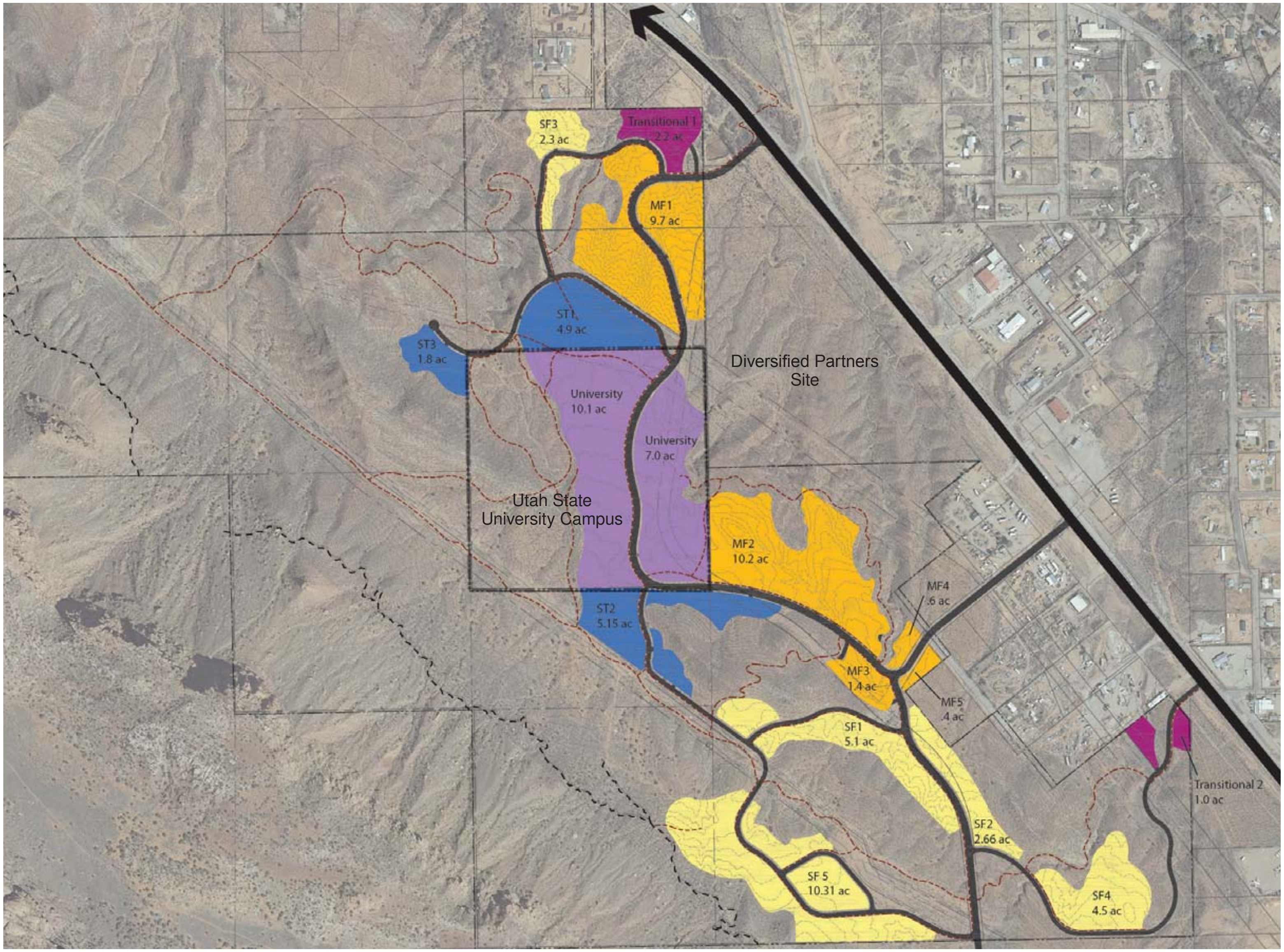
Contextual Land Use

Contextual Land Use Plan

The proposed land use plan for the 326 acres of SITLA property was developed through an analysis of the property and identifying the most developable portions of the site that are easily accessible. The areas where development is proposed are under 20% slope and the concept preserves sensitive drainages and prominent land features.

The land use plan locates student housing within easy walking distance of the new university campus creating a compact, walkable campus district.

The remainder of the plan includes multi-family residential housing, single-family residential housing and a transitional land use that could be residential or commercial uses depending upon market conditions at the time of development.



Legend

- Single Family Residential
- Multi-Family Residential
- Student Housing
- Transition
- University

Context Plan Development Summary

Based upon the site analysis and site constraints, the land available for development is approximately 60 acres or 21% of the 326-acre SITLA property. The remaining 79% of the land will be preserved as open space.

The overall density of the plan was calculated according to Moab City development code and matched against the existing conditions on the site. The overall density of the plan is 4 units per acre.

The plan illustrates approximately 260 units of student housing, 450 units of multi-family housing and 100 single family homes.

Unit Count and Density Derivation Analysis and Assumptions

Target Unit Count Derivation Per Moab City Hillside Developments Ordinance				
Slope Ranges	**Units / ac**	**Acreage**	**Units**	**Notes**
1-25%	6	188.4	1130	No Change in Density
25 - 40%	1	55	55	Must be clustered. 70% Open Space
40-45%	0.05	11	0	1 unit / 20 ac
45+%	0	71.6	0	No Development
	Total:	**326**	**1185**	

Assumed Densities Per Land Use		
Housing Type	**Units / ac**	**Occupants / unit**
Student	20-25	4
Multi-Family	15-20	3
Single-Family	4	2.4

Proposed distribution of Density Per Land Use Plan

Land Use Map Development Scenario (1)					
Pods	**Acreage**	**Housing Type**	**Units/ac**	**Units**	**Occupants**
ST1	4.9	Student	22	108	431
ST2	5.15	Student	22	113	453
ST3	1.8	Student	22	40	158
Subtotal:	**11.85**			**261**	**1042.8**
MF1	9.7	Multi-Family	20	194	582
MF2	10.2	Multi-Family	20	204	612
MF3	1.4	Multi-Family	20	28	84
MF4	0.6	Multi-Family	20	12	36
MF5	0.4	Multi-Family	20	8	24
Subtotal:	**22.3**			**446**	**1338**
SF1	5.1	Single-Family	4	20	49
SF2	2.66	Single-Family	4	11	26
SF3	2.3	Single-Family	4	9	22
SF4	4.5	Single-Family	4	18	43
SF5	10.31	Single-Family	4	41	99
Subtotal:	**24.87**			**99**	**239**
Transitional 1	2.2	MF or Comm	22	48	145
Transitional 2	1	MF or Comm	22	22	66
Total:	**59**			**806**	**2620**

Units Per Pod Analysis

Units per pod based on flat density overlay of 6 units per acre

Pod units per base density		
Pods	**Acreage**	**Units**
ST1	4	24
ST2	5.02	30
ST3	1.8	11
MF1	12.02	72
MF2	10.2	61
MF3	1.4	8
MF4	0.6	4
MF5	0.4	2
MF6	1	6
SF1	3.8	23
SF2	4.04	24
SF3	2.3	14
SF4	2.03	12
SF5	11.7	70
Total:	**60**	**362**

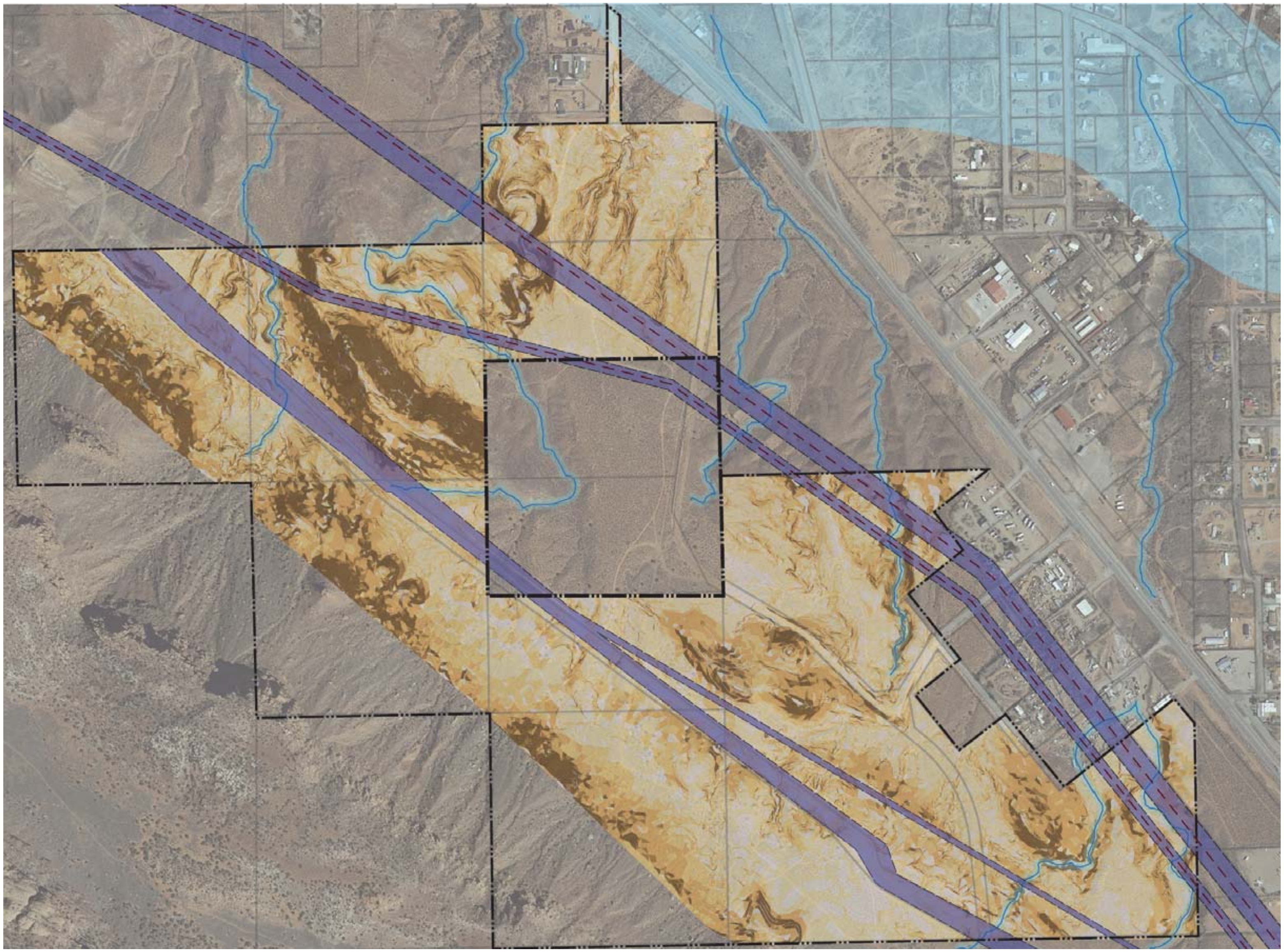
Units/acre per pod to meet Hillside Ordinance density:	**19.6**

Units / Pod to meet overlay density		
Pods	**Acreage**	**Units**
ST1	4	78
ST2	5.02	98
ST3	1.8	35
MF1	12.02	236
MF2	10.2	200
MF3	1.4	27
MF4	0.6	12
MF5	0.4	8
MF6	1	20
SF1	3.8	74
SF2	4.04	79
SF3	2.3	45
SF4	2.03	40
SF5	11.7	229
Total:	**60**	**1182**

Contextual Property Constraints

The property constraints diagram illustrates the three major constraints on the site which are steep sloes, water drainages and utility easements.

The land use plan recognizes these constraints and is organized to avoid development in these locations.



Legend

- Primary Drainages / Streams
- Shallow Ground Water
- Utility Easements

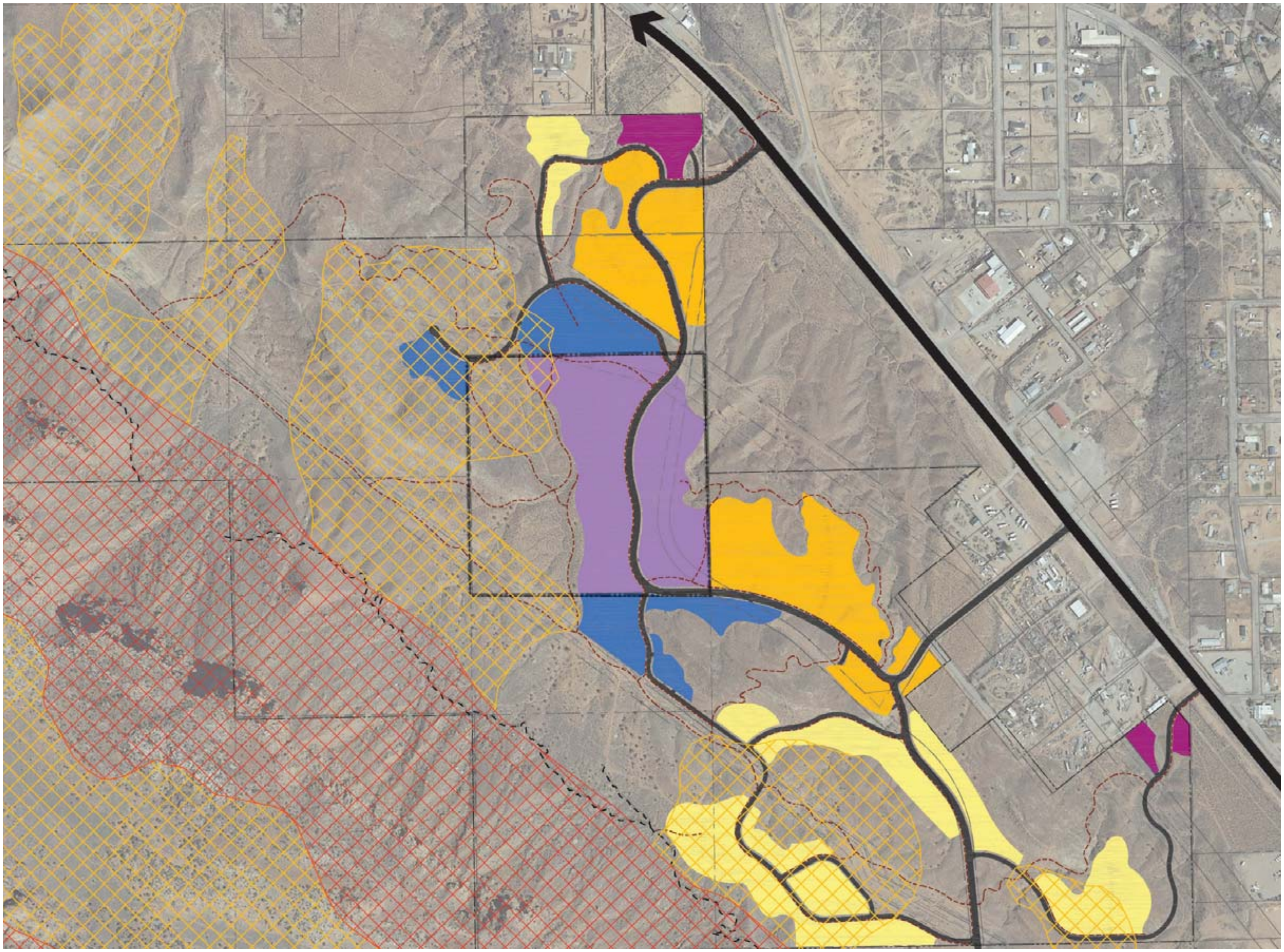
Slopes Table

Number	Minimum Slope	Maximum Slope	Area (Ac)	Color
1	0%	5%	31.5	
2	5%	15%	94.2	
3	15%	25%	62.7	
4	25%	40%	55.1	
5	40%	45%	11.0	
6	45%	100%	33.1	

Contextual Land Use Plan / Rock Fall Zones

The rock fall hazards are previously described in the analysis section. This diagram illustrates the overlay of the rock fall hazards and the land use plan for the area.

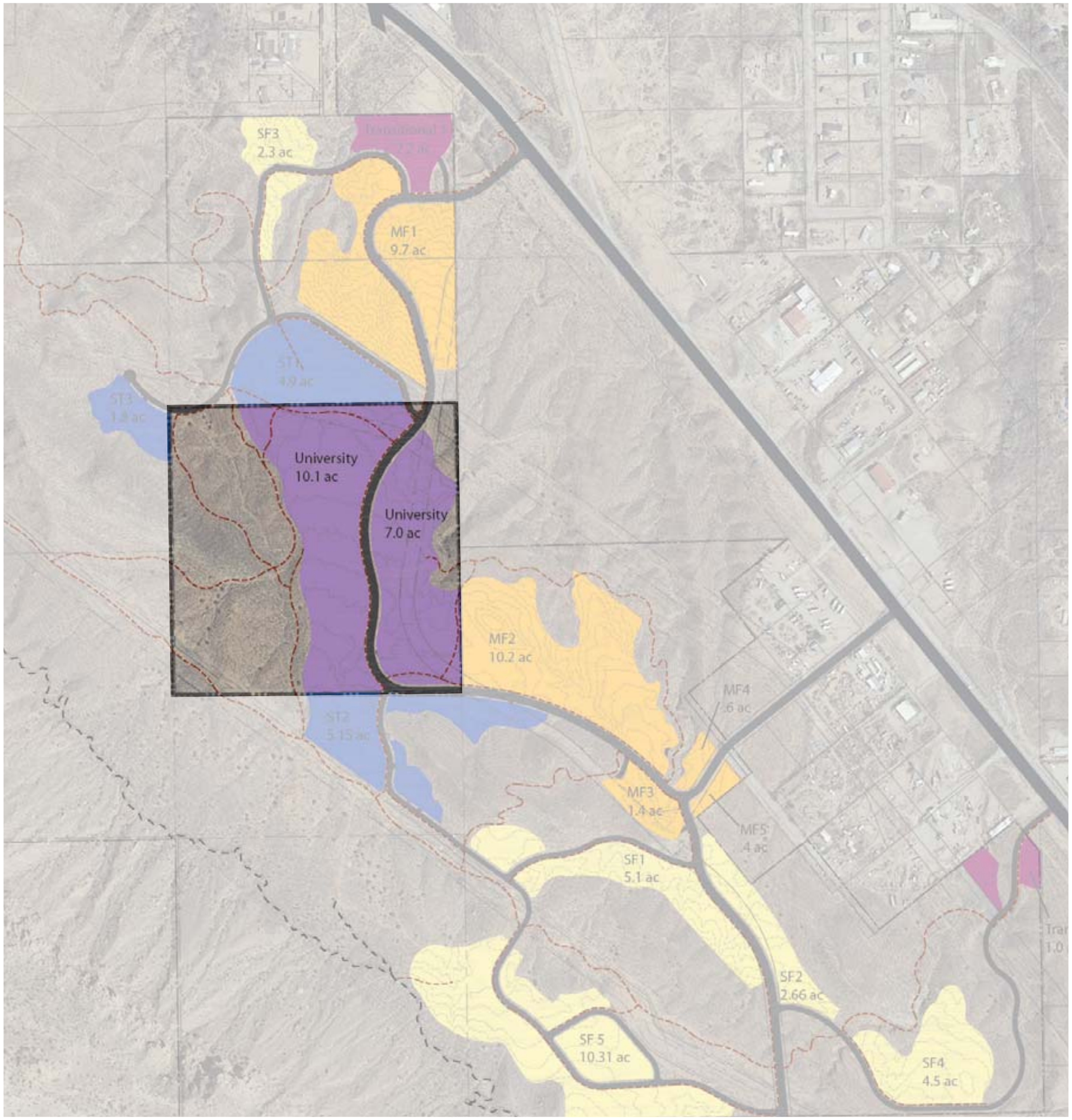
It is recommended that a geologist specializing in rock fall hazards assess and map this site for specific and local hazards. The recommended study falls outside of the scope of work for this project.



Legend

- Single Family Residential
- Multi-Family Residential
- Student Housing
- University
- Transitional
- Moderate Rock Fall Hazard
- High Rock Fall Hazard

The Planning Team on-Site



Utah State University Master Plan

Master Plan Framework

The diagram at right illustrates the primary organizational components of the proposed master plan.

The developed portion of the campus will be positioned on the flattest portion of the site, protecting existing drainages and topographic features.

The campus pods are where facilities will be constructed. The pods are organized along a primary access road that connects to Highway 191.

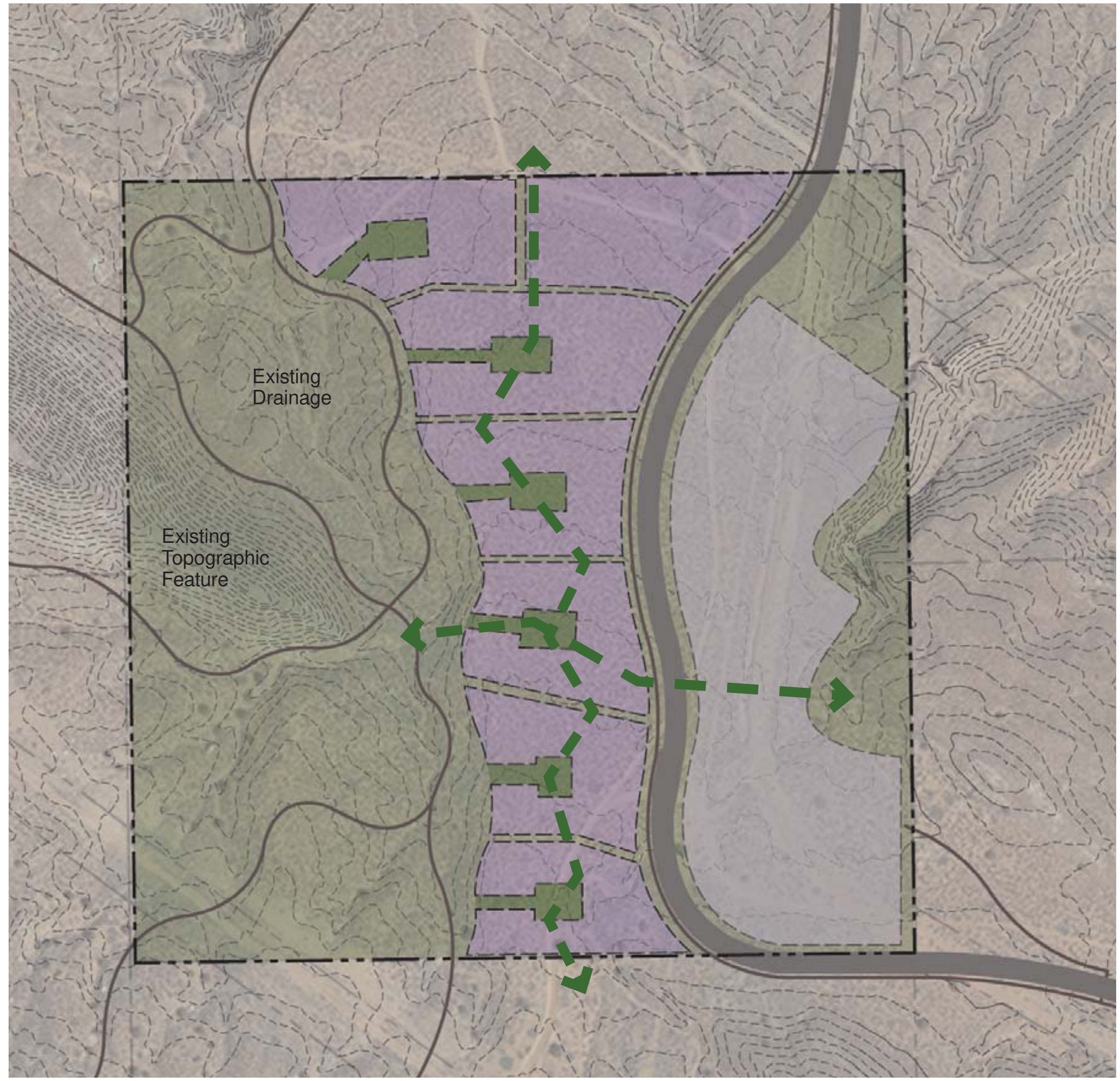
Each pod includes a small programmed / designed open space that the facilities for that pod will be positioned around.

The pods are interconnected by a pedestrian spine running north-south to planned student housing areas and east-west to a developed trail network and the greater open spaces.

The parking zone for the campus is located on the east side of the access road and is located there with the intent of separating vehicular circulation from pedestrian circulation in the heart of the campus. The parking will terrace down the existing topography and be broken up with bands of open space to reduce visual impact.

Legend

- Preserved Open Space
- Campus Pods
- Parking Zone
- Programmed / Designed Open Space
- Pedestrian Spine
- Proposed Access Road



Master Plan framework Diagram

Proposed Master Plan

The proposed master plan for the Utah State University future Moab campus as represented in this graphic is based on a 30-year build-out projection.

The buildings within the plan are organized to minimize impact on existing site conditions including natural drainages, vegetation and prominent topographic features.

The central pedestrian spine illustrated in the plan is the main circulatory route for pedestrians on campus. This spine also acts an emergency access route for fire trucks, ambulances and police cars.

Buildings on the campus primarily house academic functions but other proposed uses include a student union, a small retail center, a central heating and cooling plant and government agency facilities. Two parking garages will accommodate all the parking demands for the build-out of the campus. These garages will step down the natural grade and will be sunk into the topography to minimize their visual impact.

The aesthetics of the campus landscape and buildings will be derived from the natural character of the region. Materials, colors and textures will be referenced from the immediate context and much of the campus landscape will reflect the natural existing conditions.

The following diagrams communicate the systems and components of the plan.

Illustrative master plan

Master plan with connection to Hwy 191

Connection to Highway 191
This image of the master plan illustrates the access road connection to Highway 191. The intersection is aligned with a planned realignment of Mill Creek Drive.

Open Space

This diagram illustrates the primary public open space strategies in the master plan.

The programmed open space areas will include designed components that support outdoor gathering, interpretive teaching and passive and active recreation. These areas may include hardscape plaza areas, shade trees / shade structures, arid landscape display gardens, storm water gardens, turf areas and outdoor classrooms, etc.

Native open space areas will be rehabilitated to emulate the native context and will contain primarily water-wise, drought-tolerant plants.

A trail network will connect the campus to planned student housing areas, adjacent future neighborhoods, the Pipe Dream trail and downtown Moab via a tunnel under Highway 191.

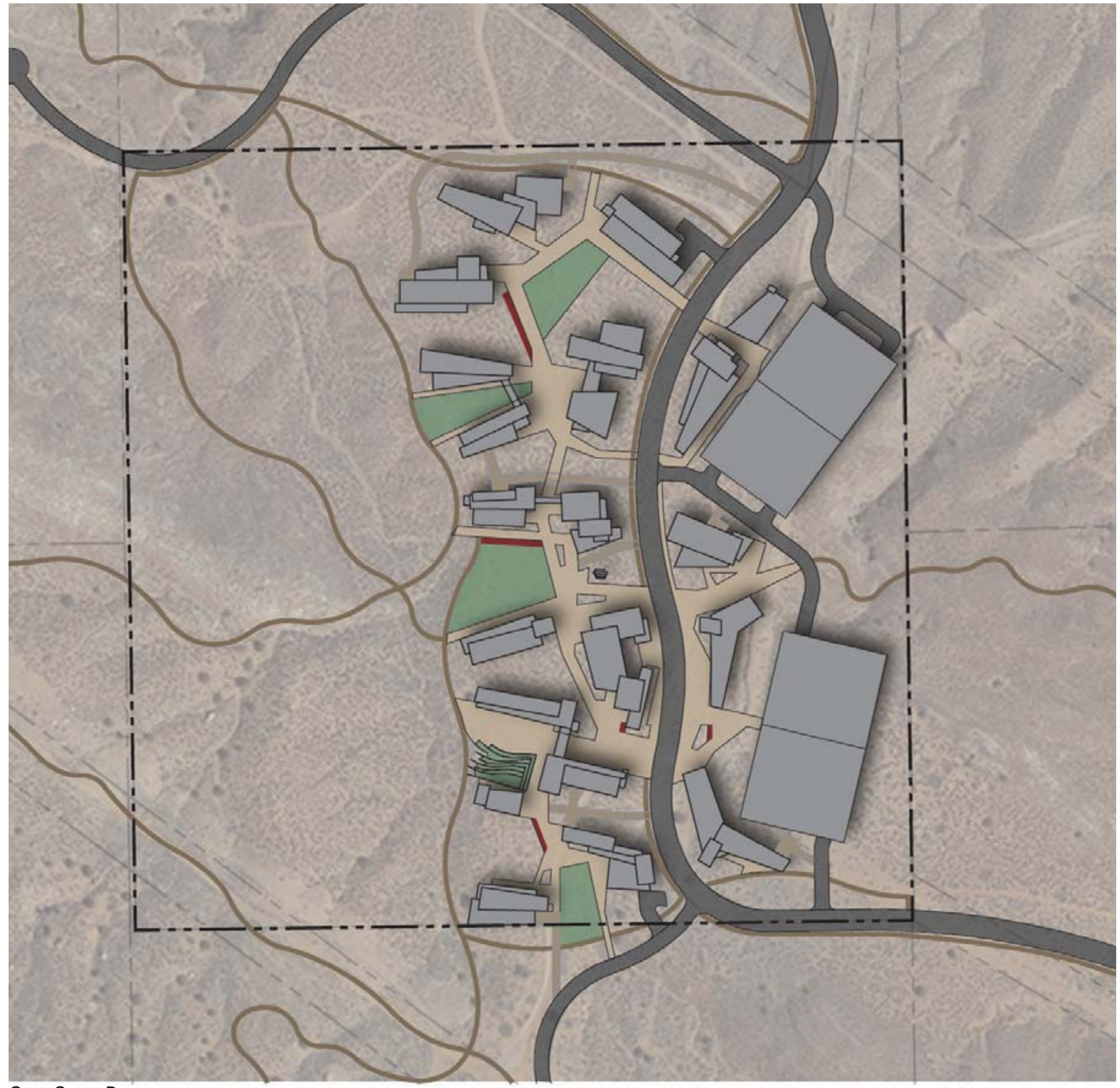
The plaza spaces throughout the campus will have color palates derived from the site and may contain zones of permeable paving where water can infiltrate into the ground. Bicycle parking areas are positioned throughout the campus.

Trail Character

Dedicated Bicycle Parking

Legend

- Hardscape
- Buildings
- Programmed / Designed Open Space
- Trails
- Bicycle Parking Locations
- Roads



Open Space Diagram

Facilities and Building Use

At build-out, it is envisioned that there will be clustered "schools" based upon degree programs and departments. Initially, all current programs will be located in the same facility. As the campus, faculty, staff, programs and enrollment grows, each building or cluster of buildings will take on a specific purpose.

The current assignment of programs to facility buildings is conceptual in this plan and assumes that the programs closest to Phase One are the programs most likely to develop in the campus first. Natural Resources, Geology / Geoscience, Digital Media / Health and Tourism Management may all develop earlier than the others.

The central plant facility is located at a low point along the central spine and is in an optimal location for its function.

The Student Union facility is positioned in the heart of the campus in order to service all areas of the campus equally. It will be built when the campus starts to form a critical mass of students. The Student Union will likely function as a mixed-use facility with academic spaces on the upper floors.

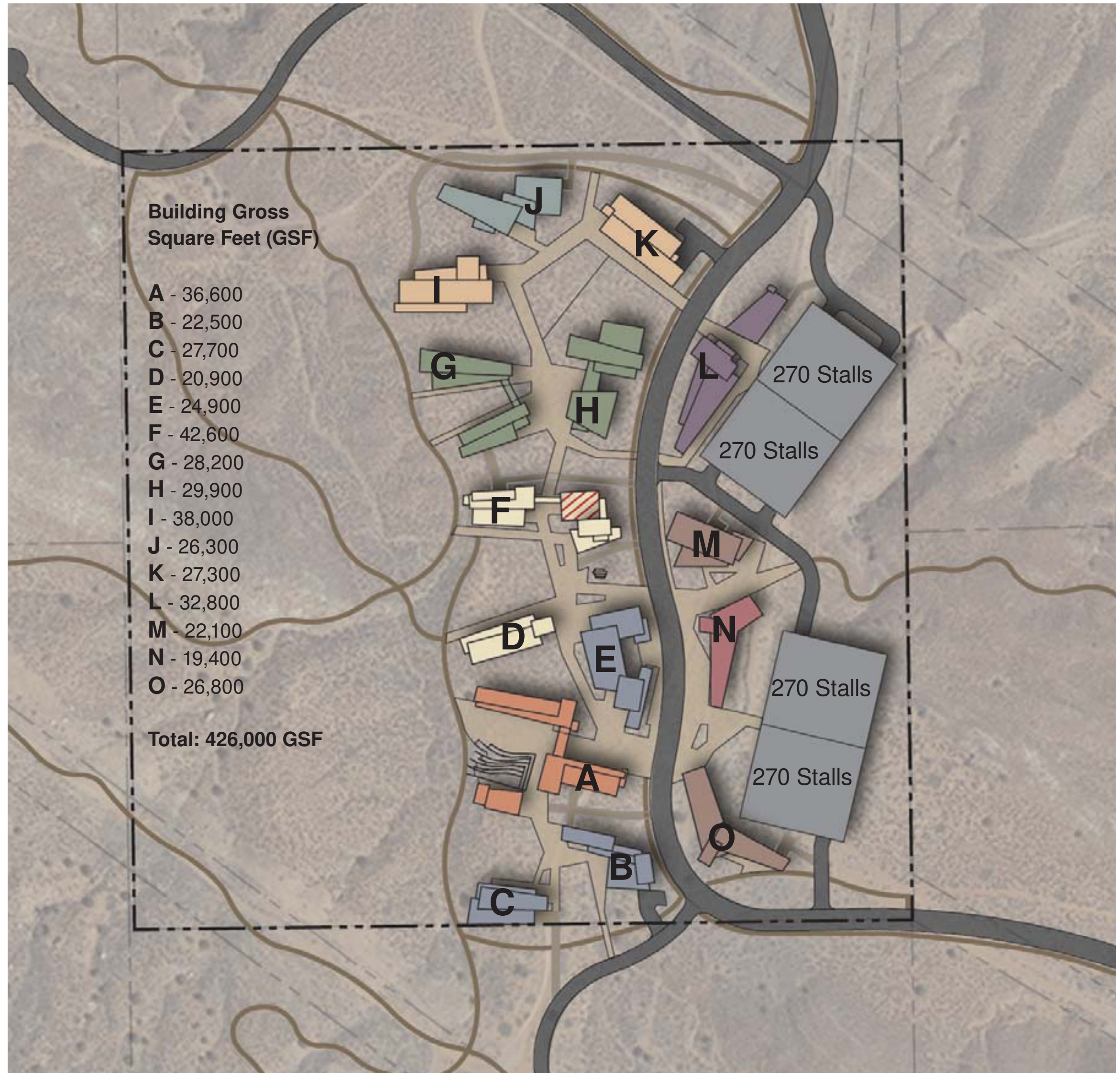
The building shown with a retail use may also be a mixed-use facility and contain space for academic functions on upper floors.

It is envisioned that the parking structures will incorporate a top floor shading mechanism to reduce visual impact, lower albedo and lower head gain in vehicles. The image above illustrates a shading device with solor panels above. This solution also supplements power needs for the campus.

Shaded Parking Structure. Springs Preserve; Las Vegas, NV

Legend

- Natural Resources
- Geology / Geoscience
- Allied Health / Social Work
- Digital Media / Film
- Tourism Management
- Education
- Government Agency
- Retail
- Student Union
- Central Plant
- Parking



Facilities and Building Use Diagram

Circulation

The circulation diagram illustrates multi-modal transportation systems in the master plan.

6-foot wide on-street bike lanes are located on both sides of the primary access road all the way from Highway 191. The bike lanes will provide safe routes for the anticipated high volume of bicycle commuters attending classes.

An emergency vehicle access route is highlighted in red and is designed to accommodate a pumper classification fire truck. The plaza surface will also be designed to support the load of that vehicle class.

A future transit stop is located on the plan with the assumption that a future bus route will serve the campus.

Pedestrian circulation routes are highlighted through the campus including designated pedestrian crossings over the access road. These crossings may be a table-top designs to control vehicular speeds or they could incorporate flashing lights (Hawk Beacons) to stop traffic and protect pedestrians.

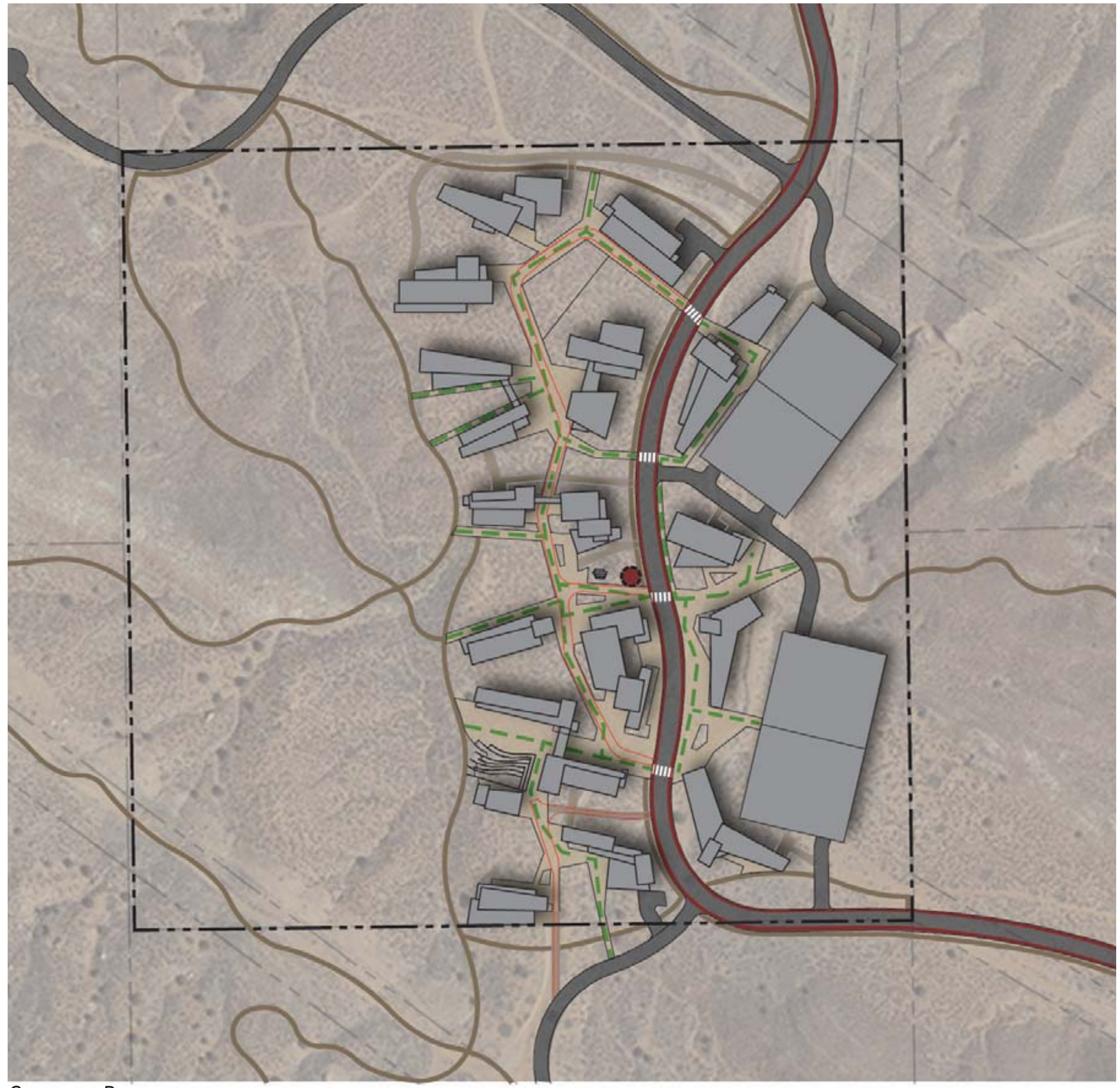
A multi-use trail network is designed to connect users to surrounding trails, communities and other destinations. A tunnel is proposed under Highway 191 to provide a safe route under the highway to the Moab City bike path network.

Pedestrian Tunnel Connection Under Highway 191

Tunnel Character

Legend

- Hardscape
- Buildings
- Pedestrian Circulation
- Multi-Use Trails
- Bicycle Lanes
- Roads
- Tunnel
- Future Transit Stop
- Emergency Vehicle Access



Circulation Diagram

Campus Utilities and Service

The campus utilities and service diagram illustrates systems components that support the campus.

The campus utility tunnel will be used to connect all facilities with the central plant and is located at a low point on the site.

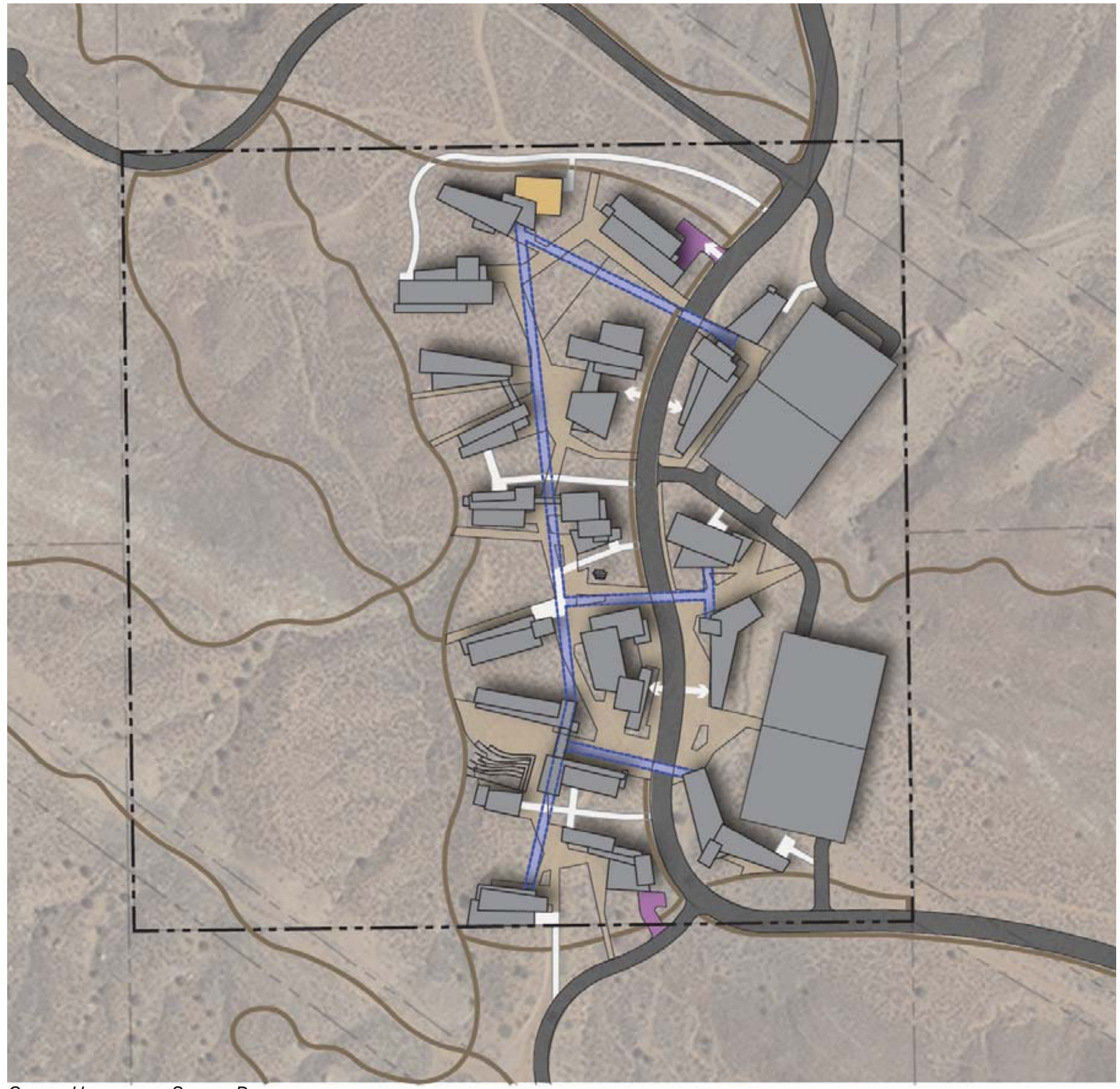
Initial buildings will have mechanical systems designed as stand-alone units. The central plant and mechanical systems will be evaluated as the campus evolves but there may be a series of interconnected central plants serving small clusters of buildings or a single central plant as shown in the diagram. Mechanical rooms in all buildings should be located to have direct access to the campus utility tunnel.

Consolidated trash and recycling centers are proposed for this campus to concentrate large vehicle access and to limit pedestrian conflicts within the campus interior. These locations would be screened with fencing and landscaping. Trash and recyclables would be delivered to these locations from the other facilities and picked up by the service provider at these locations.

There are dedicated service/delivery vehicle routes identified in the plan. Most avoid pedestrian circulation areas but there is some overlap.

Legend

- Hardscape
- Buildings
- Central Plant
- Consolidated Trash / Recycling Access
- Service Access
- Trails
- Campus Utility Tunnel
- Roads



Campus Utilities and Service Diagram

Phasing

The following phasing diagrams illustrate the conceptual build-out of the campus. Diagram 1 shows the maximum building footprint of the campus that can be accommodated with surface parking alone. Phase 1-3 include initial academic facilities and potential government agency space.

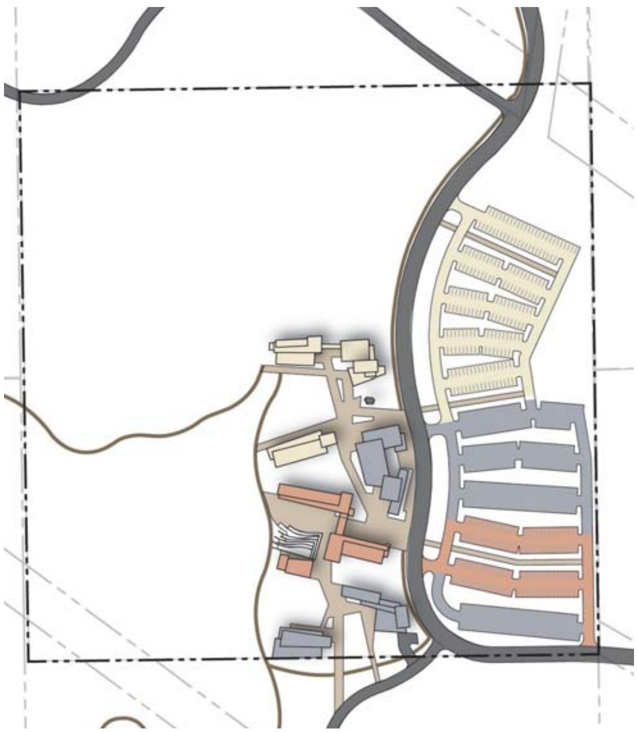
Phases 4-5 trigger the construction of the first structured parking garage, a central plant and additional academic facilities. The structured parking garage has three parked levels, steps down the slope and is set into the existing grade. It is also possible to phase the garage in two different phases to increase flexibility.

Phases 6-7 require the second parking structure in order to accommodate additional academic facilities and a potential retail facility for food service and convenience-related goods.

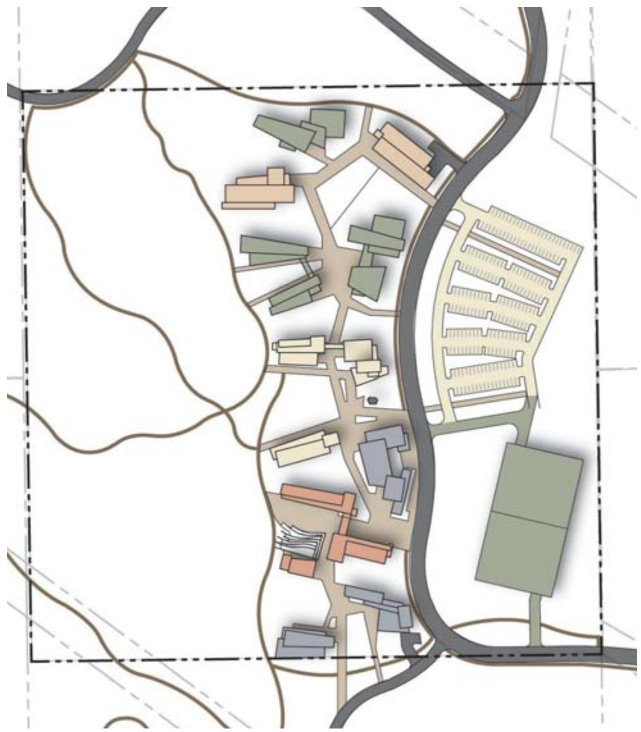
Legend

- Phase I
- Phase II
- Phase III
- Phase IV
- Phase V
- Phase VI
- Phase VII

Phases 1-3: All Surface Parked



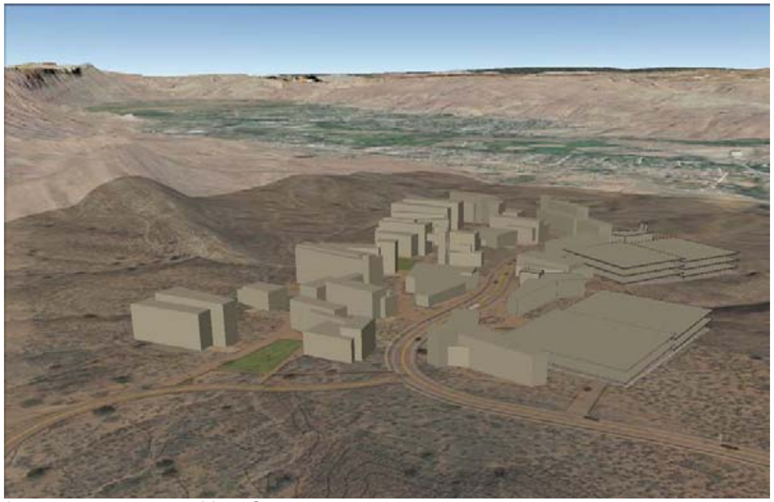
Phases 4-5: First Structured Parking



Phases 6-7: Full Build-Out

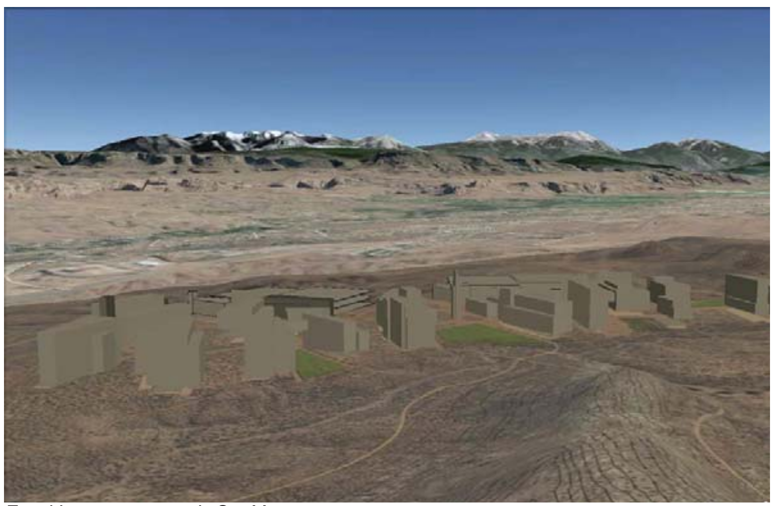
Conceptual Campus Massing

Reference Plan

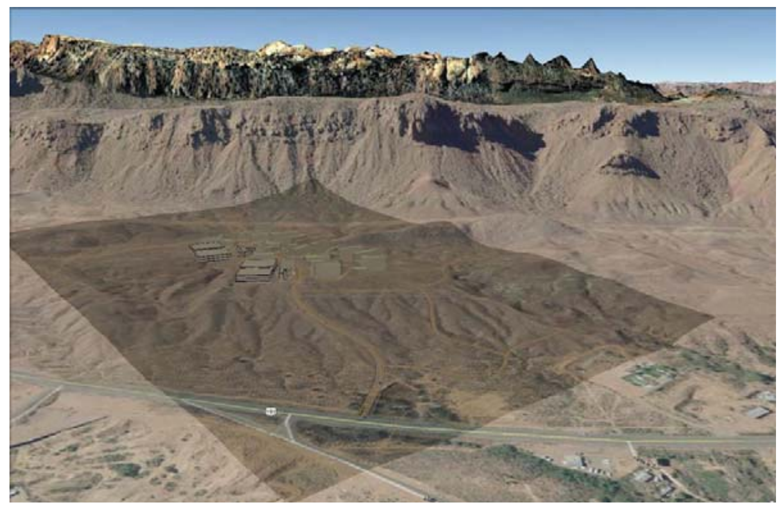


Looking north towards Moab City

South West View From Highway 191



East View towards the LaSal Mountains.



South View towards Behind the Rocks Recreation Area From Above Highway 191

Phase 1 Site Plan

Phase 1 Plan
The intent with the positioning and building layout for Phase 1 of the campus is to leverage the best assets of the site and to create a memorable place from day one.

The buildings are positioned to frame the views of major topographic features on the property and to be set back from the power lines on the northeast corner and road noise from Highway 191 that is more prevalent on the north and east sides of the property.

Splitting the building program into three smaller facilities will help to create a gathering places for students and faculty from day one. The buildings form a courtyard space that will provide students, staff and faculty a comfortable outdoor environment to be in.

About the Buildings
The new buildings provide 32,000 square feet of research, classroom, and laboratory space; student support areas; faculty and administrative offices; and multi-purpose space that can accommodate up to 500 students. As shown in the conceptual vision of the Phase 1 campus, buildings are organized to create an academic "village" surrounding an outdoor courtyard.

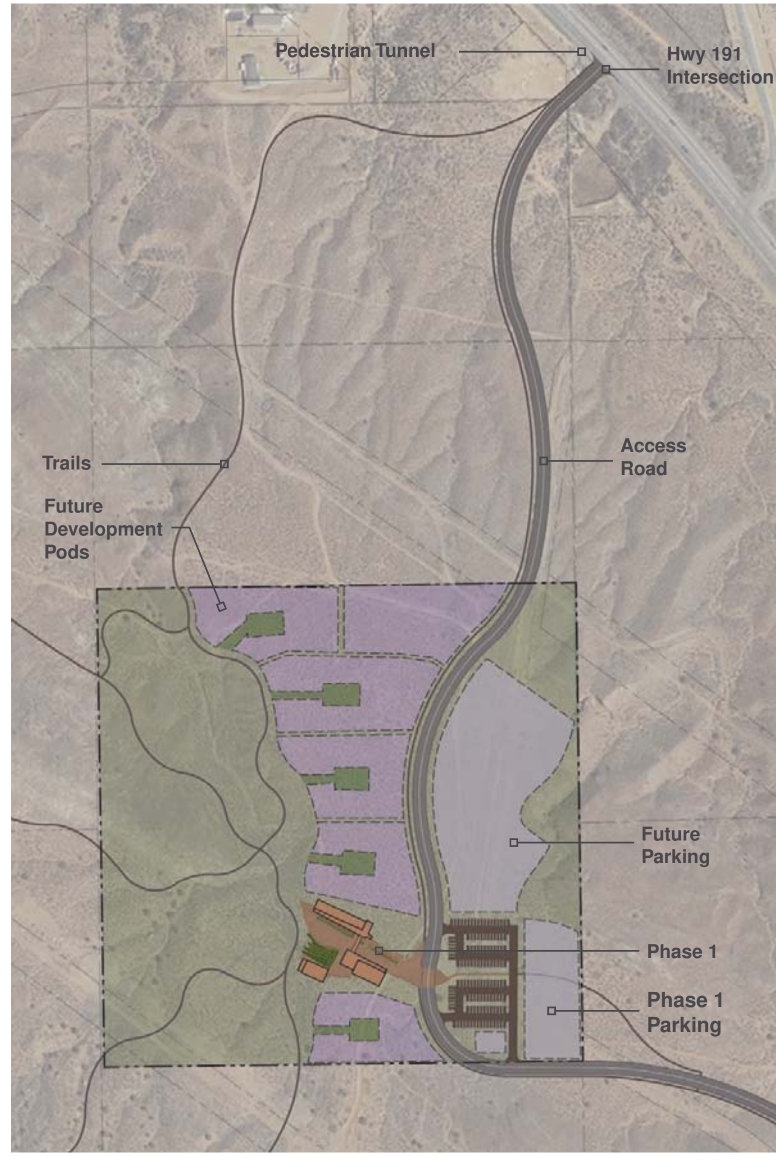
The Lecture Hall facility houses a multi-purpose space that will accommodate 200 people for small concerts, theatrical performances, receptions, banquets, film screenings, and lectures. This space also opens (via large retractable glass doors) onto the courtyard's amphitheater, which can accommodate up to 1,000 people to enjoy events performed on the multipurpose stage.

Building / Plan Objectives
The following are objectives for the plan and buildings that were integrated into this master plan and will be carried forward into the design of each phase of the project.

Reduce environmental impact
- Use natural day-lighting strategies and controls
- Utilize local and/or regionally derived materials
- Use high performance envelope and systems design
- Utilize renewable energy sources, including photo-voltaic and solar hot water
- Incorporate dark sky protocol
- Make the building a safe, healthy and comfortable place to work and study
- Incorporate innovative storm water management
- Utilize water efficient fixtures

Create a sense of place
- Establish a residential college-style (or academic "village") around an outside commons or community space
- Connect the outdoor commons with the indoor common spaces
- Create view corridors to both on- and off-site views
- Create public space (interior and exterior) that encourages passive and active engagement
- Use materials that are evocative of the desert landscape
- Make the campus a functional and aesthetic community resource---a place to want to be
- Develop a campus "brand" and user experience that is consistent with brand ethos and attributes
- Provide quality environmental graphics and wayfinding
- Incorporate art

Make the place a teaching opportunity about sustainable design
- Incorporate both traditional and innovative building technologies
- Utilize good sustainable practices
- Aspire to a high level performance rating (LEED and/or Living Building Challenge)
- Use interpretive materials to illuminate sustainability concepts and strategies

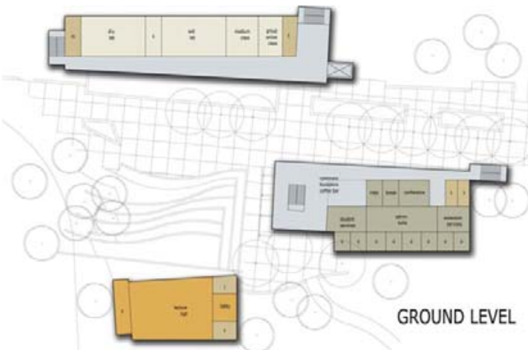


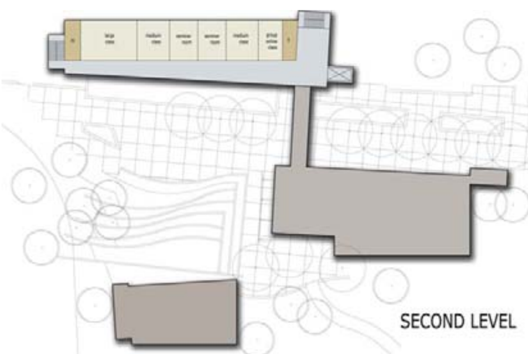

Birds-Eye Aerial View

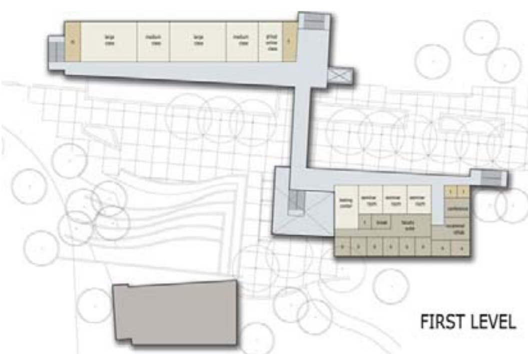
Courtyard View

Dusk Entry View

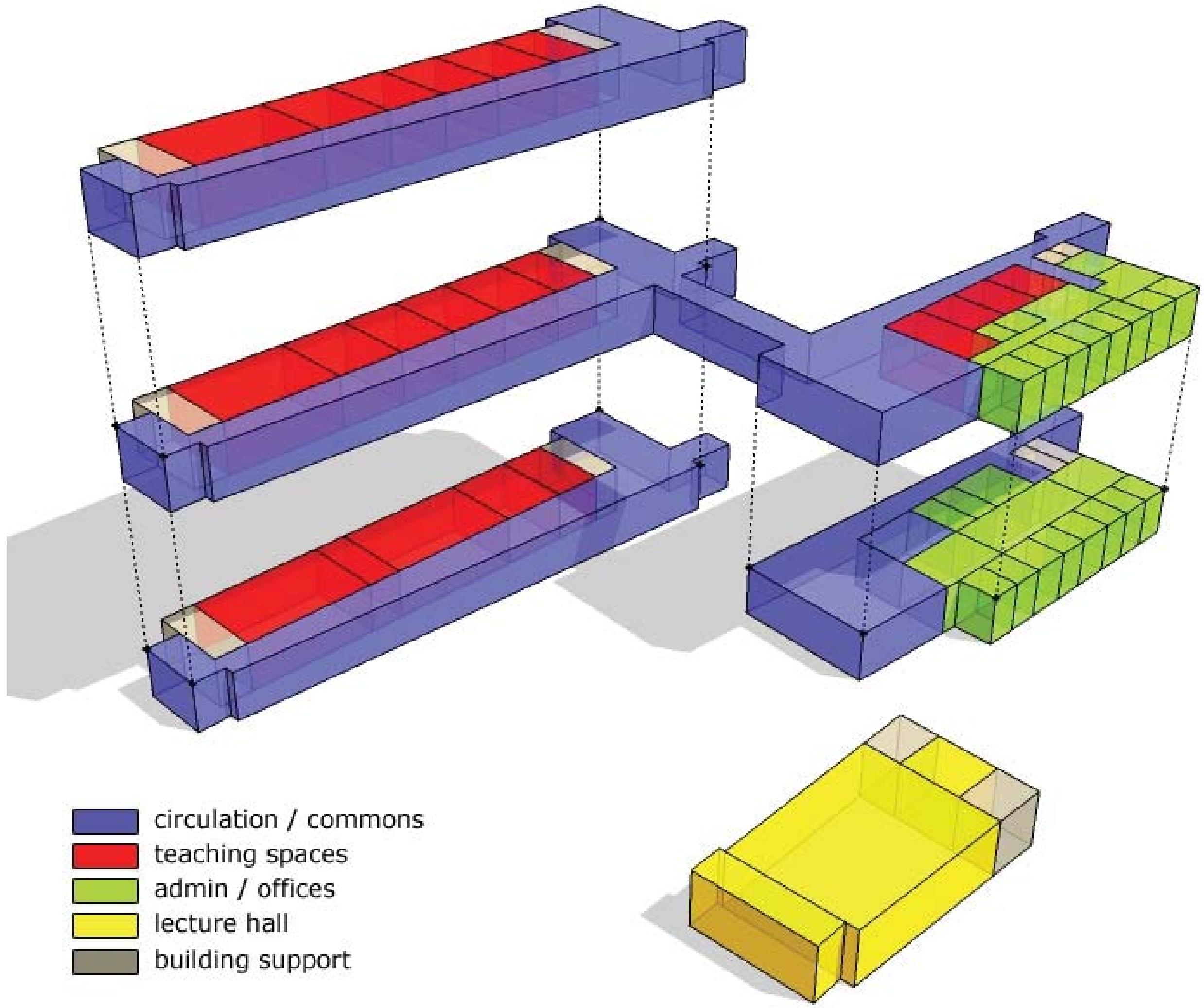
Phase 1 Floor Plans and Massing







Massing Diagram



Phase 1 Probable Cost Projections

The following projections tabulate major infrastructure costs that will likely be incurred to develop the Phase 1 infrastructure for the University.

These costs may vary significantly as design on the project gets further along and as time increases. For instance, the streets may end up as a rolled curb instead of a curb and gutter or the storm water infrastructure may end up being daylighted in swales rather than in a piped system. All costs will also likely increase with time and as the cost of materials fluctuate.

The purpose of these projections are to understand order of magnitude costs considering the currently planned infrastructure, preliminary sizing projections and system types.

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
MAJOR COLLECTOR				
1. MOBILIZATION (Approximately 5% of Subtotal Capitol Cost)	1	LS	$ 49,000	$ 49,000
2. CLEARING AND GRUBBING	3.3	AC	$ 2,000	$ 6,600
3. EXCAVATION (CUT/FILL)	11,000	CY	$ 10	$ 110,000
4. ASPHALT - 4" DEEP	12,200	SY	$ 20	$ 244,000
5. BASE - 8" DEEP	2,700	CY	$ 25	$ 67,500
6. CURB AND GUTTER	3,600	LF	$ 20	$ 72,000
7. 8" DIA. PVC SEWER MAIN	1,800	LF	$ 35	$ 63,000
8. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	7	EA	$ 3,000	$ 21,000
9. 18" DIA. ADS N-12 STORM DRAIN	1,800	LF	$ 40	$ 72,000
10. 5' x 5' STORM DRAIN BOX (~ EVERY 250 FT.)	7	EA	$ 2,500	$ 17,500
11. 12" DIP WATER LINE	1,800	LF	$ 65	$ 117,000
12. 12" GATE VALVE (~EVERY 500 FT.)	4	EA	$ 2,500	$ 10,000
13. FIRE HYDRANT W/ LATERAL AND VALVE (~EVERY 500 FT.)	4	EA	$ 4,000	$ 16,000
14. POWER, GAS, COMMUNICATIONS	1,800	LF	$ 90	$ 162,000
			SUBTOTAL	$ 1,028,000
PEDESTRIAN BOULEVARD				
1. MOBILIZATION (Approximately 5% of Subtotal Capitol Cost)	1	LS	$ 43,000	$ 43,000
2. CLEARING AND GRUBBING	2	AC	$ 2,000	$ 4,800
3. EXCAVATION (CUT/FILL)	8,000	CY	$ 10	$ 80,000
4. ASPHALT - 4" DEEP	9,000	SY	$ 20	$ 180,000
5. BASE - 8" DEEP	3,280	CY	$ 25	$ 82,000
6. CURB AND GUTTER	2,640	LF	$ 20	$ 52,800
7. 6' WIDE SIDEWALK	16,000	SF	$ 6	$ 96,000
8. 8" DIA. PVC SEWER MAIN	1,320	LF	$ 35	$ 46,200
9. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	5	EA	$ 3,000	$ 15,000
10. 18" DIA. ADS N-12 STORM DRAIN	1,320	LF	$ 40	$ 52,800
11. 5' x 5' STORM DRAIN BOX (~ EVERY 250 FT.)	5	EA	$ 2,500	$ 12,500
12. 12" DIP WATER LINE	1,320	LF	$ 65	$ 85,800
13. 12" GATE VALVE (~EVERY 500 FT.)	3	EA	$ 2,500	$ 7,500
14. FIRE HYDRANT W/ LATERAL AND VALVE (~EVERY 500 FT.)	3	EA	$ 4,000	$ 12,000
15. POWER, GAS, COMMUNICATIONS	1,320	LF	$ 90	$ 118,800
			SUBTOTAL	$ 890,000
ADDITIONAL COMPONENTS*				
1. SIGNAGE	1	LS	$ 3,000	$ 3,000
2. 8" DIA. PVC SEWER MAIN	1,350	LF	$ 40	$ 54,000
3. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	6	EA	$ 3,000	$ 18,000
4. 12" DIP WATER LINE	1,340	LF	$ 65	$ 87,100
5. 12" GATE VALVE (~EVERY 500 FT.)	3	EA	$ 2,500	$ 7,500
6. CONNECT TO EXISTING WATER LINE	1	EA	$ 5,000	$ 5,000
7. CONNECT TO EXISTING SEWER LINE	1	EA	$ 5,000	$ 5,000
			SUBTOTAL	$ 180,000
			CONSTRUCTION SUBTOTAL	$ 2,098,000
			CONTINGENCY (30%)	$ 630,000
			SUBTOTAL	$ 2,728,000
			ENGINEERING, SURVEYING, CONSTRUCTION MANAGEMENT (15%)	$ 410,000
			TOTAL COST	**$ 3,138,000**

* CAMPUS SUBSTATION SHOWN ON UT-4 IS NOT INCLUDED.

View of the Cliff Band and Character of the Site Topography

Transportation and Utilities Framework

The purpose of the Transportation Element of the USU and SITLA Master Plan is to identify needed transportation infrastructure for the proposed USU future Moab Campus and SITLA property in Moab, Utah.

The proposed project is located on the south end of Moab west of US-191 near the Mill Creek Drive / US-191 intersection. Because of the active lifestyle seen in the Moab area demographic, vehicular use and related impacts may be lower-than-normal.

This section of the master plan addresses the following points:

- Moab General Plan relating to transportation and circulation,
- Trip generation,
- Distribution and assignment,
- Proposed roadway classification and cross sections,
- Intersection control,
- Pedestrian and bicycle considerations, and
- Parking.

Moab General Plan and Street Master Plan

The City of Moab General Plan (adopted 2002) contains a Transportation and Circulation section as well as maps for Paths, Trails and Bike Lanes. The plan states that the transportation system should "address the need for all levels of circulation." How each of the following goals are proposed to be implemented with these properties is discussed later in the report.

Pedestrian
The pedestrian transportation network should "provide a viable transportation alternative for daily circulation, activities, and recreation." Specific policies applicable to the USU and SITLA properties include:

1. Provide for sidewalks of sufficient width and clear of obstructions or conflicts with other forms of transportation or land use.

2. Provide pedestrian routes to parks, schools, and other public facilities and through residential areas separate from motor traffic.

3. Encourage a more pedestrian-oriented business district.

4. Make the City 'access friendly' for persons with disabilities.

Non-Motorized Vehicles
Similar to the pedestrian system, the goal of the City of Moab General Plan is to provide a bike path system "of sufficient width and clear of obstructions or conflicts with other forms of transportation and land use" in order to provide "alternatives for daily activities and recreation." Specific policies applicable to the Moab and USU properties include:

1. Provide a pleasant, safe bicycle experience and encourage the development of bicycle-associated activities.

2. Encourage bicycle-user accommodations in the Central Business District (CBD) in order to enhance shopping opportunities for the local community (although this project is not located in the Moab CBD, these types of accommodations can still provide benefit to the university campus).

Motorized Vehicles
Moab's goal for motorized traffic is to provide "an efficient and adequate street system for Moab's future growth." Policies applicable to this project include:

1. Base vehicle circulation upon a system of arterial, major and minor collectors, and residential streets (as indicated by the Street Master Plan)

2. Prevent major arterials or through traffic from splitting residential neighborhoods. The City shall plan collector streets so they provide adequate access from residential neighborhoods to major arterials and other adjoining areas of concentration.

3. Reduce traffic congestion and conflicts. Curb cuts shall be minimized where possible, especially those opening onto US-191. Business should be clustered and associated parking access should avoid Main Street where possible. Traffic studies should be required for major new developments

4. Require adequate parking for all land use types. Moab should provide for adequate and well-designed public parking

5. Consider the feasibility of a shuttle system serving downtown Moab (if such a system comes to fruition, the transportation infrastructure on the USU campus should be designed to accommodate the shuttle system, thereby proving a link to downtown).

Street Master Plan Map
The Street Master Plan Map, though not contained in the General Plan, provides a valuable reference for coordinating the transportation master plan of this project with the rest of the City and US-191 corridor. The map, attached in the appendix, shows US-191 as an arterial and Mill Creek Drive as a major collector. All other roads in close proximity to the project are shown as minor streets. The street classification of roads internal to this project is discussed later in this report. Other Moab City maps including bike lanes and trails can be found in the Appendix.

Trip Generation

Proposed Land Use
This master-planning effort encompasses the proposed USU future Moab Campus, including space for federal agencies, as well as 326 acres of adjacent SITLA land. The following is a detailed description of land use assumptions for each of these components:

- **USU Campus:**
  - o USU building area: 369,600 sq ft
  - o Student population: 3,500
  - o Full-time equivalent students: 2,550
  - o Faculty/staff: 213 Employees
  - o Federal agencies building area: 60,000 sq ft
- **SITLA Property:**
  - o Student housing: 271 Units
  - o Multi-family dwellings: 512 Units
  - o Single Family dwellings: 95 Units

Based on an assumption of four occupants per student housing dwelling unit, it is anticipated that nearly 50 percent of the build-out student population could live in student housing adjacent to the campus.

An additional land use consideration is the triangle-shaped parcel (approximately 25 acres) located east of the USU campus. Concept plans for this piece include large-scale retail with out-parcels and hotel space.

Trip Generation

Trip generation was calculated using rates published in the Institute of Transportation Engineers (ITE) Trip Generation (8th Edition, 2008). Trip generation for the proposed land use components are included in *Tables 1* and *2*.

The ITE trip generation rates identify gross trips to and from a facility as if it were a stand-alone activity. Gross ITE trip generation rates do not account for internal capture, pass-by trips, or significant pedestrian or transit trips. ITE mixed-use methodologies do not currently account for the interaction between residential and university campuses. However, the methodology does provide a means to calculate a reduction due to internal capture between residential and retail uses. Assuming the adjacent commercial parcel develops as approximately 200,000 square feet of shopping center, approximately 24 percent of p.m. peak hour trips from the residential land uses would likely be captured by the adjacent commercial uses. Because these trips will still need to use the internal roads within the SITLA and USU campus properties, these trips were not reduced from the overall trip generation estimates. Instead, approximately 20 percent of trips were distributed to the commercial property. Should the commercial property not be developed, the trips will still occur, but will likely continue on toward Moab. In either case, the trips will still occur on the internal roadways.

It was also assumed that five percent of trips to/from the multi-family residential units will travel to/from the USU campus. This reduction is based on the assumption that some married and/or older students and school employees would live in the multi-family housing and therefore have some trips between the campus and their homes.

Alternative modes of transportation such as walking and bicycling are very popular in Moab. Journey to Work data from the 2000 U.S. Census is shown in Table 3 for Moab City as well as the U.S. for comparison purposes.

As shown in *Table 3*, non-motorized travel for work purposes is much larger in Moab than the national average. Using this data as a surrogate for overall travel in Moab, a ten percent

Table 1
Moab USU & SITLA Master Plan
USU Campus Trip Generation

Daily Land Use[1]	Number of Units	Unit Type	Trip Generation	% Entering	% Exiting	Trips Entering	Trips Exiting	Transit/Pedestrian Reduction	Net Trips Entering	Net Trips Exiting	**Total Daily Trips**
College/University (550)	3500	Students	8,245	50%	50%	4,123	4,123	10%	3,710	3,710	**7,421**
General Office Building (710)	60	1,000 Sq. Ft. GFA	661	50%	50%	330	330	0%	330	330	**661**
Project Total Daily Trips						**4,453**	**4,453**		**4,041**	**4,041**	**8,081**
a.m. Peak Hour Land Use[1]	Number of Units	Unit Type	Trip Generation	% Entering	% Exiting	Trips Entering	Trips Exiting	Transit Reduction	Net Trips Entering	Net Trips Exiting	**Total a.m. Trips**
College/University (550)	3500	Students	666	80%	20%	533	133	0%	533	133	**666**
General Office Building (710)	60	1,000 Sq. Ft. GFA	93	88%	12%	82	11	0%	82	11	**93**
Project Total a.m. Peak Hour Trips						**615**	**144**		**615**	**144**	**759**
p.m. Peak Hour Land Use[1]	Number of Units	Unit Type	Trip Generation	% Entering	% Exiting	Trips Entering	Trips Exiting	Transit Reduction	Net Trips Entering	Net Trips Exiting	**Total p.m. Trips**
College/University (550)	3500	Students	790	30%	70%	237	553	0%	237	553	**790**
General Office Building (710)	60	1,000 Sq. Ft. GFA	89	17%	83%	15	74	0%	15	74	**89**
Project Total p.m. Peak Hour Trips						**252**	**627**		**252**	**627**	**880**

1. Land Use Code from the Institute of Transportation Engineers - 8th Edition Trip Generation Manual (ITE Manual)

SOURCE: Hales Engineering, December 2011

non-motorized daily trip reduction was taken for the multi-family and single-family residential portions of the study area. This reduction assumes good connectivity of pedestrian and bicycle facilities between the study area and Moab City and surrounding areas.

Limited data exists on trip making characteristics of student housing. One study conducted at Texas A&M (College Station, Texas) showed that 20 percent of students walked to school with an additional six percent riding bicycles. Seven percent used transit. Average walking distance was measured to be 1.2 miles while average biking distance was 1.4 miles. Because the proposed student housing would be located in close proximity to campus (less than one-quarter mile), and because the intent of the housing would be for student use, a 50 percent reduction of daily traffic was assumed (In fact, much of the student housing appears to be closer to campus than much of the parking facilities). The remaining 50 percent of daily traffic would account for those students who do own vehicles and that make non-school trips to other locations for other purposes (such as shopping, recreation, and part-time jobs).

Several provisions can help reduce vehicle trips to/from the student housing such as:

- Providing services on or near campus (food, banking, laundry, etc.)
- Providing shuttle services to downtown Moab and other recreational destinations
- Providing quality pedestrian and bicycle trails and connections to campus that are safe and well lit
- Providing secure bicycle storage and showering facilities on campus

Distribution/Assignment of Vehicle Trips

Project traffic is distributed to the roadway network based on the type of trip and the proximity of project access points to major streets, high population densities, and regional trip attractions.

TABLE 3

Mode	Moab (%)	United States (%)
Car, truck, van, motorcycle	79.7	88.0
Public Transit	0.0	4.7
Bicycle	3.4	0.4
Walked	9.5	2.9
Other	1.1	0.7
Worked at home	6.3	3.3
Total non-motorized	**20.3**	**7.3**

Source: 2000 U.S. Census

Table 2
Moab USU & SITLA Master Plan
SITLA Trip Generation

Daily	Land Use[1]	Number of Units	Unit Type	Trip Generation	% Entering	% Exiting	Trips Entering	Trips Exiting	Transit/Pedestrian Reduction	Net Trips Entering	Net Trips Exiting	**Total Daily Trips**
ST1	Apartment (220)	100	Dwelling Units	730	50%	50%	365	365	50%	182	182	**365**
ST2	Apartment (220)	126	Dwelling Units	887	50%	50%	444	444	50%	222	222	**444**
ST3	Apartment (220)	45	Dwelling Units	396	50%	50%	198	198	50%	99	99	**198**
MF1	Residential Condominium/Townhouse (230)	240	Dwelling Units	1,378	50%	50%	689	689	10%	620	620	**1,240**
MF2	Residential Condominium/Townhouse (230)	204	Dwelling Units	1,196	50%	50%	598	598	10%	538	538	**1,076**
MF3	Residential Condominium/Townhouse (230)	28	Dwelling Units	213	50%	50%	106	106	10%	96	96	**191**
MF4	Residential Condominium/Townhouse (230)	12	Dwelling Units	102	50%	50%	51	51	10%	46	46	**92**
MF5	Residential Condominium/Townhouse (230)	8	Dwelling Units	71	50%	50%	36	36	10%	32	32	**64**
MF6	Residential Condominium/Townhouse (230)	20	Dwelling Units	159	50%	50%	79	79	10%	71	71	**143**
SF1	Single-Family Detached Housing (210)	15	Dwelling Units	182	50%	50%	91	91	10%	82	82	**163**
SF2	Single-Family Detached Housing (210)	16	Dwelling Units	193	50%	50%	96	96	10%	87	87	**173**
SF3	Single-Family Detached Housing (210)	9	Dwelling Units	113	50%	50%	57	57	10%	51	51	**102**
SF4	Single-Family Detached Housing (210)	8	Dwelling Units	102	50%	50%	51	51	10%	46	46	**92**
SF5	Single-Family Detached Housing (210)	47	Dwelling Units	519	50%	50%	260	260	10%	234	234	**467**
	Project Total Daily Trips						**3,120**	**3,120**		**2,405**	**2,405**	**4,810**
a.m. Peak Hour	Land Use[1]	Number of Units	Unit Type	Trip Generation	% Entering	% Exiting	Trips Entering	Trips Exiting	Transit Reduction	Net Trips Entering	Net Trips Exiting	**Total a.m. Trips**
ST1	Apartment (220)	100	Dwelling Units	53	20%	80%	11	42	50%	5	21	**26**
ST2	Apartment (220)	126	Dwelling Units	65	20%	80%	13	52	50%	7	26	**33**
ST3	Apartment (220)	45	Dwelling Units	26	20%	80%	5	21	50%	3	10	**13**
MF1	Residential Condominium/Townhouse (230)	240	Dwelling Units	104	17%	83%	18	86	10%	16	78	**94**
MF2	Residential Condominium/Townhouse (230)	204	Dwelling Units	91	17%	83%	16	76	10%	14	68	**82**
MF3	Residential Condominium/Townhouse (230)	28	Dwelling Units	19	17%	83%	3	15	10%	3	14	**17**
MF4	Residential Condominium/Townhouse (230)	12	Dwelling Units	9	17%	83%	2	8	10%	1	7	**9**
MF5	Residential Condominium/Townhouse (230)	8	Dwelling Units	7	17%	83%	1	6	10%	1	5	**6**
MF6	Residential Condominium/Townhouse (230)	20	Dwelling Units	14	17%	83%	2	12	10%	2	11	**13**
SF1	Single-Family Detached Housing (210)	15	Dwelling Units	20	25%	75%	5	15	10%	4	13	**18**
SF2	Single-Family Detached Housing (210)	16	Dwelling Units	21	25%	75%	5	15	10%	5	14	**19**
SF3	Single-Family Detached Housing (210)	9	Dwelling Units	16	25%	75%	4	12	10%	4	11	**14**
SF4	Single-Family Detached Housing (210)	8	Dwelling Units	15	25%	75%	4	11	10%	3	10	**14**
SF5	Single-Family Detached Housing (210)	47	Dwelling Units	42	25%	75%	11	32	10%	10	29	**38**
	Project Total a.m. Peak Hour Trips						**99**	**403**		**77**	**317**	**394**
p.m. Peak Hour	Land Use[1]	Number of Units	Unit Type	Trip Generation	% Entering	% Exiting	Trips Entering	Trips Exiting	Transit Reduction	Net Trips Entering	Net Trips Exiting	**Total p.m. Trips**
ST1	Apartment (220)	100	Dwelling Units	73	65%	35%	47	25	50%	24	13	**36**
ST2	Apartment (220)	126	Dwelling Units	87	65%	35%	57	30	50%	28	15	**43**
ST3	Apartment (220)	45	Dwelling Units	42	65%	35%	28	15	50%	14	7	**21**
MF1	Residential Condominium/Townhouse (230)	240	Dwelling Units	123	67%	33%	83	41	10%	74	37	**111**
MF2	Residential Condominium/Townhouse (230)	204	Dwelling Units	108	67%	33%	72	36	10%	65	32	**97**
MF3	Residential Condominium/Townhouse (230)	28	Dwelling Units	21	67%	33%	14	7	10%	13	6	**19**
MF4	Residential Condominium/Townhouse (230)	12	Dwelling Units	11	67%	33%	7	3	10%	6	3	**10**
MF5	Residential Condominium/Townhouse (230)	8	Dwelling Units	8	67%	33%	5	3	10%	5	2	**7**
MF6	Residential Condominium/Townhouse (230)	20	Dwelling Units	16	67%	33%	11	5	10%	10	5	**14**
SF1	Single-Family Detached Housing (210)	15	Dwelling Units	19	63%	37%	12	7	10%	11	6	**17**
SF2	Single-Family Detached Housing (210)	16	Dwelling Units	20	63%	37%	13	7	10%	11	7	**18**
SF3	Single-Family Detached Housing (210)	9	Dwelling Units	12	63%	37%	8	4	10%	7	4	**11**
SF4	Single-Family Detached Housing (210)	8	Dwelling Units	11	63%	37%	7	4	10%	6	4	**10**
SF5	Single-Family Detached Housing (210)	47	Dwelling Units	53	63%	37%	34	20	10%	30	18	**48**
	Project Total p.m. Peak Hour Trips						**396**	**208**		**304**	**159**	**463**

1. Land Use Code from the Institute of Transportation Engineers - 8th Edition Trip Generation Manual (ITE Manual)

SOURCE: Hales Engineering, December 2011

Existing travel patterns observed during data collection also provide helpful guidance to establishing these distribution percentages, especially in close proximity to the site. Peak hour tuning movement counts were conducted during July 2011. The resulting distribution of project generated trips is as follows:

- 90% North (US-191 and/or adjacent commercial development),
- 5% North (on Mill Creek), and
- 5% South (on US-191).

These trip distribution assumptions were used to assign the daily generated traffic to the roadway network based on the following considerations:

- Permitted intersection movements,
- Traffic control (e.g., traffic signals, stop signs, etc.),
- Speed limit and/or directness of given travel path.

The software package TRAFFIX was used to tabulate assigned trips to each road based on trip generation, distribution, and assignment assumptions.

Figure 2 shows the anticipated average daily traffic (ADT) volumes for each of the planned internal roads within the SITLA and USU study area. As shown in *Figure 2*, the main north/south collector street will have a traffic demand of approximately 11,000 vehicles per day (vpd) at its busiest location. The middle access (Canyon Rim Road) is anticipated to carry approximately 1,000 vpd. All other minor streets are anticipated to carry less than 1,000 vpd.

Roadway Hierarchy and Cross Sections

Moab City currently has four standard cross sections including:

- Major arterial (5 lanes and shoulders),
- .Minor arterial (5 lanes no shoulders),
- Major collector (3 lanes and shoulders),
- Minor collector (3 lanes no shoulders), and
- Minor street (two lanes).

These standard sections can be found in the Moab City Design standards and Public Improvement Specifications (September 1999).

This master plan proposes to use variations of four cross sections including the following:

• **Major Collector (77 feet of right-of-way)** – This cross section is similar to the City's major collector (three lanes including a center two-way left-turn lane) with the exception of the edge treatments and bike lanes. Because this road is primarily be located in open space, no curb, gutter, and sidewalks are proposed. Instead, an adjacent multi-use trail is provided.

• **University Street (61 feet of right-of-way) –** This cross section will include one travel lane in each direction of travel, bicycle lanes, and wide sidewalks. At intersections, the cross section will flare out to accommodate left-turn lanes as necessary.

• **Minor Collector 1 (63 feet of right-of-way)** – This cross section is similar to the city's minor collector except no TWLTL would be provided. Instead, the cross section contains shoulders for bicycle lanes with turn lanes provided at intersections as required. As with the major collector, a multi-use trail is be provided but no curb, gutter, and sidewalk.

• **Minor Collector 2 (58 feet of right-of-way)** – This cross section is slightly larger than the city's minor street, although curb, gutter, and sidewalk are provided. This cross section has one travel lane in each direction and an adjacent multi-use trail.

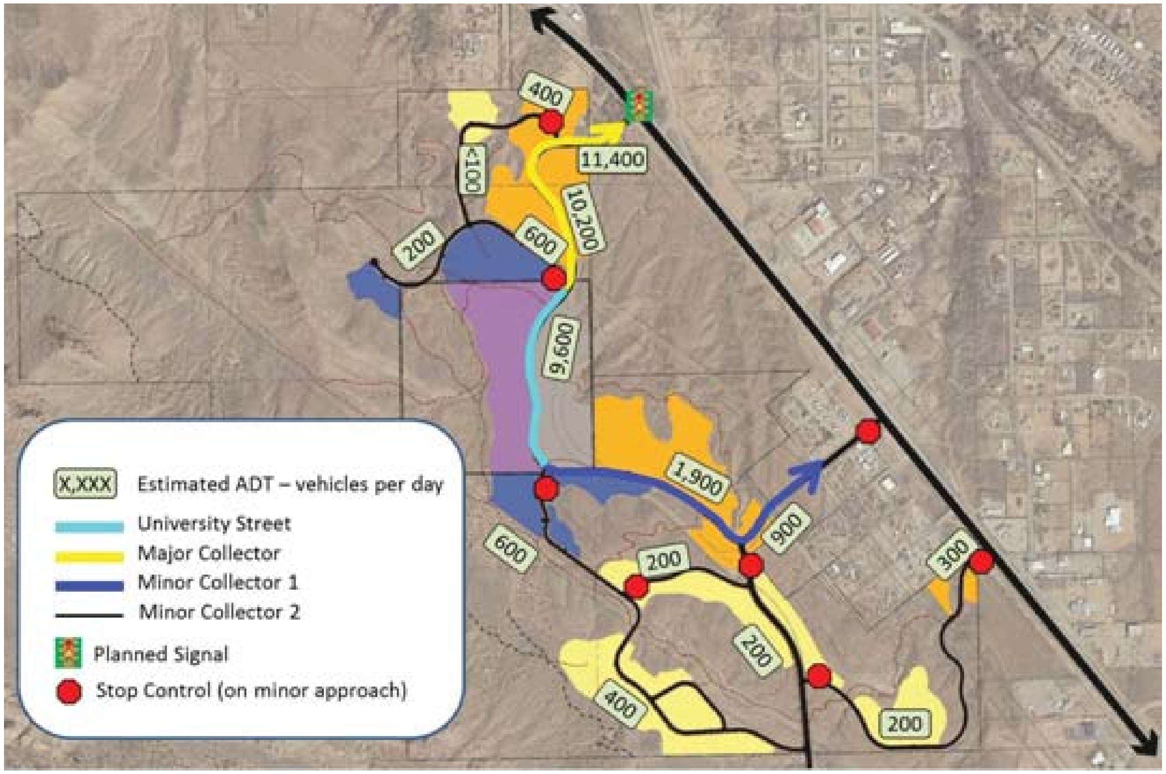


FIGURE 2 ESTIMATED ADT, PROPOSED CROSS SECTIONS, AND INTERSECTION CONTROL FOR INTERNAL ROADS.

Road classifications were chosen for each proposed street based on the anticipated daily demand volume and each street's context within the study area. *Figure 2* shows the classification of each road within the SITLA and USU study area.

Intersection Control

Based on anticipated volumes for each of the internal roadways, no traffic signals or all-way stop control will be required within the study area. Minor street approaches to intersections with collector streets should be stop-controlled. Other intersections of minor streets will likely require no control although stop signs can be placed on an as-needed basis. *Figure 2* shows the location and type of intersection control.

Pedestrian/Bicycle Considerations

As discussed previously, the Transportation Element of the City of Moab General Plan has goals relating to providing for pedestrian and non-motorized (bicycle) modes of transportation. The USU and SITLA properties should be developed so that pedestrian and bicycle transportation can be accommodated in a safe and efficient manner. Because of the future potential for transit (shuttle system), this mode should also be accommodated.

USU Campus Area
The main north/south street through campus should be constructed using "complete streets" principles. Complete streets are designed to provide safe travel by all users including pedestrians, cyclists, regular motor vehicles, and public transportation. This is in contrast to many roads which are designed primarily with the automobile as the main user.

Specific implementation strategies include the following:

• Narrow lane widths (10 to 11 feet) to discourage excessive speeds and unnecessary cut through traffic. This also creates shorter crossing distances.

• Raised center median to provide aesthetic quality as well as to provide additional traffic calming benefit and pedestrian refuge at mid-block crossing locations (if applicable).

- Provision for one or more of the following bicycle facilities (in order of most preferred to least preferred):
  - o Exclusive bike bath in parallel corridor
  - o Striped on-street bike lane
  - o Shared vehicle/bike lane (with use of shared-lane marking or “sharrow”)
  - o “Bike Route” sign

- Bike path connections between campus and other areas of the SITLA properties, especially the student housing and multi-family pods, as well as connections to existing bike paths external to the development area.

- Bus (shuttle) provisions:
  - o Bus pull-outs or exclusive pick-up/drop-off loop in close proximity to campus buildings
  - o Bus stop shelters and siting areas

- Wide sidewalks/paths separate from bike paths which include street furniture (benches, garbage cans, decorative lighting, etc.).

- Buffers between sidewalks and travel lanes such as park strips or on-street parking (if applicable).

- Bulb-outs at intersections to minimize the pedestrian crossing distance, exposure to vehicles, and improve sight distance and visibility of pedestrians.

- Adequate bicycle storage facilities (bike racks, lockers, etc.) in convenient locations near campus.

- Raised crosswalks with alternate texture (such as pavers) to better delineate pedestrian space.

Other programs/policies that can reduce automobile traffic and increase pedestrian and bicycle activity include:

- On-site showering facilities,

- Hourly car rental programs (such as U Car Share in Salt Lake City and the University of Utah),

- Bike sharing program (such as U-bike at University of Utah), and

- Appropriate campus parking fees to dis-incentivize driving.

SITLA Properties

The development plan for SITLA properties have a clustered housing development pattern separated by large open space areas.

Multi-use trails should connect all of the residential pods as well as connect to campus and externally to adjacent areas of Moab. The multi-use trail should be a minimum of 10 feet wide to accommodate both pedestrians and bikes. Sidewalks outside of the residential pods are not necessary.

Within the residential pods, adequate sidewalks and trails should parallel all internal roads. If long blocks become necessary due to terrain, trails should be provided mid-block to increase neighborhood walkability.

Parking

Currently, it is proposed that parking stalls be provided for the campus area at a ratio of one stall per four traditional students and one stall per two faculty, staff, and non-traditional students. The overall “blended” parking ratio is approximately 0.28 stalls per school population.

A parking ration of 3 stalls per 1,000 square feet should be provided for government agency or general office space.

A review was completed of data in ITE Parking Generation (4th Edition, 2010), as well as parking data obtained from Brigham Young University in Provo, Utah.

ITE Data

ITE data are available for both Junior/Community Colleges as well as Universities. Data for Junior/Community Colleges in both suburban and rural areas show that peak parking demand occurs in the late morning at a rate of 0.18 parked vehicles per school population (which includes all students, faculty, and staff).
University data showed peak parking also occurring in the late morning. Average demand was approximately 0.33 vehicles per school population in suburban locations but only 0.29 vehicles per school population at urban locations. It should be noted that only one of the 13 sites studied had paid parking, which likely affects parking demand.

Additional Data

USU Toole precedent:
No formal parking demand study was available from USU Tooele. However, some rough estimates from parking demand and school size were available. USU Tooele is approximately 80,000 square feet. The student enrollment is approximately 900 students with an additional 42 employees. The parking demand is approximately 180 to 200 vehicles. The average peak parking demand per school population is 0.19 to 0.21 vehicles.

Based on this additional data, the average peak parking demand is approximately 0.2 vehicles per school population. This appears to be in-line with ITE data and provides confidence for the master-planned parking estimate of 0.28 stalls per school population.

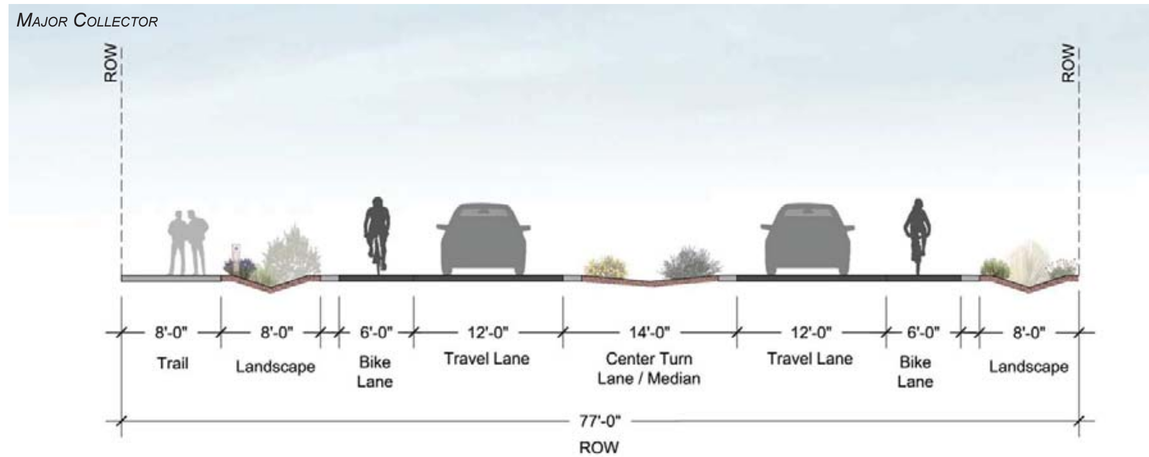
Typical Street Sections

Major Collector

The Major Collector road typifies the section of road from Highway 191 to the edge of the University parcel. This section of road has the highest volume of traffic and will need the widest right-of-way.

The 77-foot right-of-way shown includes one travel lane in each direction, a bike lane in each direction, an 8' trail on one side, a landscape swale for storm water infiltration and conveyance on both sides and a center turn lane / landscaped median. This center section will need to be a turn lane when other roads intersect this main road but will remain as native landscape everywhere else.

This section of road primarily navigates through open space so flat curbs are utilized to ensure that storm water makes its way into the swales to infiltrate as fast as possible. The swales may also contain small check dams and detention basins along its length to further control storm water.



University Street

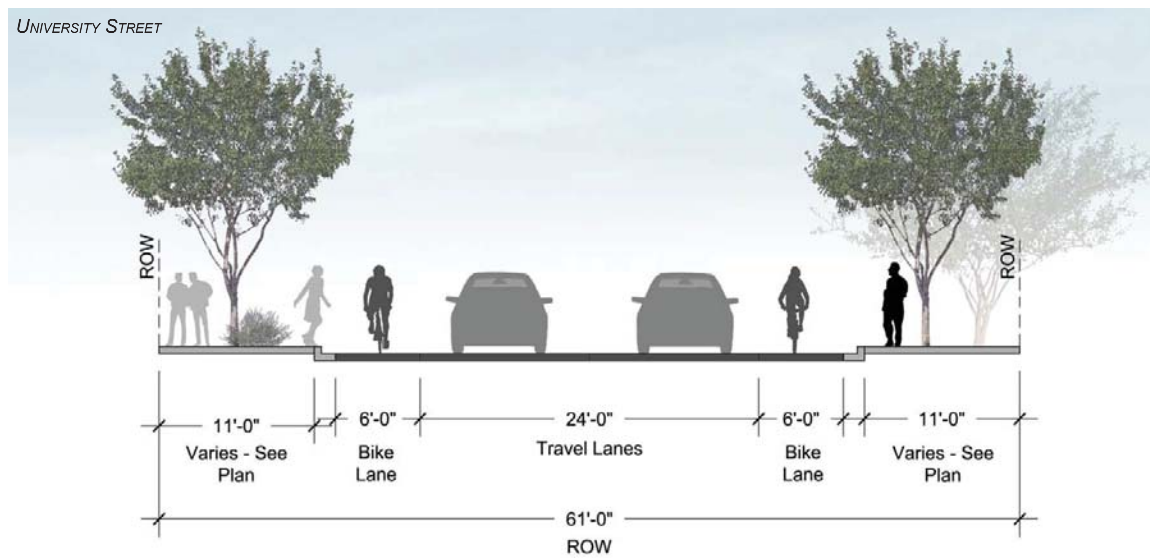
The University street is the section of road that runs through the USU campus area. The intent is to make this section of road as narrow as possible while still conveying the volumes of traffic that are projected for this zone.

A narrow street will allow buildings to be closer to the street, provide shorter crossing distances for pedestrians and will visually indicate a slower corridor for vehicles passing through.

The 61-foot right-of-way includes a travel lane in each direction, a bike lane in each direction and a sidewalk / landscape zone. This condition varies depending on where you are in the campus along that street.

The University street is the only section of road that will contain some groupings of trees that you would not typically find on-site. The trees are used to provide human comfort in the landscape, to further visually narrow the road and to add to the aesthetics of the campus. The trees will be a drought tolerant species adapted to desert environments.

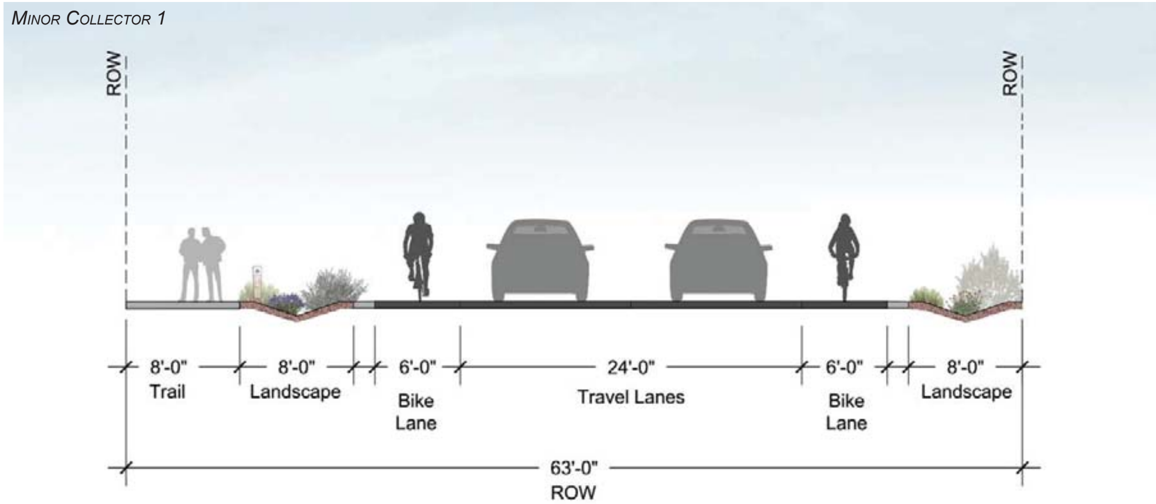
This section of road will also contain frequent cross walks and may contain Hawk Beacons, raised intersections or other pedestrian friendly devices at some time in the future.



Minor Collector 1
This primary minor collector starts from the south end of the University Street, winds its way through SITLA properties and ends up on Canyon Rim Road and Highway 191.

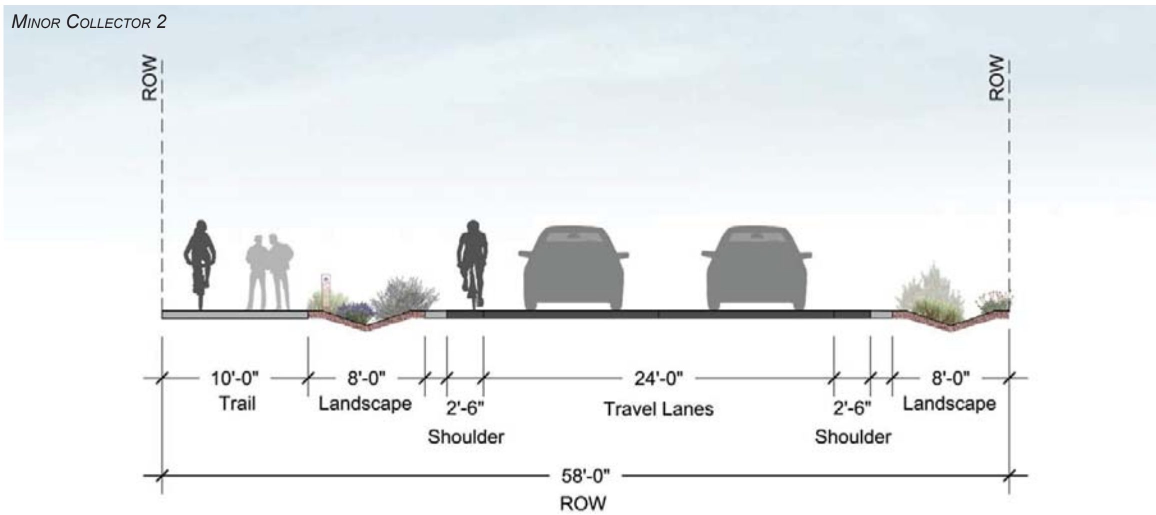
The 63-foot right-of-way includes a travel lane in each direction, a bike lane in each direction, an 8-foot wide trail on one side and a swale on each side to convey and infiltrate storm water run-off.

As on the Major Collector street, this street has flat curbs as well.



Minor Collector 2
The second minor collector road is primarily for low volume side streets that will only have local traffic. Cyclists along these streets can either ride in the travel lanes when no vehicles are around, in the shoulder of the street or in a larger wide trail.

This street also includes swales for storm water and flat curbs.



Introduction

As part of the Utah State University Future Moab Campus Master Plan, the design team has completed an infrastructure master plan. The infrastructure master plan is an evaluation of the existing utility services in proximity to the USU and SITLA properties as well as a description of the required improvements necessary to support the Campus development.

The surrounding SITLA property was included in the project study area to evaluate connectivity of water, sewer, power, natural gas, and communications. A storm water master plan was also completed for the USU Moab Campus.

Water

The water system master plan was developed to integrate the USU Campus into the existing Grand Water and Sewer Service Agency (GWSSA) system. Water demands were calculated for the USU Campus and the surrounding SITLA property based on the proposed land use plan in this document and State of Utah Division of Drinking Water (UDDW) standards. The water demands were used to size water lines and identify source and storage demands for the project.

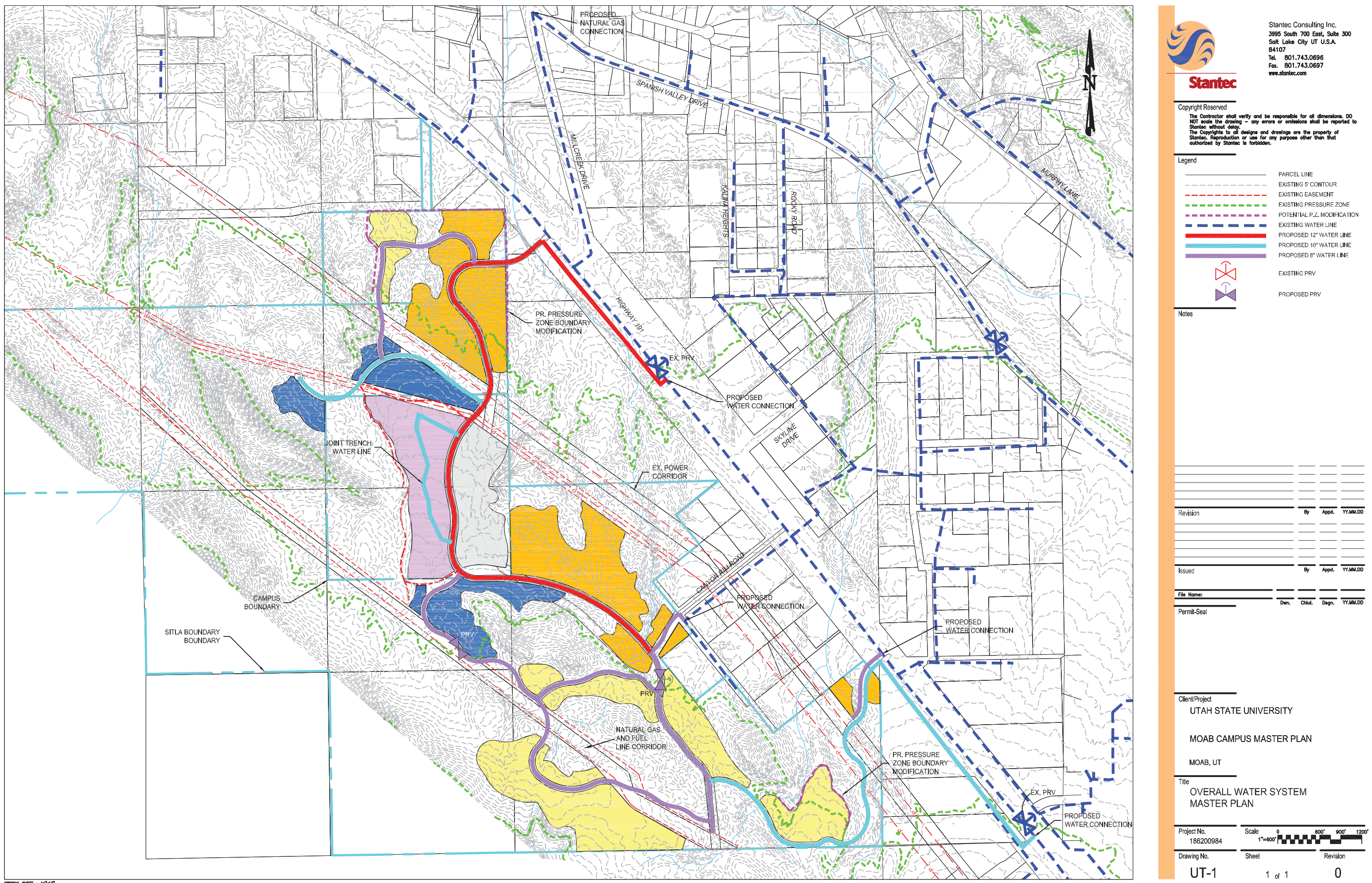


Figure UT-1: Water System Framework

Pressure zones were evaluated based on conversations with GWSSA as well as GIS information provided by GWSSA (See *Figure UT-1* for the water system master plan).

Demands

The UDDW standards require water system demand calculations for source, storage, line sizing, and water rights. The following describes the basis for the UDDW demands:

- *Peak Day Demand*
  This is used to identify the required source capacity for a water system.

- *Average Day Demand*
  This is used to identify the required storage demand for a water system. Storage must also be provided to supply fire flow.

- *Peak Day + Fire Flow*
  This demand typically controls line sizing and is the sum of the project fire flow demand + the peak day demand.

- *Peak Instantaneous Demand*
  This is considered the highest instantaneous use on a water system. This is also used to evaluate line sizing, but typically does not control the line size.

- *Annual Water Right Demand*
  This is equal to the annualized average day demand for indoor demands and annual water demand for irrigation.

There are several land use types associated with the water system master plan including students, faculty/staff, student housing, multi-family housing, single family housing, and irrigation. The following two sections summarize the demands applied to this master plan for indoor and outdoor use. Refer to the appendix for detailed calculations.

Indoor Demands

<u>*Peak Day Demands*</u>

UDDW standards are based on equivalent residential units (ERU's). Typical values for other standard uses are also provided in section R309-510 of the Rules Governing Public Drinking Water Systems. An ERU is a single family home representing an average of (4) residents per home and equates to a peak day demand of 800 gpd/unit. For this project the following unit peak day demands were derived from R309-510 and applied to the project:

- Students: 20 gpd/FTE

- Faculty & Staff: 15 gpd/unit

- Student Housing: 1200 gpd/unit (1 unit = 6 residents)

- Multi-Family: 600 gpd/unit (1 unit = 3 residents)

- Single Family: 480 gpd/unit (1 unit = 2.4 residents)

When applying the total number of Campus and SITLA uses it was determined that the Peak Day Indoor Demands are 40 gpm for the Campus and 460 gpm for the SITLA property.

<u>*Average Day Demands*</u>

Average day demands represent the amount of water that must be available in a storage facility. The UDDW standards for average day demands are equivalent to half of the peak day demand. For the USU Master plan this equates to the following:

- Students: 10 gallons/FTE

- Faculty & Staff: 7.5 gallons/unit

- Student Housing: 600 gallons/unit (1 unit = 6 residents)

- Multi-Family: 300 gallons/unit (1unit = 3 residents)

- Single Family: 240 gallons/unit (1 unit = 2.4 residents)

The total average day demand for the USU Campus and the SITLA property is 27,100 gallons and 330,960 gallons respectively.

<u>*Fire Flow Demands*</u>

The State of Utah has adopted the International Fire Code (IFC) for fire safety regulations. As part of the IFC standard, needed fire flow can be calculated for a water system area by evaluating the largest fire flow demand for the area. For the purposes of this study, fire flow calculations were evaluated for a large Campus building and for a typical student housing building. The IFC calculation is based on building area and construction type.

For the purposes of this study, a fire area of 75,000 ft2 and construction Type IIB was assumed. The IFC allows for a reduction of up to 75% of fire flow for buildings that are constructed with fully integrated fire sprinklers. In no case may the fire flow be less than 1,500 gpm. Based on the assumptions, it was determined that the fire flow demand for the project is 1,500 gpm for (4) hours. It should be noted that the duration is not reduced with the presence of fire sprinklers.

<u>*Peak Instantaneous Demands*</u>

UDDW calculates peak instantaneous indoor demand based on an empirical equation that relates the number of ERU's to the peak day demand. This equation is expressed as follows:

Q=10.8*(n)0.64

Where:

Q = Peak Instantaneous Demand in gpm

n = Number of ERU's

The Campus and SITLA uses were converted to ERU's for this calculation. The peak instantaneous demand for the Campus and SITLA properties are 160 gpm and 800 gpm respectively.

<u>*Average Annual Water Right Demands*</u>

The average annual water right demand represents the amount of water rights that are required to be held by the water system. Based on conversations with GWSSA, the water company has access to water rights. Based on the calculations, the Campus will require 30.4 ac-ft of water annually while the SITLA land will require 370.7 ac-ft.

Outdoor Demands
Outdoor demands were calculated for the project based on irrigated area assumptions and the estimated consumptive use for turf grass. Based on the land use plan, it is assumed that the majority of the open space will be native/non-irrigated. It was assumed that a small portion of manicured open space will be incorporated into the project as follows:

- Campus: 1.2 acres (based on current master plan)
- Student Housing: 5% Irrigated (assumed)
- Multi-family Housing: 5% Irrigated (assumed)
- Single Family Housing: 10% irrigated (assumed).

These relatively small portions of irrigated area were deemed appropriate given the vision of the master plan and the desert setting.

The consumptive use was calculated based on the Utah Division of Water Rights Consumptive Use Tables. These tables were derived from a report completed by Utah State University (1998) and are based on climate. Peak day demand is determined by applying the consumptive use values for turf grass in the Moab area coupled with an application efficiency. Annual demands are also calculated based on the seasonal consumptive use in a drought year. The following irrigation unit demands were calculated for the Moab area and are applicable to this project:

- Peak Day Demand: 8,850 gpd/irrigated acre
- Average Day Demand: 4,425 gallons/irrigated acre
- Peak Instantaneous demand: 12 gpm/irrigated acre
- Average Annual demand: 3.39 ac-ft/irrigated acre

Please refer to the appendix for detailed irrigation demands.

System Expansion
To serve the project at build-out, four connections to the existing GWSSA system are assumed. Three connections are proposed to the water line in the US 191 ROW, and one connection is assumed to the water line in Canyon Rim Road. As part of the water system layout, pressure zones were established based on the location of existing PRV's in US 191. Based on these locations, it was determined that the overall project spans three pressure zones. Potential adjustments to the hard elevation pressure zones are shown on the master plan figure to promote connectivity. Water line sizes illustrated on UT-1 were sized based on the peak demand scenarios described and experienced with similar systems. Final water line sizing should be based on design level information.

Sewer

The sewer system master plan for the USU Moab Campus was developed in concert with the water system master plan. Flow rates were derived from the appropriate water system demands with applicable peaking factors. The study area for this master plan includes the Campus and the surrounding SITLA property. The key objectives of the sewer master plan are to identify points of connection, illustrate sewer collector alignments, and calculate sewer flows for the study area. *Figure UT-2* illustrates the proposed sanitary sewer master plan.

Sanitary Sewer Flows
The master plan was completed to Utah Department of Environmental Quality (UDEQ) standards. Title R317 of the Utah Administrative Code governs sanitary sewer design for the state. Section R317-3 details the requirements for sizing wastewater collection, treatment and disposal systems.

The requirements of this section were applied to the land use plan for the Campus and the surrounding SITLA property. The first step in the master plan is the calculation of sewer flows for the project area. The two key sewer flow calculations are as follows:

- Annual Average Daily Flow Rate (AADF): This is an average of the daily flow rates for a period of not less than one year. For the purposes of this study, this number was set equal to the average day water demand described above. Typically this demand is used in evaluating treatment capacity. While separate treatment is not an aspect of this project, the AADF will need to be incorporated into the regional treatment facility.
- Maximum Design Flow Rate (MDF): This represents the design flow rate used to size key infrastructure such as collectors, interceptors and lift stations. A peaking factor is applied to the AADF to determine the MDF. For collector pipes (pipes less than 12"-diameter), a peaking factor of four is applied.

Based on the these calculations, the AADF for the USU Campus is 19 gpm, and the MDF is 75 gpm. For the SITLA property, the AADF is 230 gpm, and the MDF is 919 gpm. For detailed calculations, please refer to the Appendix.

System Expansion
To serve the Study Area at build-out, two connections to the existing GWSSA system will be required. A third connection may be needed for the MF-2 area. This area will require coordination with the adjacent property owner. In lieu of this third connection, a lift station could be provided to deliver flows to the new sewer main proposed in Canyon Rim Road. Coordination with GWSSA related to available capacity is ongoing. Preliminary coordination will be completed prior to the completion of this study. Further coordination will be required as it relates to development phasing.

Storm Water

The master plan strategy for the USU campus was completed to identify key constraints that must be addressed during design development and final design for the project. To complete this portion of the master plan, relevant hydrologic data was assembled for the project area including GIS topography, the location of major drainage courses, precipitation data, and existing soil types. *Figure UT-3* illustrates the on-site storm water analysis for the USU Moab Campus.

<u>*Detention/Retention*</u>

Several options were evaluated for this system including retention, detention ponds, and buried detention galleries. On site retention was the initial goal for the project because Moab currently experiences several drainage issues during large storms; however, retention is not allowed in Moab City due to the tendency to promote insect habitat. Given this, detention was evaluated as the preferred option for controlling increased storm water flows from the campus site.

Surface water detention is recommended for several reasons. Sanding will be an ongoing issue for storm water management on the project. Underground galleries will present operations and maintenance difficulties over the life of the system. Furthermore, as the campus develops, surface parking will be replaced with parking structures and campus buildings making it difficult to locate a drainage gallery area that will be sufficient for the project.

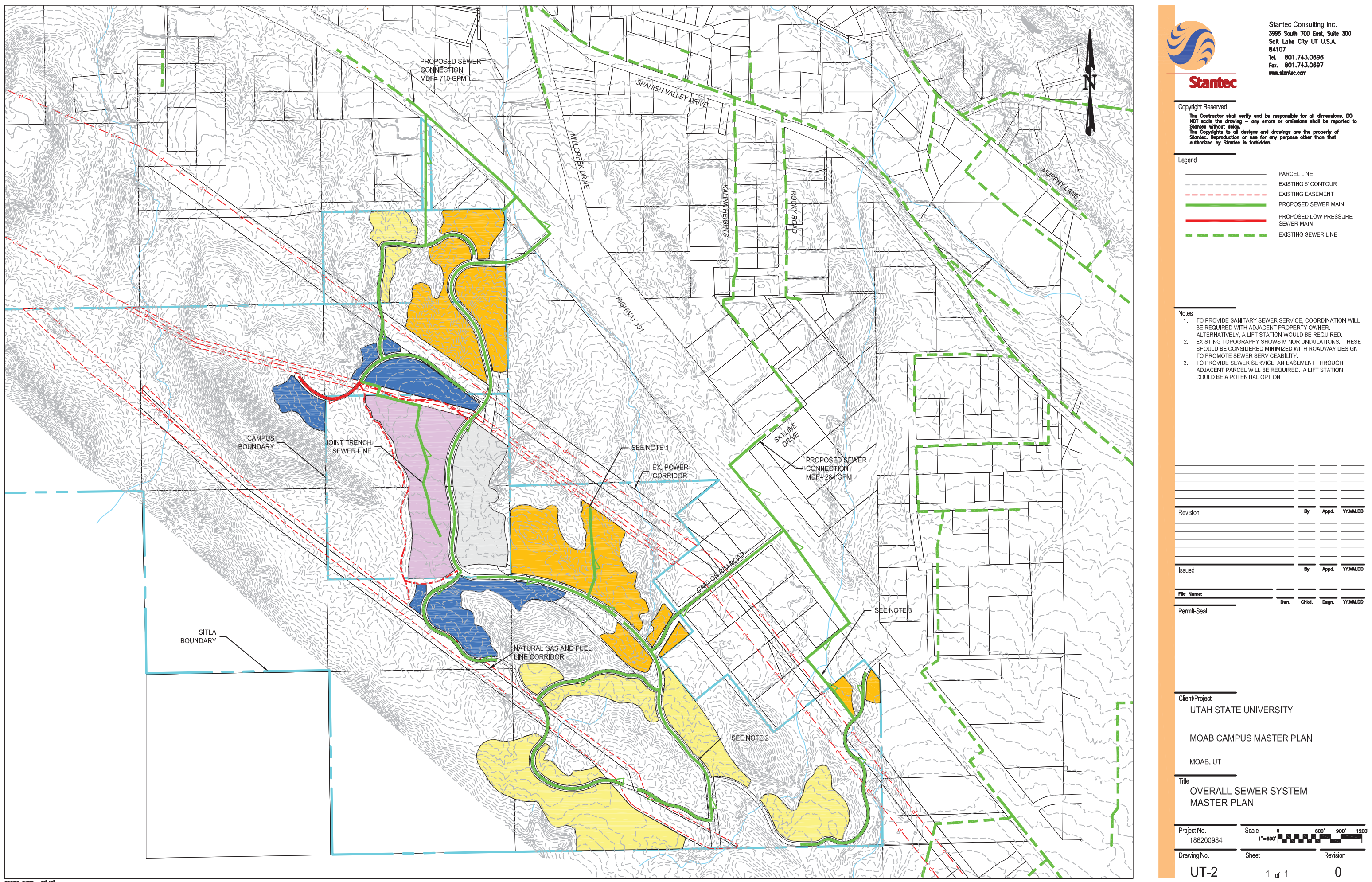


Figure UT-2: Sewer System Framework

Offsite Conveyance

As stated previously, there are two major drainage channels or arroyos that cross the campus parcel (See *Figure UT-3*). The western drainage is considered to be a pass through drainage, with little impact to the campus. The southeastern drainage must be incorporated into the design of the campus to allow existing off-site upstream flows to pass through the site while detaining additional flows generated by campus hardscape.

On-site Drainage Basins

Based on existing topography and the proposed land use plan, the site divides well into three on site drainage basins. A fourth basin exists west of the western drainage, but this area is not proposed for development and will not increase storm water runoff.

On site detention ponds are proposed to reduce post development discharge from the campus to predevelopment rates. These ponds were sized based on a predevelopment runoff assumption that historical discharge is approximately 0.2 cfs/acre in a 100 year storm event. Refer to the appendix for pond sizing calculations. Pond #1 requires .6 acre feet of detention volume, pond #2 requires .5 acre feet and pond three requires .2 acre feet.

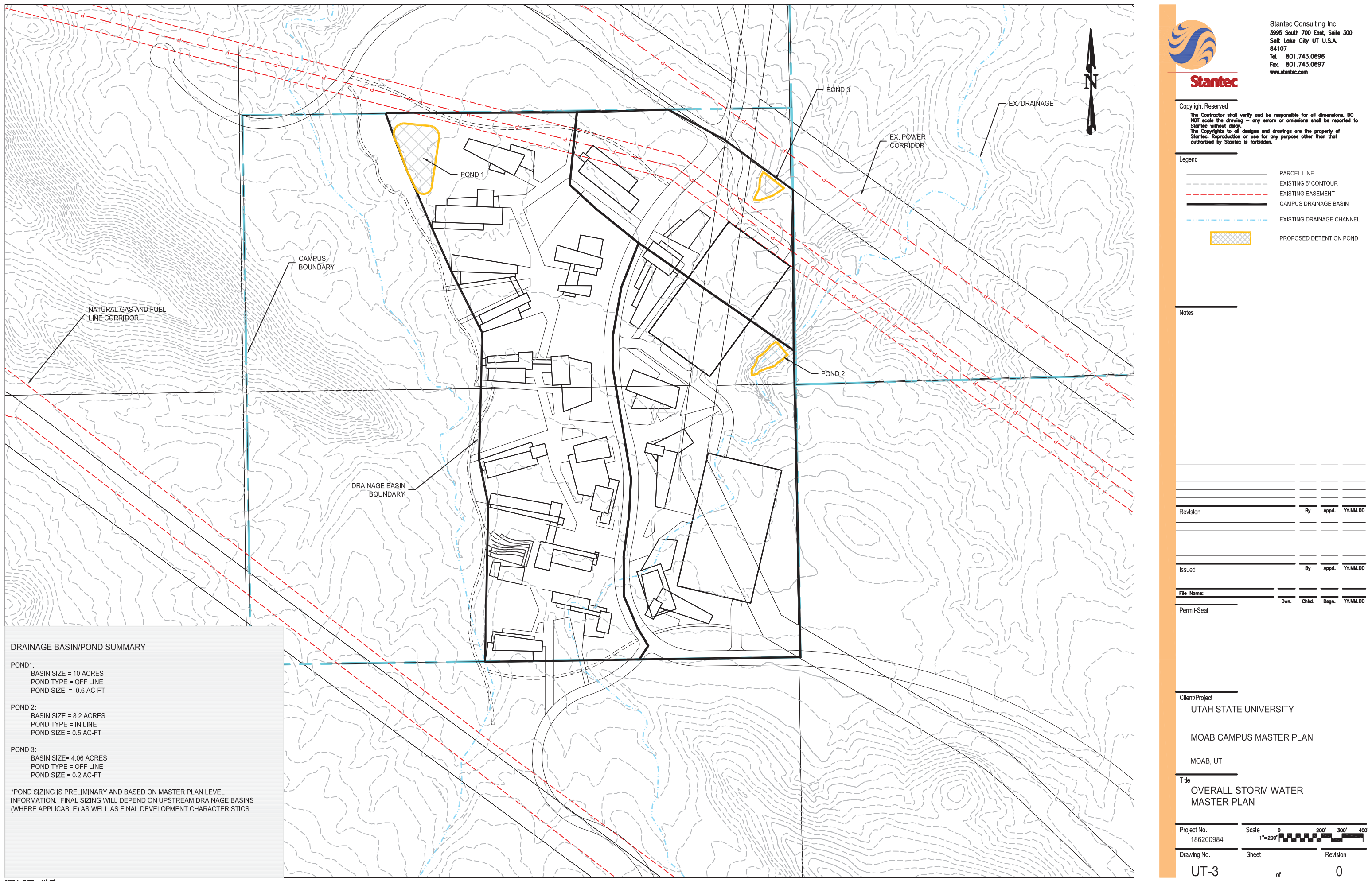


Figure UT-3: Storm Water System Framework

Hydrologic Data

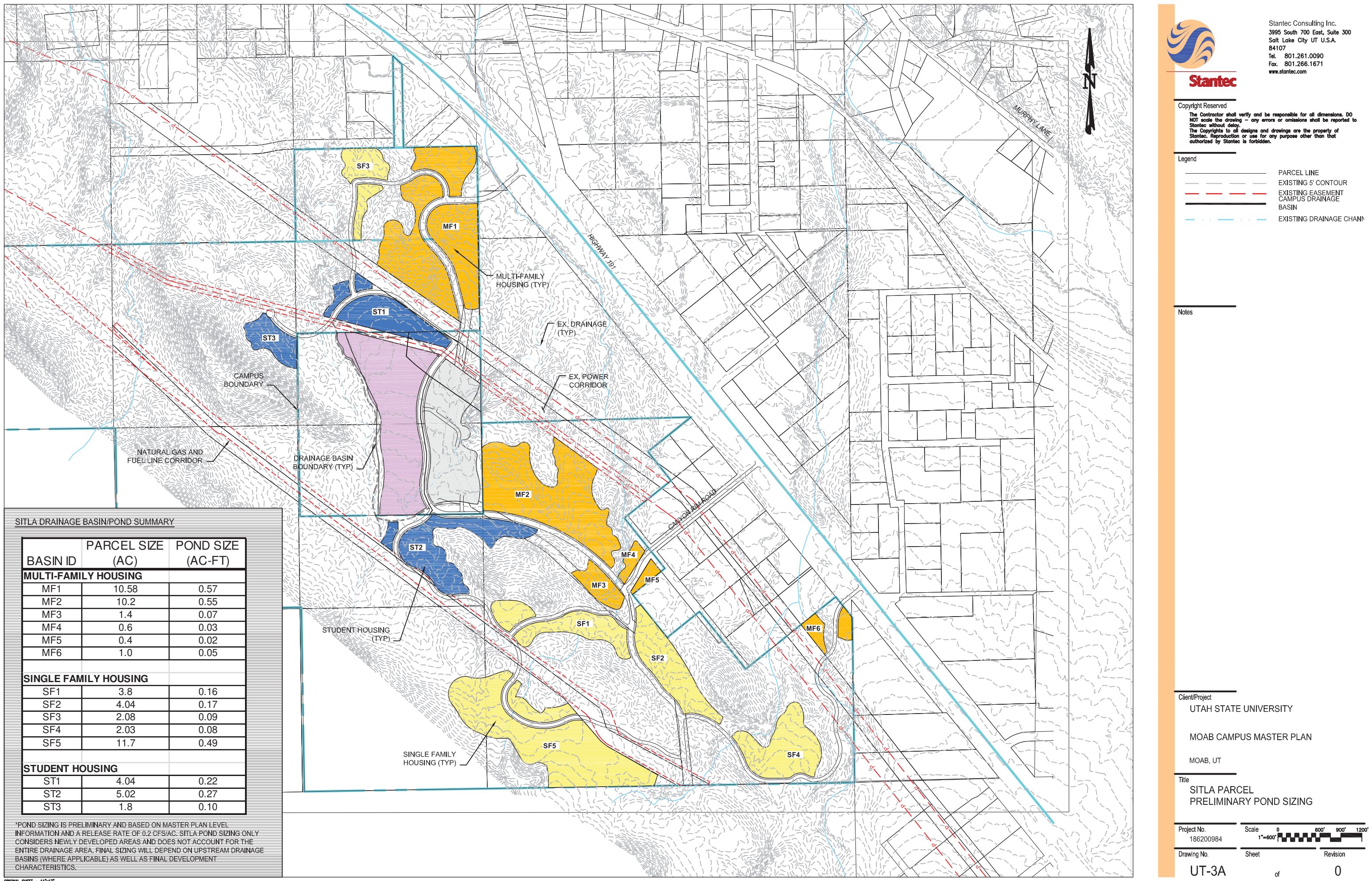
In developing the storm water strategy for this master plan, soil information and hydrologic data were reviewed for the study area. Soil types were obtained from the Natural Resources Conservation Service (NRCS). A soil map and soil description table are available in the appendix. Based on this information, the native soil on the campus site has relatively good hydrologic properties and should infiltrate water reasonably well. The site is surrounded by rock cliffs and other poor soils that will runoff more readily.

Precipitation data was obtained from the National Oceanic and Atmospheric Administration (NOAA) and is available in the appendix.

This information was used as part of the on-site detention basin sizing.

System Expansion

As design development and final design for the campus occurs, careful attention should be given to the storm water system off-site flows. These should be identified and routed through the project. Best Management Practices should be employed to maintain water quality and promote operations and maintenance. Examples of best management practices



SITLA DRAINAGE BASIN/POND SUMMARY

BASIN ID	PARCEL SIZE (AC)	POND SIZE (AC-FT)
MULTI-FAMILY HOUSING		
MF1	10.58	0.57
MF2	10.2	0.55
MF3	1.4	0.07
MF4	0.6	0.03
MF5	0.4	0.02
MF6	1.0	0.05
SINGLE FAMILY HOUSING		
SF1	3.8	0.16
SF2	4.04	0.17
SF3	2.08	0.09
SF4	2.03	0.08
SF5	11.7	0.49
STUDENT HOUSING		
ST1	4.04	0.22
ST2	5.02	0.27
ST3	1.8	0.10

*POND SIZING IS PRELIMINARY AND BASED ON MASTER PLAN LEVEL INFORMATION AND A RELEASE RATE OF 0.2 CFS/AC. SITLA POND SIZING ONLY CONSIDERS NEWLY DEVELOPED AREAS AND DOES NOT ACCOUNT FOR THE ENTIRE DRAINAGE AREA. FINAL SIZING WILL DEPEND ON UPSTREAM DRAINAGE BASINS (WHERE APPLICABLE) AS WELL AS FINAL DEVELOPMENT CHARACTERISTICS.

Figure UT-3b: Storm Water System Framework that should be applied to the project include:

- Oil/water separation from parking lots prior to retention/detention.
- Extended catch basins and/or hydrodynamic separators for removal of suspended solids and sand.
- Annual maintenance will be required to remove sand deposits from catch basins, pipelines, and ponds.
- Minimum slope requirements should be evaluated against maintenance costs to limit sand deposits in pipe lines.
- Sediment storage shall be included detention pond sizing.

Power

The design team has conducted several conversations with Rocky Mountain Power (RMP) to discuss power service for the USU future Moab Campus. Additionally, conversations were held to discuss service to the surrounding SITLA property. The power master plan was completed to identify connection points to existing RMP infrastructure and to determine off-site upgrades that would be required to service the study area. *Figure UT-4* illustrates the power distribution master plan.

Proposed System Expansion
There are two options for serving power to the USU Campus. Option 1 includes construction of a separate substation served from either the 138 kV line or the 69 kV line. Voltage would be reduced to a standard 12 kV distribution voltage that could be delivered to each building via the joint utility trench. Individual building transformers would be used convert the power based on the needs of the individual buildings. Under this option, the Campus would have one point of delivery and maintain private distribution throughout the Campus. On-site location of the substation could be difficult and require coordination with SITLA to identify an acceptable location for the substation. This option provides for lower power costs, but will likely require higher capital costs. Additionally, operations and maintenance costs would be borne by the University.

The second option for serving campus power is based on commercial delivery of RMP to each individual building. This would likely remove the need for an on-site substation but would increase power costs at the individual meters. The surrounding SITLA property would receive power service via extension of the existing RMP distribution in the Moab/Spanish Valley area.

Based on conversations with RMP personnel, there is distribution power in the area. Expanding the power system to serve the residential SITLA uses will be completed on an as needed basis, as the development expands.

Natural Gas

Questar Gas operates and maintains the natural gas system in Moab and Spanish Valley. Several conversations and meetings were conducted with Questar Gas in the development of the natural gas master plan. The master plan is preliminary and was completed based on the Campus square footages and surrounding SITLA densities.

Figure UT-4 illustrates the proposed natural gas layout for the study area.

Proposed System Expansion
Should USU campus construction initiate prior to the Moab City's installation of the new 6" main, a connection to the 4" IHP main in Spanish Valley Drive will be required. With proper Questar Gas coordination, it is possible that the 6" extension could be coordinated with the first phase of Campus development.

Questar anticipates that 2-3 connections to the future 6" IHP would be required to support the Campus/SITLA area at build-out. Based on preliminary design, a primary IHP main (4-6" in diameter) would be constructed between the north and south connections. Side streets would have 2-4" diameter IHP mains.

Fiber Optics/Communications

A reliable communications network is critical to the success of the USU future Moab Campus. Furthermore, access to fiber optics is a basic necessity for residential property planned on the surrounding SITLA property.

The design team has coordinated with Frontier Communications to identify the available capacity and potential connection points to the Frontier system.

Frontier communications currently provides integration of the existing USU Moab Campus to the Utah Education Network.

Proposed System Expansion
A higher level of design detail will be required to layout all required system improvements for the fiber optics and communication systems. Based on conversations with Frontier, two connections will be required to the existing 96 strand fiber optic line in US 191. The exact location of the connections will need to be coordinated with Frontier throughout the design process.

Of the available 70 strand capacity, two strands will be required to serve the needs of the Campus and the surrounding SITLA property.

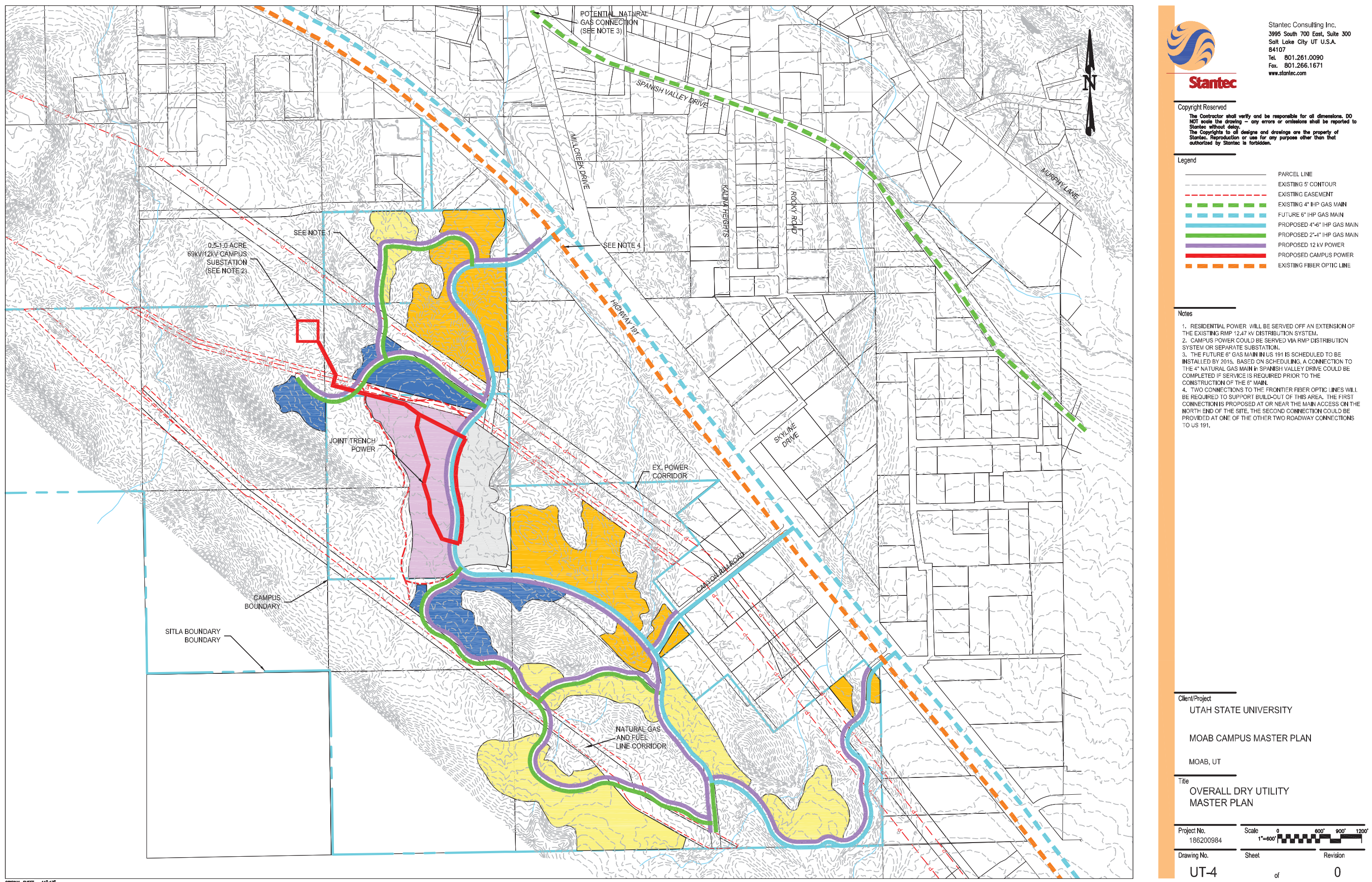


Figure UT-5: Dry Utilities

Project wide Probable Cost Projections

The following projections tabulate major infrastructure costs that will likely be incurred to develop the Roads and infrastructure for the University and surroundding neighborhoods on SITLA property.

These costs may vary significantly as design on the project gets further along and as time increases. For instance, the streets may end up as a rolled curb instead of a curb and gutter or the storm water infrastructure may end up being daylighted in swales rather than in a piped system. All costs will also likely increase with time and as the cost of materials fluctuate.

The purpose of these projections are to understand order of magnitude costs considering the currently planned infrastructure, preliminary sizing projections and system types.

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT
MAJOR COLLECTOR				
1. MOBILIZATION (Approximately 5% of Subtotal Capitol Cost)	1	LS	$ 49,000	$ 49,000
2. CLEARING AND GRUBBING	3.3	AC	$ 2,000	$ 6,600
3. EXCAVATION (CUT/FILL)	11,000	CY	$ 10	$ 110,000
4. ASPHALT - 4" DEEP	12,200	SY	$ 20	$ 244,000
5. BASE - 8" DEEP	2,700	CY	$ 25	$ 67,500
6. CURB AND GUTTER	3,600	LF	$ 20	$ 72,000
7. 8" DIA. PVC SEWER MAIN	1,800	LF	$ 35	$ 63,000
8. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	7	EA	$ 3,000	$ 21,000
9. 18" DIA. ADS N-12 STORM DRAIN	1,800	LF	$ 40	$ 72,000
10. 5' x 5' STORM DRAIN BOX (~ EVERY 250 FT.)	7	EA	$ 2,500	$ 17,500
11. 12" DIP WATER LINE	1,800	LF	$ 65	$ 117,000
12. 12" GATE VALVE (~EVERY 500 FT.)	4	EA	$ 2,500	$ 10,000
13. FIRE HYDRANT W/ LATERAL AND VALVE (~EVERY 500 FT.)	4	EA	$ 4,000	$ 16,000
14. POWER, GAS, COMMUNICATIONS	1,800	LF	$ 90	$ 162,000
			SUBTOTAL	$ 1,028,000
MINOR COLLECTOR				
1. MOBILIZATION (Approximately 5% of Subtotal Capitol Cost)	1	LS	$ 46,000	$ 46,000
2. CLEARING AND GRUBBING	2.9	AC	$ 2,000	$ 5,800
3. EXCAVATION (CUT/FILL)	9,300	CY	$ 10	$ 93,000
4. ASPHALT - 4" DEEP	9,100	SY	$ 20	$ 182,000
5. BASE - 8" DEEP	2,040	CY	$ 25	$ 51,000
6. CURB AND GUTTER	3,800	LF	$ 20	$ 76,000
7. 8" DIA. PVC SEWER MAIN	1,900	LF	$ 35	$ 66,500
8. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	8	EA	$ 3,000	$ 24,000
9. 18" DIA. ADS N-12 STORM DRAIN	1,900	LF	$ 40	$ 76,000
10. 5' x 5' STORM DRAIN BOX (~ EVERY 250 FT.)	8	EA	$ 2,500	$ 20,000
11. 12" DIP WATER LINE	1,500	LF	$ 65	$ 97,500
12. 12" GATE VALVE (~EVERY 500 FT.)	3	EA	$ 2,500	$ 7,500
13. 8" DIP WATER LINE	400	LF	$ 45	$ 18,000
14. 8" GATE VALVE (~EVERY 500 FT.)	1	EA	$ 1,800	$ 1,800
15. FIRE HYDRANT W/ LATERAL AND VALVE (EVERY 500 FT.)	4	EA	$ 4,000	$ 16,000
16. POWER, GAS, COMMUNICATIONS	1,900	LF	$ 90	$ 171,000
			SUBTOTAL	$ 953,000
LOCAL ROADS				
1. MOBILIZATION (Approximately 5% of Subtotal Capitol Cost)	1	LS	$ 241,000	$ 241,000
2. CLEARING AND GRUBBING	13.7	AC	$ 2,000	$ 27,400
3. EXCAVATION (CUT/FILL)	36,000	CY	$ 10	$ 360,000
4. ASPHALT - 4" DEEP	36,000	SY	$ 20	$ 720,000
5. BASE - 8" DEEP	8,900	CY	$ 25	$ 222,500
6. CURB AND GUTTER	24,000	LF	$ 20	$ 480,000
7. 8" DIA. PVC SEWER MAIN	10,060	LF	$ 35	$ 352,100
8. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	48	EA	$ 3,000	$ 144,000
9. 18" DIA. ADS N-12 STORM DRAIN	12,000	LF	$ 40	$ 480,000
10. 5' x 5' STORM DRAIN BOX (~ EVERY 250 FT.)	48	EA	$ 2,500	$ 120,000
11. 10" DIP WATER LINE	6,150	LF	$ 55	$ 338,250
12. 10" GATE VALVE (~EVERY 500 FT.)	12	EA	$ 2,200	$ 26,400
13. 8" DIP WATER LINE	6,300	LF	$ 45	$ 283,500
14. 8" GATE VALVE (~EVERY 500 FT.)	13	EA	$ 1,800	$ 23,400
15. FIRE HYDRANT W/ LATERAL AND VALVE (~EVERY 500 FT.)	25	EA	$ 4,000	$ 100,000
16. PRV STATION	2	EA	$ 30,000	$ 60,000
17. POWER, GAS, COMMUNICATIONS	12,000	LF	$ 90	$ 1,080,000
			SUBTOTAL	$ 5,059,000
PEDESTRIAN BOULEVARD				
1. MOBILIZATION (Approximately 5% of Subtotal Capitol Cost)	1	LS	$ 43,000	$ 43,000
2. CLEARING AND GRUBBING	2	AC	$ 2,000	$ 4,800
3. EXCAVATION (CUT/FILL)	8,000	CY	$ 10	$ 80,000
4. ASPHALT - 4" DEEP	9,000	SY	$ 20	$ 180,000
5. BASE - 8" DEEP	3,280	CY	$ 25	$ 82,000
6. CURB AND GUTTER	2,640	LF	$ 20	$ 52,800
7. 6' WIDE SIDEWALK	16,000	SF	$ 6	$ 96,000
8. 8" DIA. PVC SEWER MAIN	1,320	LF	$ 35	$ 46,200
9. 5' DIA. SEWER MANHOLE (~ EVERY 250 FT.)	5	EA	$ 3,000	$ 15,000
10. 18" DIA. ADS N-12 STORM DRAIN	1,320	LF	$ 40	$ 52,800
11. 5' x 5' STORM DRAIN BOX (~ EVERY 250 FT.)	5	EA	$ 2,500	$ 12,500
12. 12" DIP WATER LINE	1,320	LF	$ 65	$ 85,800
13. 12" GATE VALVE (~EVERY 500 FT.)	3	EA	$ 2,500	$ 7,500
14. FIRE HYDRANT W/ LATERAL AND VALVE (~EVERY 500 FT.)	3	EA	$ 4,000	$ 12,000
15. POWER, GAS, COMMUNICATIONS	1,320	LF	$ 90	$ 118,800
			SUBTOTAL	$ 890,000
ADDITIONAL COMPONENTS*				
1. SIGNAGE	1	LS	$ 15,000	$ 15,000
2. TRAFFIC SIGNAL	1	EA	$ 300,000	$ 300,000
3. 8" DIA. PVC SEWER MAIN	8,600	LF	$ 35	$ 301,000
4. 12" DIP WATER LINE	1,340	LF	$ 65	$ 87,100
12. 12" GATE VALVE (~EVERY 500 FT.)	3	EA	$ 2,500	$ 7,500
5. 10" DIP WATER LINE	3,140	LF	$ 55	$ 172,700
12. 10" GATE VALVE (~EVERY 500 FT.)	6	EA	$ 2,200	$ 13,200
6. CONNECT TO EXISTING WATER LINE	4	EA	$ 5,000	$ 20,000
7. CONNECT TO EXISTING SEWER LINE	2	EA	$ 5,000	$ 10,000
			SUBTOTAL	$ 927,000

CONSTRUCTION SUBTOTAL	$ 8,857,000
CONTINGENCY (30%)	$ 2,658,000
SUBTOTAL	$ 11,515,000
ENGINEERING, SURVEYING, CONSTRUCTION MANAGEMENT (15%)	$ 1,728,000
TOTAL COST	**$ 13,243,000**

* CAMPUS SUBSTATION SHOWN ON UT-4 IS NOT INCLUDED.

6

Sustainability Considerations

USU Commitment to Sustainability

In early 2007, USU President Stan Albrecht signed the American College and University Presidents Climate Commitment, as part of a nationwide movement to reduce global warming by achieving climate neutrality. USU was the first institution of higher education in the state of Utah to sign on to the commitment. The USU Sustainability Council was convened immediately following the signing of the commitment, and was charged with developing strategies to achieve the goals and benchmarks set forth by the Climate Commitment, administered by the Association for the Advancement of Sustainability in Higher Education (AASHE). Since the signing, the university has developed a Sustainability Policy (Policy #106 of the USU Policies Manual). It reads

Utah State University (USU) is one of the nation's premier, student-centered, land-grant, and space-grant universities. The University is committed to enhancing the quality of life for individuals and communities by promoting sustainability in its operations and academic and service missions.

USU will develop appropriate systems for managing environmental, social, and economic sustainability programs with specific goals and objectives. This policy supports the goal of the USU statewide system to prepare students, faculty, and staff to proactively contribute to a high quality of life for present and future generations.

Additionally, USU established a benchmark document to establish its carbon footprint, and is tracking changes annually. The USU Climate Action Plan document outlines key areas of focus and strategies to achieve carbon neutrality by 2050.

Because the USU Climate Action Plan ambitiously aims for climate neutrality by 2050, USU will need to take big steps towards this goal. Commuting and energy usage by buildings are by far the biggest contributors to the university's carbon footprint. Energy efficiency, alternative energy, and alternative transportation strategies will be the major areas of focus in achieving climate neutrality. Culture and educational programs will also play a major role in behavioral shifts.

What is required?

DFCM's 'High Performance Building Rating System' (HPBRS), communicated in the last few pages of the DFCM Design Standards (Appendix), is required for all State projects.

HPBRS selectively mandates the following:

- LEED 'Silver' minimum certification level; suggest 'Gold' or better.
- 'Integrative' charrette-based process, with guidelines for length and inclusivity
- Life Cycle Cost Assessment methodology (LCCA)
- LEED credits to be made mandatory:

  a. WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%

  b. EA Credit 3 Enhanced Commissioning (specialty 3rd-party contractor selected by DFCM)

  c. EQ Credit 3.1 Construction IAQ Management Plan: During Construction

  d. EQ Credit 4.1: Low-Emitting Materials: Adhesives and Sealants

  e. EQ Credit 4.2: Low-Emitting Materials: Paints and Coatings

  f. Energy performance to high standard, measured under EA Credit 1- Optimize Energy Performance (minimum 'score' or energy cost saving is not stipulated; as an example, University of Utah mandates minimum credit score of 15 points out of 19 for Eac1 Optimize Energy Performance = 40% better than ASHRAE 90.1-2007 energy cost savings; other institutions may or may not follow suit)

  g. Energy Modeling ('Whole Building Energy Simulation') using eQUEST or other DOE-2 based computer model, applied early and iteratively through project, both in support of EAc1 and in support of design critique and confirmation

  h. EA Credit 5: 'Measurement & Verification' is encouraged, in order to establish scientifically derived data for initial and ongoing trending of systems HVAC, lighting, plug loads, renewable energy productivity, water use, and so forth.

Following the USU 'Climate Action Plan' (2010) is also a requirement for the Moab campus: The USU CAP was signed in January 2007. Primary strategies for attainment are:

- Reducing campus energy consumption, through landscape, building and operations-maintenance improvements.
- Obtaining energy from renewable and sustainable sources
- Institutionalizing a sustainable culture among students, faculty and staff.

Purchasing carbon offsets, as a last resort, and accounting for offsets inherent in SITLA lands dedicated to the support of USU around the State. State of Utah Commitment to Green Buildings

USU Precedent

USU has met or exceeded these standards since it was implemented. In the past several years, USU has constructed 1 LEED Platinum certified building, 2 LEED Gold certified buildings (+1 pending), and 1 LEED Silver building (+ 1 pending).The Utah State University future Moab Campus has an opportunity to be a model campus for the University, the City of Moab, the State of Utah and beyond.

Additional Information

The following paragraphs provide more information on established methods for developing measurable, high performance projects. Early objectives should be set by the University and implemented through a collaborative process with the design team to guide decision making.

The University may want to consider appointing a sustainability manager for this campus to champion these efforts and follow through on tasks that will be required after the design team has completed their scopes of work.

Living Building Challenge 2.0

The living building challenge is a certification system that is the most advanced level of sustainability measurement available today. This system addresses seven categories: Site, Water, Energy, Health, Materials, Equity and Beauty. Certification is based on actual performance of the facility after 12 months in operation. Attributes:

- All facilities are required to be Net Zero Energy and Net Zero water.
- Uncompromising, mandatory system of 20 'Petals' within 7 'Clusters'. All elements are imperative.
- Overlays enable adaptation to development types along a scale from rural to high density urban center in six gradations.

LEED

LEED-New Construction is the predominant LEED (Leadership in Energy & Environmental Design) system among at least nine other certification categories.

LEED is Divided into seven 'chapters'
•Sustainable Sites
•Water Efficiency
•Energy & Atmosphere
•Materials & Resources
•Indoor Environmental Quality
•Innovation & Design
•Regional Priorities

Points earned according to system to total 100 + ten bonus points possible (typical of all systems except LEED-Homes).

LEED-Schools (as overlay on NC) offers a few additional, relevant points such as classroom acoustics, master planning, mold prevention and environmental site assessment. There is also a guidance document on how to efficiently certify multiple buildings on a campus by completing a number of group credits that can be completed once instead of each time a new facility is certified.

LEED-Neighborhood Development
LEED ND is a rating system that integrates smart growth, urbanism and green building into the certification process. This may be appropriate as a guide to design the development as a whole but may be tough to get certification in. An initial analysis was completed on the USU project for LEED ND and the site selection prerequisite will likely not be attainable for this site and will negate 27 of the 110 total available points immediately.

LEED-Existing Building: Operations and Maintenance:
This rating system is the sole LEED guidance to ongoing operations & maintenance into the future and is possibly the most important of LEED systems for long run performance, and to enable a building to "learn."

LEED EBOM consists of systems of major environmental management plans, as well as several minor ones:

• Sustainable Sites: Numerous written plans to guide how users commute to work, and how building and site respond to solar heating, and so forth.

• Water Efficiency: Water system performance, irrigation and cooling tower water management.

• Energy & Atmosphere: Prerequisites, performance optimization, commissioning, controls, renewables and related plans.

• Materials & Resources: Sustainable purchasing and solid waste management .

• Indoor Environmental Quality: Prerequisites, BMPs, daylight/views, and 'Green Cleaning.'

• Innovation in Operations: Four innovation opportunities.

•Regional Priority: Four additional points for points selected by USGBC Chapter.

Sustainable Sites

The Sustainable Sites Initiative™ (SITES™) is an interdisciplinary effort by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at The University of Texas at Austin and the United States Botanic Garden to create voluntary national guidelines and performance benchmarks for sustainable land design, construction and maintenance practices. In short, Sustainable Sites is a guidance system and set of performance benchmarks for everything outside of the building

Additional Considerations

Establish clear goals & objectives for sustainability variables, both within and beyond LEED

- *Longevity:*
  Target a minimum life-expectancy for each facility – suggest 100 years, min.
- *Energy and Carbon:*
  Formulate energy performance and carbon footprint expectations, starting with EUI (energy use intensity) not greater than 25 (25,000 BTU/SF/YR), and estimating likely LEED EAc1 'energy cost savings' score, targeting at least 15 of 19 points, as U. of U. is doing, as result of 'Energy Action Plan'; Develop energy-carbon accounting for all choices considered, and use in USU curriculum at various levels. Analyze each project for what would be necessary to achieve 'Net Zero' or 'Carbon Neutral,' in course of setting performance targets, and construct consistent records of how choices are made either to raise or lower performance expectations; use records in curricula and research. Extend technological evaluations to all possible renewable and high-performance alternatives, emphasizing first the creation of thermally inert, passively lighted and heated envelopes, followed by the addition of thermal and light requirements by the highest-efficiency systems. Study and consider traditional ways of providing heating, cooling, ventilation and water needs in cultures around the region and around the world.
- Analyze site development impacts using a formal discipline, adapting 'sustainable sites' from LEED, possibly combined with 'sustainable infrastructure' discipline being developed by several municipalities in US; use in USU curriculum

- *Build with on-site materials:* Use on-site materials unless it is demonstrated to be infeasible (possibilities include stone, earth or modified earth materials)

- *Build with 'local' materials:* If on-site materials are not feasible; establish distance limit for materials derivation (suggest 100 miles); formulate life-cycle impacts and costs analysis methodology to use in USU curriculum, or adopt a proven system such as Athena Institute's "Environmental Impacts Calculator" to arrive at energetic , material and ecological balance sheets for the catalog of materials choices represented throughout the Campus. (Possibilities include soil-cement, using imported cement mixed with earth and built in the manner of rammed earth; timber, reclaimed timber, and regionally/sustainably harvested wood products; and other variants of natural materials including utilization of invasive reed and woody plants as strategy to help eradicate invasive species like Phragmites sp. and Tamarisk sp.)

- *Geographic/Geological, Ecological, Cultural and Economic Context:* Exercise transparency in describing choices of location, siting, and community relationships, applying 'Permaculture Analysis' or other holistic discipline (e.g., 'Bioclimatic Design') to characterize the site, integrating at least the following:

    • Solar energy and diurnal variations

    • Topography, geological structures and history

    • Soils and geotechnical characteristics, faults, seismic activity

    • Watershed and water cycles, and historical variability

    • Climate and weather cycles

    • Climate change projections

    • Site-specific thermal variations, possible climate change impacts

    • Climate change adaptation possibilities

    • Air movement, patterns and events

    • Biological community, vegetation, wildlife

    • Cultural history and context

    • Regional architectural history and context, and how traditions can be integrated into design excellence

    • Land uses and trends

    • Recreational geography of 'Wonder'

    • Economic history and geography, unsustainable and sustainable

    • Sustainable economy context and future

- *Progression of Analyses and Design Thinking*. Adopt formal and transparent sustainability disciplines appropriate to the Campus as a whole, and to each facility type within the Campus, adapting each in support of university curriculum applications; use multiple systems to compare and to track comparatively over time, incorporating analyses into research and curricula:

    a. Living Building Challenge v2.0 for uncompromising but flexible evaluation.

    b. LEED-NC for New Construction; or, LEED-CI for Interiors, within shells provided by others, and as constructed for systemic continuity with LEED-CS.

    c. LEED-EBOM to guide operations & maintenance/ management of new buildings and existing (2 years old or more), providing a comprehensive catalog of guidelines and minimum standards for long-term improvement of procurement, energy and water efficiency, toxic s avoidance, and adaptation for performance improvement

    d. International Green Construction Code (IGCC), soon to be put into effect, along with ASHRAE Standard 189.1 for High-Performance Buildings / International Green Construction Code implementation.

- *Develop connectivity with Moab Community and Region*

    a. Infrastructure and systems: Work toward sustainable transportation connectivity (e.g., electric shuttles, bicycle promotion and use).

    b. Co-locate community program needs with University facilities in flexible spaces.

    c. Follow LEED-ND (Neighborhood Development) where applicable.

- *Emphasize healthfulness and inquiry throughout USU-Moab Campus creation process, facilities, and life*.

    a. Make the entire Campus 'teach' and 'learn' as a laboratory and exhibit in sustainable design, construction and learning from the commencement of design, through construction of each element, and into the future, for the life of the Campus.

    b. Promote development of sustainability communications, emphasizing USU Moab Campus community capacity to articulate clearly in writing and graphics (computer, manual and artistic) observations, problem descriptions, planning processes and options, design solutions, and civil critiques of everything around them, as well as their own effects on environments at all scales (immediate place, community, region, planet)

Planning and Implementation Next Steps

Next Steps

1. Traffic Impact Study
UDOT will require an access permit and a traffic impact study (TIS) for any new access locations to US-191. A TIS will study the existing traffic operations and the traffic operations with proposed development traffic added. This provides information to UDOT and the City on how traffic conditions will be changed and to determine what mitigation measures, if any, may be required.

Typically, UDOT requires that all phases of a proposed project be analyzed to determine the full impact on the roadway system. Based on the total trip generation for the SITLA and USU areas, a UDOT Level IV TIS would be required. This would require two future analysis years to also be analyzed in order to determine the longer-term effects of the added project. The pedestrian tunnel under Highway 191 should be integrated in the study.

Timing: Enough data has been generated to conduct this study at any time in the near future though additional data relating to the Diversified Partners parcel should be incorporated into the TIS. The approvals process with UDOT may take a substantial amount of lead time so it is recommended that those items be coordinated a year in advance of phase 1 construction.

2. Geotechnical Report
A geotechnical report will be required for building foundation design, storm water calculations and to understand what the subgrade conditions in the vicinity of the proposed buildings will be. This report can also influence the angle of cut / fill slopes for roads and other grading operations.

Timing: The geotechnical report can be developed immediately and should be completed prior to any infrastructure and site design.

4. Rock Fall Hazard Study
It is recommended that a site specific rock fall hazard study be completed prior to the construction of the phase 1 building to ensure there are no high risk hazards in that location and to identify any hazards on the remainder of the campus / SITLA property

5. Access Road Infrastructure
Road improvements will need to be made prior to the start of construction of the phase 1 facility. The primary access road should be designed to include horizontal and vertical alignments. The pedestrian tunnel under Highway 191 should be designed at the same time to get it in the approvals pipeline. No utility work would need to be completed initially. A construction access road can be built along the designed alignment and upgraded with utilities and surfacing materials near the end of phase 1 construction. Design of this road should be developed in coordination with a Landscape Architect to ensure trail alignments, entry monumentation, road/streetscape aesthetics and green infrastructure objectives are integrated. A construction access road will likely require a grading permit prior to any work.

Timing: Design of the access road can occur as soon as the access permit is issued by UDOT and the TIS is approved.

6. General Infrastructure
Implementation level design work for all utility infrastructure should ideally occur during the design of the phase 1 building.

7. Power Infrastructure
As the USU Campus project moves forward, the project team will need to coordinate expected loads and phasing with both RMP engineering and the RMP accounts manager. It will beimportant to select a preferred option for service to the Campus. It should be noted that required power improvements are eligible for reimbursement based on usage.

Timing: The approvals process with Rocky Mountain Power may take a substantial amount of lead time so it is recommended that implementation level design drawings be coordinated with RMP up to a year in advance of construction.

8. Gas Infrastructure
Given that Questar is in the midst of system upgrades in the Moab City area, it will be beneficial to provide early information related to the proposed campus expansion. This will allow Questar the opportunity to include the future campus natural gas demands in their planning process thus incorporating any additional upgrades into their operations and maintenance program. As design development and final design occur, the USU project team will need to provide expected natural gas loads for the phase 1 project as well as for the potential project build-out

Timing: Generally, the lead time for coordinating gas demands is not long but considering the new line will be installed in US 191 in 2015, the gas demands for the campus build out should be communicated to Questar to ensure adequate capacity is planned for. Providing this master plan to Moab City Engineering is a good starting point

7. Fiber Infrastructure
Coordination with Frontier will be critical as design development and final design for phase 1 occur. This coordination will define the type of telephone and internet service required for the Campus and SITLA, and can identify infrastructure corridors, equipment locations and service locations.

8. Water Infrastructure

During the development of the Master Plan, GWSSA was contacted and provided a review copy of the water system master plan. As the design of the Phase 1 Campus begins, it will be important to coordinate further with GWSSA. GWSSA will need to incorporate the expected build out demands and Campus distribution configuration into their water system distribution model. This model will confirm line sizes and off-site infrastructure requirements. Initial coordination should also include the completion of a review schedule that will define the design stages where GWSSA review will be required.

9. Architectural Design

Architectural programming and design for the phase 1 building will take approximately eight months to complete. Bidding and construction will likely take eighteen months to two years to complete.

10. Sewer Infrastructure

During the development of the Master Plan, GWSSA was contacted and provided a review copy of the sanitary sewer master plan. As the design of the Phase 1 campus begins, it will be important to coordinate with GWSSA and Moab City. It is likely that some level of off-site improvement will be required to support the build out of the Campus and SITLA properties. It will be important to clarify where the improvements are required and how the improvement costs will affect both projects. It is not anticipated that up-sizing will be required to support phase 1 of the campus. Moab City is included in the wastewater coordination effort because the GWSSA system connects to the Moab system prior to reaching the Wastewater Reclamation facility.

11. Storm Drain Infrastructure

The design of the storm water system will require coordination with the building Architect and Landscape Architect. Additionally, Moab City will review the elements of the storm drain collection and detention design. Design level analysis and modeling will be required to size the ponds, and evaluate the effects of water quality and water quantity. Sediment storage should be included in the pond sizing. This will be critical for ensuring a functioning system between periodic maintenance of the ponds.

12. Parking Study

As beginning phases of construction for the school begin, we recommend that actual parking demand be evaluated to more precisely determine what future parking needs will be required. For example, it is possible that the bicycle culture and close proximity of student housing may create a need for far less parking as is originally estimated. Conversely, if close-proximity student housing does not occur, parking demand may be higher. More detailed evaluation of on-going parking needs could save millions of dollars if structured parking can be reduced for the full build-out of the university campus.

Timing: The best time to conduct the parking study is after the initial phase I facility is built so that pedestrian and vehicle counts can be surveyed to base the parking projections on actual usage in Moab.

8

Appendix

Public Open House Summary

USU Moab Town Meeting
Tuesday, December 13, 2011

1. Introduction by Steve Hawks
2. Terrall of Design Workshop (DW) discussed the DW Legacy Design, and overall plan for the USU Moab Campus. The overview of his presentation goes as follows:
    - The design is very important because Moab is a unique setting and it must show "characteristics of this place." The DW Legacy Design is composed of four elements.
        - Environment –the whole range of environmental implications.
        - Art – Allows the people to connect to the campus. The identity of a place.
        - Economics –Creation of value over time.
        - Community- Cultural and social aspect of the project.
    - Audience is oriented to where the campus is located
        - USU has 40 acres which is part of a larger parcel SITLA owns.
    - Analysis of Site Conditions
        - Slopes, Hydrology, Aspect, Soils, Rock Fall Hazard, Wildlife, Views (on site and off site), Easements, Transportation, Utilities, Cultural Resources.
    - Conceptual Surrounding Land Uses
    - Future Moab Campus Objectives
        - Reduce environmental impacts
        - Respectful Natural Design for drainage corridors and topographic
        - Access to trails around surrounding property
        - Many more innovative ideas
    - Create a sense of place
        - Comfortable place with a character
        - A residential college-style campus will be created
        - It will be made a learning opportunity (i.e. sustainable practices, interpretive materials)
        - Support local community and provide programs based on the community
    - Campus Framework
        - Preserve the native landscape and site character
        - Create an immediate place with the 1st building
        - Utilize a "pod concept." Pods each have certain space, and character. They are cohesive with the departments that surround them.
    - Full Build-out master plan is revealed.
    - **Q &A Begins**
        - Q: What is the village concept?
            - A: Cluster common buildings around gathering spot. Compatible departments are put together and centered around a green space that students can gather on.
        - Q: Was there a water study? (This question was asked several different times)
        - Q: What are the 2nd and 3rd phases of this design?
            - A: There really isn't a detailed design of these at this time
    - Steve Hawks- "Moab is a unique setting that lends itself to certain degrees."
        - Q: Give an orientation about the current situation. How will we grow?
            - A: We have grown over the last 3 years. We will factor in historical enrollment trends here, and at different centers.
        - Q: What is the projected number of students?
            - A: 700-800 Students per phase.
        - Q: What phase will the student housing take place in?
            - A: Sometime after phase 1 and when the Moab economy demands it.
        - Q: What is the projected date for phase 1?
            - A: Around 5 years, but this is not a definite answer.
        - Q: What will the balance of undergrad/graduate students be?
            - A: Very high undergraduate- 95% undergraduate.
        - Q: How will commuters, workers, etc. affect everything? Will a bus system become available?
            - A: We hope at that time to see a public means of transportation that has stops at USU Moab.
        - Q: Where are the bike lanes?
        - Q: Infrastructural Design- How will it be created to effect the sustainability to the environment?
            - A: We can't project technology in the future, but the best technologies will be used at that time to ensure it is environmentally sound.
        - Q: How will this affect the hospital, and the programs facilitated at the hospital?
            - A: We've got programs and are developing more and more. This campus will have many more programs to support an education in varying health education areas.
        - Q: There won't be any food service at the campus?
            - A: There will be some food services, but not full on food services. The food service will be kept as minimal as possible so that students will support local restaurants.
        - Q: What is the square footage projection for phase 1?
            - A: 32,000 square foot.
        - Q: What will be the economic impact?
            - A: We are hoping that there will be a very positive impact.
        - Q: What partnerships will be included?
            - A: We have one and will continue to have one with Moab Regional Hospital. There will also be square footage that could be dedicated to federal agencies.
        - Q: During phase 1 how many additional employees are projected at this phase?
            - A: 8-12 Faculty Members
            - 5-6 Full Time Staff
            - IT Staff
        - Q: What are the estimated costs?
            - 10 million for construction

- Lastly, a graduate class from USU in Logan looked at the surrounding SITLA land, and what could be done on the property. There was also a very short Q & A period after this presentation.

Public Comments—USU Moab Master Plan

"At some time in the future a 4-lane by-pass to get truck traffic off Main Street in Moab will be built. The Matheson Wetlands will direct a route at the portal and along the ridge line. Is the campus property likely to be impacted?"

"What about solar power? I hope that sustainability is an important part of the Campus plans. I also hope that local/regional contractors will be considered first for campus construction."

"In some stage of development I think the plan should incorporate more food and restaurant options. With several hundred students and employees there will be substantial traffic to & from town. Yes students can bring or make food in future apartments but realistically w/o options on campus they will leave. Sound (from highway)? Access from Doc Allen Drive (west side of town)?"

"This is a unique site in a very unique place (town). It appears they've done a good job of site planning considerations, but the building conceptual drawings look mainstream block-like masses. Need to see better indigenous building design, better flow, maybe replicating the iconic Rim in the background."

"Kudos for a well thought plan; especially the phased concept with the initial pod designed for early community buy-in (local students). One concern of mine is the campus interface with the traffic on and off of Hwy 191 (high speed commercial trucking and high volume tourist and commuter traffic.) Public transportation would be key to lower the impacts, I think."

"The outdoor stage/amphitheater seems like it could be a glacier in the winter."

"Pat Holyoak asks that you remember that this is Ray Holyoak not "Ron" Holyoak land. She has seen it misprinted I guess. TX! Pat's # is if you have questions."

December 13, 2011

"Handout of the basic #'s, costs, time line, & map would have been helpful. Why not a parking garage – smaller footprint – place for solar panels – shaded parking."

"This is very exciting! Great work." ~Rita Rumrill

"Yah!"

"Thanks to all presenters for sharing all their work w/the public and keeping us in the loop! Their depth of research and visioning has clearly produced a wholistic approach and plan for the much-desired facility! While I can see much work will continue in the development of a final master plan, I think Steve Hawks' and Terral's leadership with this effort is the expertise we need! Thank you all again!"

"Sounds like a great plan."

"Very fabulous design & concept."

"Multi Model Transportation – I like it. Good presentation. As progress happens I think it would be helpful to keep the community updated."

"Consider Geology Programs. Oil companies currently send Geologists/Geophysicists to area. Could be a resource for funding of University."

"The City of Moab wholly supports the Regional Campus of USU in Moab. We are behind the University 100%." ~Mayor Dave Sakrison

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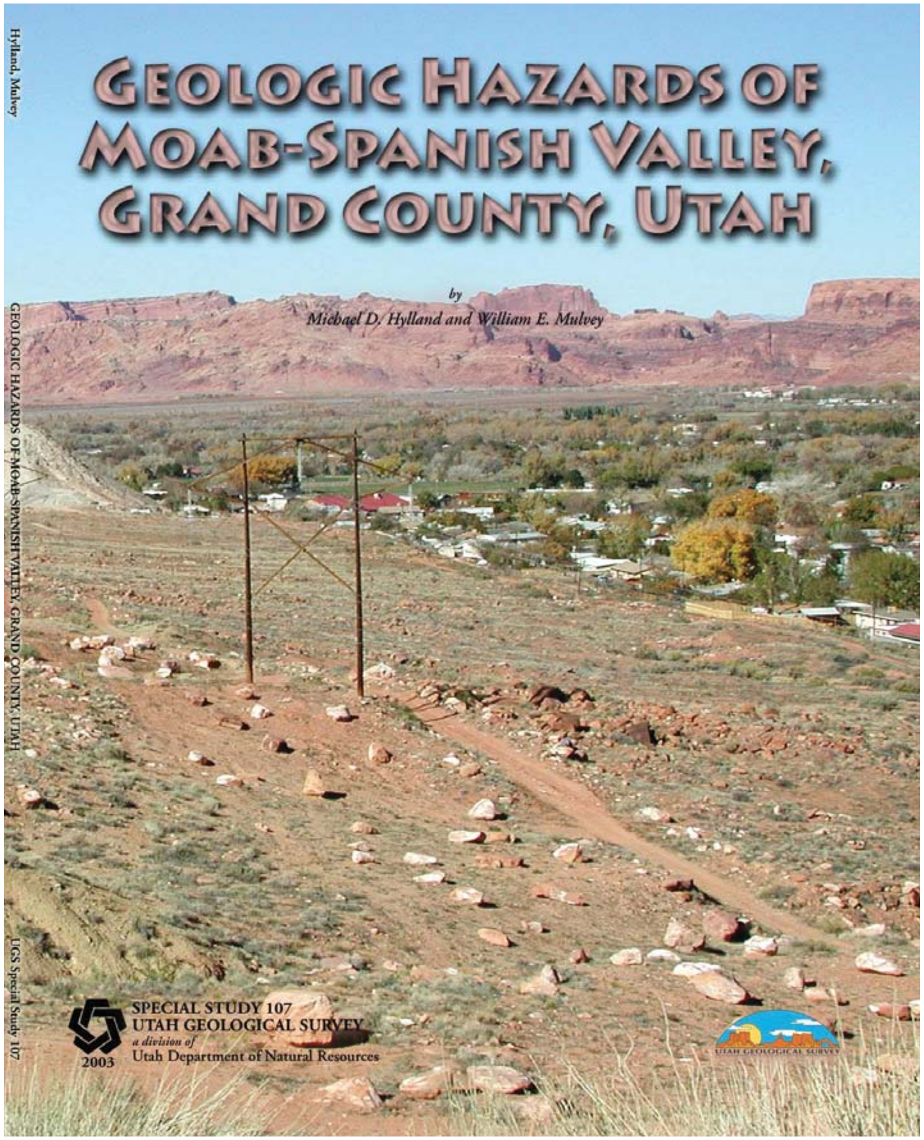

GEOLOGIC HAZARDS OF MOAB-SPANISH VALLEY, GRAND COUNTY, UTAH

by

Michael D. Hylland and William E. Mulvey

Digital compilation by Justin P. Johnson and Matt Butler

Cover photo: Northwest view of the northern end of Moab-Spanish Valley. Light-colored Chinle Formation in lower left corner is extensively fractured, highly susceptible to erosion, and may locally contain expansive clays. White hill (left edge of front cover) is exposed Paradox Formation cap rock, which contains expansive clays and soluble gypsum. Gentle, boulder-strewn slope in middle ground comprises alluvial fans where debris flows, alluvial-fan flooding, and collapsible soils may occur. The upper part of the alluvial fans is within a runout zone for rock falls originating from Wingate Sandstone cliffs above (in shadow). Much of the valley floor is an area of shallow ground water, particularly at the northern end of the valley.

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STATE OF UTAH
Michael O. Leavitt, Governor

DEPARTMENT OF NATURAL RESOURCES
Robert Morgan, Executive Director

UTAH GEOLOGICAL SURVEY
Richard G. Allis, Director

UTAH GEOLOGICAL SURVEY

The **UTAH GEOLOGICAL SURVEY** is organized into five geologic programs with Administration and Editorial providing necessary support to the programs. The **ENERGY & MINERAL RESOURCES PROGRAM** undertakes studies to identify coal, geothermal, uranium, hydrocarbon, and industrial and metallic resources; initiates detailed studies of these resources including mining district and field studies; develops computerized resource data bases, to answer state, federal, and industry requests for information; and encourages the prudent development of Utah's geologic resources. The **GEOLOGIC HAZARDS PROGRAM** responds to requests from local and state governmental entities for engineering-geologic investigations; and identifies, documents, and interprets Utah's geologic hazards. The **GEOLOGIC MAPPING PROGRAM** maps the bedrock and surficial geology of the state at a regional scale and at a more detailed scale by quadrangle. The **GEOLOGIC INFORMATION & OUTREACH PROGRAM** answers inquiries from the public and provides information about Utah's geology in a non-technical format. The **ENVIRONMENTAL SCIENCES PROGRAM** maintains and publishes records of Utah's fossil resources, provides paleontological and archeological recovery services to state and local governments, conducts studies of environmental change to aid resource management, and evaluates the quantity and quality of Utah's ground-water resources.

The UGS Library is open to the public and contains many reference works on Utah geology and many unpublished documents on aspects of Utah geology by UGS staff and others. The UGS has several computer databases with information on mineral and energy resources, geologic hazards, stratigraphic sections, and bibliographic references. Most files may be viewed by using the UGS Library. The UGS also manages the Utah Core Research Center which contains core, cuttings, and soil samples from mineral and petroleum drill holes and engineering geology investigations. Samples may be viewed at the Utah Core Research Center or requested as a loan for outside study.

The UGS publishes the results of its investigations in the form of maps, reports, and compilations of data that are accessible to the public. For information on UGS publications, contact the Natural Resources Map/Bookstore, 1594 W. North Temple, Salt Lake City, Utah 84116, (801) 537-3320 or 1-888-UTAH MAP. E-mail: geostore@utah.gov and visit our web site at http:\mapstore.utah.gov.

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GEOLOGIC HAZARDS OF MOAB-SPANISH VALLEY, GRAND COUNTY, UTAH

by

Michael D. Hylland and William E. Mulvey[1]

Digital compilation by Justin P. Johnson and Matt Butler

ABSTRACT

Moab Valley and the contiguous Spanish Valley comprise a popular residential and recreational area in east-central Utah. Geologic processes that created the rugged and scenic landscape of Moab-Spanish Valley are still active today and can be hazardous to property and life. To address development in areas with geologic hazards, the Utah Geological Survey (UGS) conducted a geologic-hazards investigation to provide information to Moab City and Grand County to help guide development and reduce losses from geologic hazards.

Development in Moab-Spanish Valley could be impacted by a variety of geologic hazards. Paradox Formation cap rock poses a hazard associated with expansive and gypsiferous soil and rock. The Chinle Formation also locally contains expansive clays, but the hazards related to high clay content (shrink-swell, landsliding) in the Chinle are not as great in Moab-Spanish Valley as they are elsewhere in Utah. Flooding can occur along the Colorado River, Mill and Pack Creeks, and ephemeral stream channels in the area, as well as on alluvial fans. Holocene alluvial fans are also sites of debris-flow and collapsible-soil hazards. Fine-grained, Holocene alluvial and eolian deposits are susceptible to erosion by flowing water, and are locally susceptible to piping. The Chinle Formation and associated soils can also be highly erodible, and sand on the valley floor is easily eroded by the wind and can migrate over roads. The cliffs that border the valley are source areas for rock falls that can travel out onto the edge of the valley floor. Shallow ground water is present beneath much of the valley floor, and zones of highly fractured rock lie along the edges of the valley. Other geologic hazards may exist that are difficult to predict and map, but need to be considered in the design and construction of new development in Moab-Spanish Valley as appropriate; these hazards include earthquakes, subsidence, landslides, and indoor radon.

This report includes maps of Moab Valley and the northern and central parts of Spanish Valley that provide information on geologic hazards to assist homeowners, planners, and developers in making informed decisions. The maps show areas where hazards may exist and where site-specific studies are advisable prior to development. The maps are for planning purposes only, and do not preclude the necessity for site investigations. Site-specific studies by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) should evaluate hazards and, if necessary, recommend hazard-reduction measures. Because of the small scale of the maps, some hazard areas are not shown; hazard studies are therefore recommended for all critical facilities (for example, hospitals, schools, fire stations), including those outside the mapped hazard areas.

INTRODUCTION

Moab Valley and Spanish Valley are in Grand County in east-central Utah (figure 1). The composite Moab-Spanish Valley trends northwest-southeast, is 15 miles (24 km) long, and averages 2 miles (3.2 km) wide. Cliffs along the northeast and southwest margins of the valley rise to broad bedrock uplands. The Colorado River emerges from an incised canyon at the northeastern corner of the valley, flows across the broad flood plain of northwestern Moab Valley, and then enters the mouth of another incised canyon at The Portal on the southwestern margin of the valley. Mill and Pack Creeks traverse the valley from southeast to northwest; their headwaters are approximately 12 miles (19 km) to the east in the La Sal Mountains, which reach elevations of over 12,000 feet (3,700 m). Elevations in the study area range from about 6,000 feet (1,830 m) at the top of the southwestern valley-margin cliffs to about 3,950 feet (1,205 m) along the Colorado River at The Portal. The central business district of the city of Moab is along the northeastern margin of the valley between Mill Creek and the Colorado River.

Many of the geologic processes that shaped Moab-Spanish Valley's scenic and rugged landscape over millions of years are still active today and potentially hazardous to property and life. Principal geologic hazards mapped in the Moab-Spanish Valley area are: (1) expansive soil and rock, (2) gypsiferous soil and rock, (3) stream and alluvial-fan flooding and debris flows, (4) collapsible soils, (5) soils susceptible to piping and erosion, (6) rock fall, (7) shallow

[1]*Now at 4408 Surry Ridge Circle, Apex, North Carolina 27502*

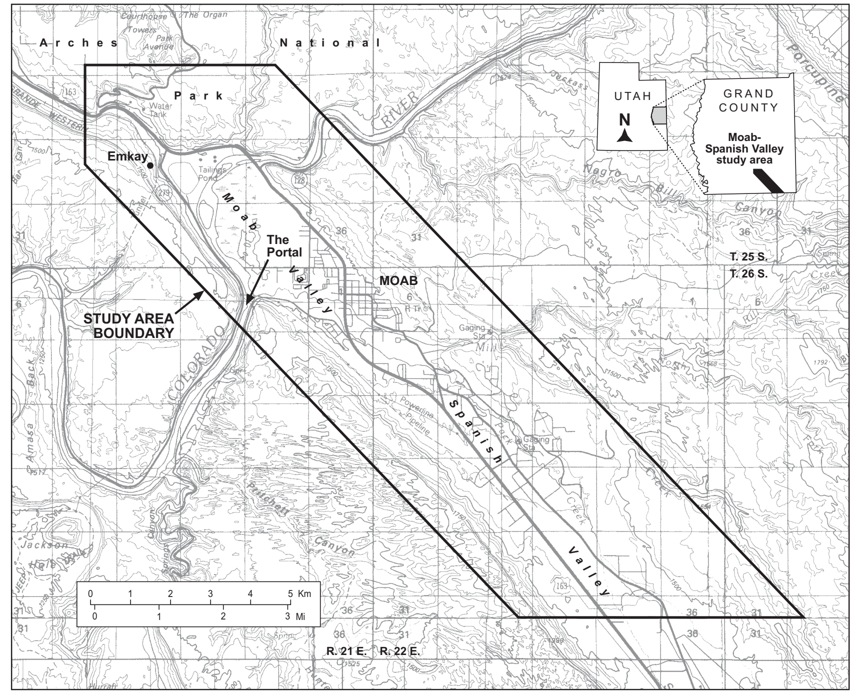

***Figure 1.** Location of Moab-Spanish Valley study area. Base from USGS Moab (1983) and La Sal (1982) 30 x 60-minute quadrangles.*

ground water, and (8) fractured rock. Other possible hazards include earthquakes, subsidence due to salt dissolution, landslides, and indoor radon. In this report, the term "soil" is used in an engineering context and refers to all unconsolidated earth materials; it is not used in an agricultural context.

This report includes discussions of each of the principal geologic hazards listed above. Each discussion describes the characteristics of the hazard and the types of damage that may result, summarizes measures that may be taken to reduce the hazards, and provides guidance for recommended site investigations. The maps that accompany this report show areas associated with each of the principal geologic hazards where site-specific studies are recommended to evaluate the hazard and develop hazard-reduction measures appropriate for the planned development. This report also includes discussions of the geologic hazards for which hazard areas have not been mapped. A glossary at the end of the report gives definitions of technical terms used in the text. Appendix materials include a geologic time scale and list of local, state, and federal government agencies that can provide additional information on geologic hazards and related issues.

PURPOSE AND SCOPE

Where development takes place in geologically hazardous areas, geological input is most important early in the planning and development process; redesigning subdivisions and other development around geologic problems or repairing damage from hazard events is costly and time consuming. This report provides Moab-Spanish Valley homeowners, government officials, and developers and their consultants with maps and other information concerning geologic hazards that may affect development in Moab Valley and the central and northern parts of Spanish Valley.

The hazard maps included with this report are derived largely from published geologic maps of the area (Doelling, 2001; Doelling and others, 2002) and unpublished geologic mapping by the Utah Geological Survey (UGS). The geologic-hazards data were compiled and mapped at a scale of 1:24,000. The areal extent of many geologic hazards is based on the distribution of surficial and bedrock deposits associated with known and potential geologic hazards. The maps are designed to stand alone, and include a summary discussion of each hazard depicted.

The scope of work for this report included meeting with local-government officials and residents, review of pertinent literature and aerial photographs, and field reconnaissance. Most of the work was conducted in 1994; the report was finalized following completion of detailed studies of the Moab fault (Olig and others, 1996; Woodward-Clyde Federal Services, 1996), detailed studies of the uranium mill tailings site along the Colorado River northwest of Moab (see references in U.S Nuclear Regulatory Commission, 1997), and publication of new UGS geologic mapping in the Moab area (Doelling, 2001; Doelling and others, 2002). The report presents a detailed discussion of geologic hazards specific to Moab-Spanish Valley and addresses (1) possible hazard-reduction measures, (2) the scope of recommended site-specific hazards investigations, and (3) application of the maps to land-use planning.

GEOLOGY

Moab-Spanish Valley lies within the Colorado Plateau physiographic province, which overall is characterized by relatively simple "layer-cake" geology. The local geology of Moab-Spanish Valley, however, has been complicated by the interactions of salt-diapir development, salt dissolution, and erosion by running water. Because of this complexity, detailed discussion of the geology of the area is beyond the scope of this report, and only a brief description of geologic units in the area is included herein. Detailed information on the geology of the greater Moab-Spanish Valley area can be found in Doelling (1985, 1988, 2000a, 2000b, 2001), Huffman and others (1996), and Doelling and others (2002).

Exposed bedrock in the Moab-Spanish Valley area consists of a vertical sequence of sedimentary rock layers ranging in age from Pennsylvanian (about 300 million years ago) to Jurassic (about 150 million years ago) (appendix A). Bedrock units are shown diagrammatically on figure 2. Various unconsolidated deposits of Quaternary age (1.6 million years ago to present) overlie the bedrock. The following descriptions of geologic units are modified from Doelling (2001) and Doelling and others (2002).

The oldest rock unit is the Middle Pennsylvanian Paradox Formation. Evaporite minerals, including halite (table salt) and some potash and magnesium salts, may constitute as much as 85 percent of the formation. The buried, low-density salts readily deform and migrate upward in salt diapirs, and subsequently dissolve and leave behind a cap-rock residue consisting of contorted beds of gypsum, shale, and limestone. Paradox Formation cap rock is exposed in two discontinuous bands along the northeastern and southwestern margins of Moab-Spanish Valley. The Upper Pennsylvanian Honaker Trail Formation crops out in slopes across the valley from the Arches National Park visitor center. It is

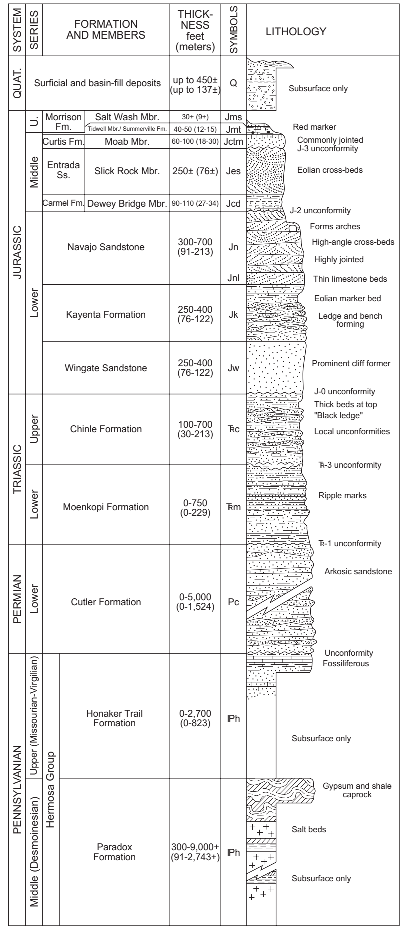

Figure 2. *Summary of geologic units exposed in the Moab-Spanish Valley area (from Doelling and others, 2002).*

composed of grayish sandstone, siltstone, and limestone. Overlying the Honaker Trail Formation is the Lower Permian Cutler Formation, also seen across from Arches National Park. It forms cliffs and slopes of red-brown and maroon cross-bedded sandstone and conglomerate with a few thin

siltstone and limestone beds.

Above the Cutler Formation is the Lower Triassic Moenkopi Formation. The Moenkopi forms steep slopes with ledges around the entrance to the railroad tunnel at Emkay (figure 1). It consists of brown, micaceous sandstone, siltstone, mudstone, and shale. Above the Moenkopi is the Upper Triassic Chinle Formation, also a slope-forming unit. The Chinle is red-brown sandstone, siltstone, conglomeratic sandstone, and mudstone. Near the base of the unit is a poorly cemented gritstone. Capping these formations are cliffs of the Lower Jurassic Wingate Sandstone and Kayenta Formation. The Wingate Sandstone forms the massive cliffs south and west of Moab, and along the Colorado River north of Moab. It is composed of fine-grained, well-sorted sandstone that forms a dark-brown cliff. On top of the Wingate is the Kayenta Formation, a ledgy, step-like, lavender-gray and dark-brown sandstone. The Kayenta Formation caps many of the cliffs in the valley. The Lower Jurassic Navajo Sandstone overlies the Kayenta, forming the irregular surface of pale-orange to light-gray sandstone fins, hills, and swales on the northeastern and southwestern sides of Moab-Spanish Valley.

Overlying the Navajo Sandstone is a Middle to Late Jurassic sequence of mostly sandstone units exposed in and near Arches National Park. These rocks include the Dewey Bridge Member of the Carmel Formation, Slick Rock Member of the Entrada Sandstone, Moab Member of the Curtis Formation, Summerville Formation, and Tidwell and Salt Wash Members of the Morrison Formation. The Dewey Bridge and Moab Members had previously been assigned to the Entrada Sandstone (for example, Wright and others, 1962; Doelling, 1985; Peterson, 1988), but recent work by O'Sullivan (2000) and the UGS (Doelling, 2001; Doelling and others, 2002) resulted in the reassignment of these units. Most of the arches in Arches National Park are formed in sandstone of the Dewey Bridge, Slick Rock, and Moab Members. Strata of the Summerville and Morrison Formations, exposed in only a small part of the study area within Arches National Park, generally consist of red to brown sandstone and siltstone and gray limestone, overlain by pale-yellow-gray sandstone interbedded with green and red mudstone and siltstone.

The floor of Moab-Spanish Valley is composed of Quaternary deposits derived from the La Sal Mountains and local valley slopes. Valley side slopes are covered with colluvium and talus largely derived from rock falls from the cliffs above. Downslope of these deposits are alluvial fans derived from erosion of upstream channel deposits and slope sediments. The alluvial-fan deposits interfinger with stream alluvium of Mill and Pack Creeks and the Colorado River in the interior of the valley.

EXPANSIVE AND GYPSIFEROUS SOIL AND ROCK

Expansive soil and rock contain clay minerals capable of absorbing large quantities of water. As their moisture content changes, the clay minerals expand (water added) and contract (water removed), causing as much as a 10 percent change in soil volume (Sheldon and Prouty, 1979). When water is added, clay minerals expand both vertically and horizontally. Clay soils may swell either by absorption of water between clay particles or by incorporating water directly into the crystal lattice of individual clay minerals (figure 3). In both processes, the added water causes the soil or rock to expand. As the material dries, the loss of water causes shrinkage that can create near-surface cracks in the material (figure 4). This "shrink-swell" process can churn and disturb the surface of expansive deposits, giving some of them a characteristic "popcorn" surface texture. In Moab-Spanish Valley, the Paradox and Chinle Formations, and the soils derived from them, are the most likely sources of expansive minerals (plate 1). However, clayey mudstone and shale comprise a relatively minor component of the Chinle Formation in the Moab area, so the expansive-soil-and-rock hazard associated with the Chinle is significantly less here than it is elsewhere in Utah (for example, the St. George area).

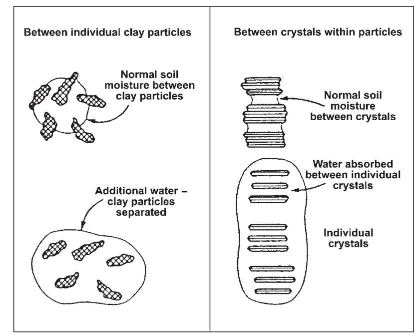

Figure 3. *Schematic diagram of water-absorption processes in expansive clay minerals (modified from Mulvey, 1992).*

The volumetric changes associated with expansive soil and rock may damage structures, roads, and utilities built on or buried in the expansive materials. Problems commonly associated with expansive soil and rock include cracked foundations and other structural damage to buildings; heaving and cracking of roads, sidewalks, and driveways; damage to pipelines; and plugging of wastewater-disposal drain fields. Single-family homes are particularly susceptible to heave because foundation loads (typically 1,500 to 2,500 pounds per square foot [7,400-12,200 kg/m^2]) may be less than expansive pressures from clays (3,000 to 11,200 pounds per square foot [14,600-54,700 kg/m^2]) (Costa and Baker, 1981). Larger, heavier buildings are less susceptible to expansive-soil problems.

Maps published by the U.S. Department of Agriculture Soil Conservation Service (now Natural Resources Conservation Service) indicate that soils in the Moab-Spanish Valley area generally have a low shrink-swell potential (Hansen, 1989; Lammers, 1991). Also, Lammers (1991) shows a moderate shrink-swell potential in soils of the Jocity series, found in a localized area of alluvial deposits adjacent to Pack Creek in the NW1/4 sec. 22, T. 26 S., R. 22 E., Salt Lake Base Line and Meridian.

Figure 4. Fractures formed by shrinkage in expansive clay in a mudstone interbed of the Chinle Formation. Outcrop exposed in cut at base of slope east of downtown Moab.

Gypsiferous soil and rock are very localized hazards in Moab-Spanish Valley. These deposits contain significant amounts of the evaporite mineral gypsum. Gypsum is a weak material with low bearing strength, which can cause foundation problems for heavy structures. Gypsiferous deposits are also subject to subsidence and collapse due to dissolution of gypsum and other soluble evaporite minerals commonly associated with gypsum, which creates a loss of internal structure and volume within the deposit. Dissolution of gypsum and associated ground settlement may take place where water is introduced into the subsurface as the result of irrigation, wastewater disposal, or ponded water due to natural topography or altered surface drainage. If thick gypsum beds are present, underground solution cavities may develop and collapse, forming sinkholes. Paradox Formation cap rock and associated soils contain significant amounts of gypsum (figure 5; plate 1).

Gypsiferous soil and rock can promote concrete deterioration over time. When gypsum weathers it forms sulfuric acid and sulfate, which may react with certain types of cement and weaken foundations. Soil Conservation Service maps show that soils in the Moab-Spanish Valley area generally have a moderate concrete corrosion potential (Hansen, 1989; Lammers, 1991). However, Lammers (1991) indicates soils of the Moenkopie series, located along the northeastern valley margin and in the southwestern corner of the study area, are mildly to strongly alkaline (pH 8.8) and have a high concrete corrosion potential. (Note that the distribution of the Moenkopie soil series does not correspond to the distribution of Moenkopi Formation outcrops.) Also, Lammers (1991) shows soils having a high concrete corrosion potential along the flood plains and terraces of the Colorado River, Mill Creek, and Pack Creek.

Figure 5. Outcrop of gypsiferous Paradox Formation cap rock on western side of valley, just south of The Portal, showing small dissolution caverns. Apparent large cavern to right of geologist is actually the base of a rock-fall boulder from Wingate Sandstone cliffs exposed below skyline.

Hazard-Reduction Measures

Surface drainage conditions affecting soil-moisture content are important in areas of expansive soil and rock. Gutters and downspouts should direct water at least 10 feet (3 m) away from foundation slabs (Costa and Baker, 1981). Vegetation that requires substantial amounts of irrigation should not be placed near foundations. Concrete foundations can be strengthened with additional steel reinforcing bars. Walls and floors can be supported on piles or footings placed to depths below the active shrink-swell zone (Costa and Baker, 1981).

Wide shoulders and good drainage along highways can minimize road damage from expansive soil and rock. In highway foundations, a combination of hydrated lime, cement, and organic compounds can be added to road subgrade materials to stabilize the underlying soil (Costa and Baker, 1981). Wastewater disposal systems are generally not viable in areas of expansive soil and rock. The addition of water from disposal systems expands the soil, reducing percolation rates below acceptable limits and clogging drain lines. Buried pipelines can be protected by backfilling around the pipe with sand and gravel, which increases permeability and permits expansion and contraction of the soil without damage to the pipe.

In gypsiferous soils, laboratory tests are required to determine the amount of gypsum present. Control of drainage around structures as recommended above for expansive soils pertains to construction in gypsiferous soils as well. Also, the outer walls of concrete foundations can be covered with impermeable membranes or bituminous coatings to protect them from deterioration, and special sulfate-resistant concrete can be used.

Scope of Recommended Site Investigations

Site investigations in areas of problem soil and rock (plate 1), as well as other areas of unconsolidated Quaternary deposits along the valley margins and floor, should include a standard soil-foundation investigation to identify expansive and gypsiferous soil and rock. If present, further specialized soil testing to determine clay mineralogy, expansive pressures, and gypsum content may be advisable to better understand the problem. The report should include recommendations on foundation design.

STREAM FLOODING, ALLUVIAL-FAN FLOODING, DEBRIS FLOWS, AND COLLAPSIBLE SOILS

Cloudburst storms and snowmelt can produce stream and alluvial-fan flooding, and debris flows. Sediment deposited in alluvial-fan floods and debris flows may be prone to collapse due to hydrocompaction when rewetted.

Cloudburst storms are the most common cause of flooding in streams and on alluvial fans in Moab-Spanish Valley. The flood potential of cloudburst rainstorms depends on numerous factors including: (1) the intensity or amount of rainfall during a given period of time, (2) the duration or length of time of rainfall, (3) the distribution of rainfall and direction storms move over a drainage basin, (4) soil characteristics, (5) antecedent soil moisture, (6) vegetation, (7) topography, and (8) drainage pattern. Because many of these conditions are unknown until rain is falling on critical areas, the magnitude of flooding from a particular storm is difficult to predict. In contrast, snowmelt floods from rapid melting of snow in the La Sal Mountains are more predictable because flood levels depend primarily on snow amounts in the mountains and temperature. Snowmelt floods are characterized by high-volume runoff, moderately high peak flows, and diurnal fluctuation in flow.

Rapidly deposited sediment in alluvial-fan floods and debris flows may retain an open structure subject to collapse and subsidence when wetted. Thus, areas of collapsible soil typically coincide with areas of alluvial-fan-flooding and debris-flow hazard and are discussed together here.

Stream Flooding

Stream flooding can occur in Mill and Pack Creeks, and Moab has had numerous damaging floods from these creeks (Woolley, 1946; Butler and Marsell, 1972). In addition, floodwaters from the Colorado River inundated the low-lying Moab Slough area in the northwestern part of the valley (site of the Scott M. Matheson Wetlands Preserve) in 1983 and 1984. The primary source of flooding in Moab-Spanish Valley is cloudburst storms, which typically occur between mid-April and September; seasonal snowmelt can also cause stream flooding. Flood-hazard-boundary maps (Federal Emergency Management Agency, 1981) are available for the unincorporated part of Moab-Spanish Valley, and flood-insurance rate maps (U.S. Department of Housing and Urban Development, 1980) are available for the city of Moab; these maps can be viewed online at <hazardmaps.gov>. These maps show flood-hazard areas as delineated in the Federal Insurance Administration's National Flood Insurance Program. Because of the existence of these maps, we did not map stream-flood hazards as part of this study.

Alluvial-Fan Flooding

Alluvial-fan flooding occurs with little advance warning. Flooding generally occurs when cloudburst storms drop large volumes of water over an area in a short period of time. Storms generate high-velocity flows that may simultaneously occupy several different channels on the fan surface at once. Floodwaters erode some channels while depositing large volumes of sediment in others, making it difficult to predict flood paths on alluvial fans. Alluvial-fan floodwaters commonly contain large amounts of coarse sediment, including boulders and cobbles.

The areas of potential alluvial-fan flooding shown on plate 2 correspond to active (Holocene) alluvial fans. Channels on these alluvial fans are generally incised at the apex of the fan and become shallower where sediment deposition is more active on the middle and distal parts of the fan. The flood hazard is therefore greatest where floodwaters first overflow main channels and move across the fan surface as sheet flow or in shallow minor channels. Floodwater depth then decreases down-fan. In places, distal fan surfaces have been isolated by a road or other drainage diversion, and are no longer susceptible to alluvial-fan flooding except in extreme events. Older alluvial fans are more deeply incised than younger fans, and the channels can generally contain floodwaters. We therefore excluded these older alluvial fans from the flood-hazard area.

Debris Flows

Debris flows are a heavily sediment-laden phase of alluvial-fan flooding that remain in the channel until the channel loses confinement or incision, allowing the flow to spread onto the fan surface. Debris flows are mixtures of water, sediment (such as boulders, cobbles, sand, silt, and clay), and organic material and other solid debris that form a muddy slurry much like wet concrete (Wieczorek and others, 1983). By a conventional engineering interpretation, debris flows have sediment concentrations of 80 percent or greater by weight (60 percent or greater by volume), and flows having sediment concentrations of 40 to 80 percent by weight (20-60 percent by volume) are called hyperconcentrated flows (Beverage and Culbertson, 1964; Costa, 1984). In spite of this technical distinction, our use of the term "debris flow" in this report refers to all floodwaters that are heavily sediment-laden, including hyperconcentrated flows. Debris flows generally remain confined to stream channels in mountainous areas, but may reach and deposit debris over large areas on alluvial fans at canyon mouths. Alluvial fans on the southwestern side of Moab-Spanish Valley are particularly susceptible to debris-flow hazards (plate 2) because of the steep slopes below cliffs and the highly erodible bedrock (Chinle and Wingate Formations).

Debris flows form in at least two different ways: (1) hillside and channel erosion by runoff during cloudburst storms, and (2) directly from debris slides. In Moab-Spanish Valley, runoff from cloudburst storms can scour materials from the ground surface and stream channels, increasing the proportion of soil materials to water until the mixture becomes a debris flow. The size and frequency of debris-flow events generated by rainfall runoff depend on several factors, including the amount of loose material available for transport, the magnitude and frequency of the storms, the density and type of vegetative cover, and the moisture content of the soil (Campbell, 1975; Pack, 1985; Wieczorek, 1987). Debris flows can also mobilize from debris slides, which are landslides composed mainly of coarse-grained debris, usually derived from colluvium. A debris flow may form when a debris slide reaches a stream, or when the water content otherwise increases until flow begins. Little geologic evidence exists for debris slides on hillsides above alluvial fans in the Moab-Spanish Valley area, so this does not appear to be a significant mechanism of debris-flow initiation in this area.

Collapsible Soils

Hydrocompaction, which causes subsidence in collapse-prone soil, occurs in loose, dry, low-density deposits. These deposits decrease in volume or collapse when saturated for the first time since deposition (Costa and Baker, 1981). Collapsible soils are subject to volumetric reductions that can damage structures. Collapsible soils are mainly found in alluvial-fan and loess deposits. When wetted for the first time since deposition (by irrigation, wastewater disposal, surface drainage), collapsible soils lose the internal bonds holding the soil grains together, causing the ground surface to subside or collapse. These soils generally consist of fine sand and silt held together by small amounts of clay (less than 12 percent). When the soil becomes saturated, the clay bonds dissolve and the soil collapses.

Collapsible soils are common in Utah, particularly in alluvial fans that have shale in their source areas. The Paradox, Moenkopi, and Chinle Formations contain shale (clays) and contribute sediments to alluvial fans in Moab-Spanish Valley. Because collapsible soils are common in alluvial-fan deposits, maps of alluvial-fan-flood and debris-flow hazard areas where such deposits are found (plate 2) also show where collapsible soils may be found. Eolian deposits in Moab-Spanish Valley are typically sand sheets and dunes rather than loess (Doelling, 2001; Doelling and others, 2002), and therefore are generally not prone to collapse. However, unmapped loess deposits may be present locally.

Hazard-Reduction Measures

Much of the flood damage to roads and culverts in Moab-Spanish Valley is due to alluvial-fan flooding. Methods for reducing stream-flooding, alluvial-fan-flooding, and debris-flow hazards and damage include: (1) avoidance, (2) drainage-basin improvement, (3) flow modification and detention, (4) floodproofing, and (5) flood-warning systems. Different methods or combinations of methods may be appropriate for individual drainages or types of development.

Stream-flood, alluvial-fan-flood, and debris-flow hazards may be reduced by avoiding areas at risk (source areas, stream channels, and alluvial fans) either permanently or at the time of imminent danger. Permanent avoidance is not possible in some areas, because existing development already occupies the flood plains along Mill and Pack Creeks and active alluvial fans. Permanent avoidance may be required for new development through enforcement of Federal Emergency Management Agency regulations under the National Flood Insurance Program and zoning ordinances.

Channel modifications are designed to reduce erosion and improve the ability of the channel to pass debris downstream. Scour of unconsolidated material in stream channels and undercutting of stream banks are two of the most important processes that contribute sediment to floods. Check dams (small debris and water-retention structures in channels that are designed to prevent erosion by reducing velocity and causing deposition) reduce damage from flooding and debris flows. Stream channels may be stabilized by lining the channels. The potential for stream channels to pass floodwaters and debris downstream can be improved by: (1) removal of channel irregularities, (2) enlargement of culverts combined with installation of removable grates over the mouth of the culverts to prevent blockage, and (3) construction of flumes, baffles, deflection walls, and dikes (Jochim, 1986; Baldwin and others, 1987). Whenever these methods are used, attention must be given to possible related adverse effects to other properties downstream.

Structures crossing channels may be protected by: (1) bridging the channel to allow floodwater and debris to pass underneath, and/or (2) strengthening the structures to withstand floodwater and debris-flow impact, burial, overtopping, and re-excavation (Hungr and others, 1987).

Defensive measures in the debris-flow deposition zone are designed to limit both the areal extent of deposition and damage to structures in the zone (Hungr and others, 1987). Defensive measures include deflection devices and debris basins. Deflection devices are used to control flow direction and reduce the velocity of debris flows (Baldwin and others, 1987). Types of deflection devices include: (1) pier-supported deflection walls, (2) debris fences (a series of steel bars, cables, or mesh fences placed horizontally at increasing elevations above the stream channel), (3) berms, (4) splitting-wedge walls (a reinforced concrete wall in the shape of a "V" with the point facing uphill), and (5) gravity structures like gabions (hollow metal wicker-works or iron cylinders filled with cobbles or earth) (Jochim, 1986; Baldwin and others, 1987).

Two types of debris basins, open and closed, are commonly used to reduce debris-flow hazards. Both types are designed to control the area of debris deposition (Hungr and others, 1987). Any suitable location along a debris-flow path can be chosen to erect a dam and create a basin. Open debris basins commonly have a basin-overflow spillway designed to direct water and excess material to a noncritical area or back into the stream channel. Open debris basins should be located where they utilize the original natural depositional area as much as possible (Hungr and others, 1987). Closed debris basins have both straining outlets to pass water discharges, and spillways to handle emergency debris overflows (Hungr and others, 1987). Closed debris basins can be located in the lower part of the main channel or on the alluvial fan (Hungr and others, 1987). Both types of debris basins require periodic removal of debris and maintenance.

Although collapsible soils have not been documented in Moab-Spanish Valley, geologic conditions on alluvial fans are locally favorable for them. Collapsible soils have few diagnostic field characteristics, although a pinhole texture and low density are indicators of collapsible soil. Laboratory soil consolidation tests are generally needed for positive identification. If present, collapsible soils must be compacted, removed, or "collapsed" by presoaking prior to development. In areas of collapsible soils, drainage from the roof and sprinkler systems should be channeled away from structures to reduce potential damage.

Scope of Recommended Site Investigations

Site investigations in stream-flood, alluvial-fan-flood, and debris-flow hazard areas may include: (1) definition of 100-year flood plains in areas subject to stream flooding, (2) delineation of the most active alluvial-fan surfaces, including parts of the fan subject to sheet flow, (3) analysis of debris-flow potential on alluvial fans based on the number and size of past debris slides, volume of colluvium-filled slope concavities, and debris accumulation in channels and on slopes in the drainage, (4) examination of drainages to determine if they will supply debris, impede flow, or contain flows in the area of the proposed development, (5) analysis of existing upstream structures that might divert, deflect, or contain flows, and (6) recommendations concerning channel improvements, flow-modification and catchment structures, direct-protection structures, or floodproofing measures necessary to protect the proposed development.

For development in alluvial-fan-flood and debris-flow hazard areas, the storage capacity and design of existing debris basins or other structures that may divert floodwaters (such as roads or storm drains) upstream from the site should be evaluated to ensure that they are capable of diverting, containing, or passing floodwaters. The mapped hazard areas shown on plate 2 do not consider the possible role of these existing structures in reducing the hazard. Debris basins must be regularly maintained. Predicting flow discharge rates and volumes, extent of alluvial-fan flooding, and volumes of debris is difficult, particularly in Moab-Spanish Valley, where few data on previous events have been recorded. Because of this lack of data, sizing of water-retention structures and debris basins should incorporate a considerable degree of conservatism to increase margins of safety.

Collapsible soils should be addressed in standard soil-foundation investigations prior to development, and laboratory soil-consolidation tests performed when their presence is suspected.

SOIL SUSCEPTIBLE TO PIPING AND EROSION

Soil susceptible to piping and erosion covers much of the floor of southern Moab-Spanish Valley (plate 2). The soil consists of eolian and minor fine-grained alluvial deposits composed of sand, silt, and clay, and is up to 30 feet (10 m) deep based on data from water-well logs.

Piping is subsurface erosion by ground water that moves in permeable, noncohesive layers in unconsolidated materials and exits at a free face that intersects the layer (figure 6). Removal of fine-grained particles (silt and clay) by this process creates voids that act as minute channels that further direct the movement of water. Channels enlarge as water velocity increases and removes more material, forming a "pipe." The pipe becomes a preferred avenue for ground-water flow and enlarges as more water is intercepted. Pipe enlargement removes support of the walls and roof, causing eventual collapse of the pipe. Sinkholes may form at the surface above the pipes, directing even more surface water into them. Eventually, total pipe collapse may form a gully on the surface that continues to enlarge as water flows through it.

Characteristics that make soil susceptible to piping also make it subject to rapid erosion by running water or wind. Soil susceptible to erosion covers much of the floor of Moab-Spanish Valley (plate 2). Also, the Chinle Formation and soils derived from the Chinle can be highly erodible (figure 7; plate 2). Erosion commonly occurs during cloudburst storms. Associated sheetwash may erode fine-grained valley-floor sediments, and channelized runoff can create gullies on slopes and erode the banks of stream channels. High winds associated with cloudburst storms or the approach and passage of frontal systems commonly create dust clouds in southern Moab-Spanish Valley that reduce visibility on U.S. Highway 191 and county roads.

Piping and erosion can damage roads, earth-fill dams, farmland, bridges, culverts, and buildings. In Moab-Spanish Valley, roads are the most susceptible because they parallel and cross incised drainages, altering natural runoff and channeling water.

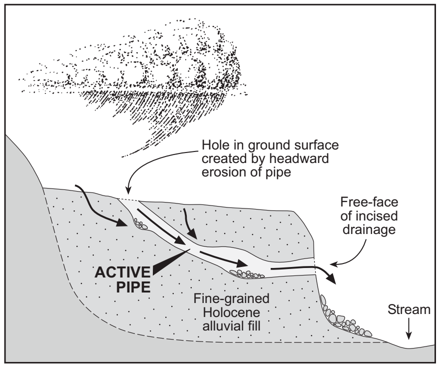

Figure 6. Schematic cross section of a pipe in Holocene alluvium.

Hazard-Reduction Measures

The best method of reducing piping and erosion hazards is to control drainage and avoid concentrating runoff. Riprap can be used on slopes around culverts and near bridges to reduce the potential for erosion and development of pipes. Erosion can be reduced by lining canals and drainages with concrete, riprap, or gabions. Diversion of natural drainage or site grading must be done carefully to avoid initiating or accelerating piping or erosion. Irrigation ditches in suscept-ible areas should be lined and maintained. Landscape designs should distribute runoff away from structures and disperse flow. Wind erosion can be limited by reducing disturbance of vegetation during construction, careful management of livestock grazing, and limiting vehicle traffic on erodible soils.

Scope of Recommended Site Investigations

The presence of soil susceptible to piping and erosion should be addressed in standard soil-foundation investigations prior to development.

Figure 7. Gully erosion in slope underlain by Chinle Formation, along the northeast side of U.S. Highway 191 northwest of downtown Moab.

ROCK FALL

Rock falls originate when erosion and gravity dislodge rocks from cliffs or slopes. The dislodged rocks may then travel great distances by falling, rolling, bouncing, and sliding. The primary factor in determining if an area is susceptible to rock falls is the presence of a source of rocks (figure 8). If there are no cliffs, bedrock outcrops, or rocks on a steep slope, the rock-fall hazard is negligible. Other major considerations are the distance and direction rocks will travel downslope.

Primary causes of rock falls are chemical and physical weathering, including root growth and freeze-thaw of water in outcrop discontinuities; erosion of the rock and surrounding material; and ground shaking during earthquakes. Keefer (1984) found that rock falls may be triggered by earthquakes as small as magnitude (M) 4. The August 1988 San Rafael Swell earthquake (M 5.3) near Castle Dale in central Utah generated hundreds of rock falls that temporarily obscured the surrounding cliffs in clouds of dust (Case, 1988).

With the exception of the Paradox Formation, all of the bedrock units in the Moab-Spanish Valley area produce rock-fall debris (Doelling and others, 2002); however, the units most susceptible to rock falls are the Wingate Sandstone, Kayenta Formation, and Navajo Sandstone. In these units, outcrops are disrupted by bedding surfaces, joints, or other discontinuities that break rock into loose fragments, blocks, or slabs.

We determined runout distances for rock falls and the lower limit of the rock-fall hazard area (plate 3) by mapping on 1:20,000-scale aerial photographs the outermost rock-fall boulders on slopes below cliffs. We also checked the rock-fall "shadow angle" in the field at several locations. The shadow angle is the angle of a line drawn between the top of the talus slope and the lower limit of the runout zone (Evans and Hungr, 1993). Based on empirical data, Evans and Hungr (1993) suggested a minimum shadow angle of about 28 degrees may be useful for establishing a preliminary estimate of the maximum rock-fall runout distance. Our spot checks supported a 28-degree minimum shadow angle as being reasonably consistent with maximum runout distances of rock falls in Moab-Spanish Valley.

Rock-fall-hazard areas delineated on plate 3 have either a relatively high or moderate hazard. Areas shown as having a high rock-fall hazard are generally cliff areas of high relief, typically with steep slopes below the cliffs (figure 8). Rocks dislodged in these areas may include very large boulders that can become airborne by falling and bouncing, reach high velocities, and travel long distances (in excess of 1,000 feet [300 m]) in the runout zones. Areas shown as having a moderate rock-fall hazard are generally low-relief upland areas underlain by exposed bedrock or colluvium, and areas with locally steep slopes underlain by massive, competent bedrock (figure 9). Rock falls are possible in these areas, but dislodged rocks are unlikely to reach high velocities or travel more than a few tens of feet. Where plate 3 does not indicate either a high or moderate rock-fall hazard, the hazard is low due to gentle slopes and an absence of rock-fall sources.

Rock falls present a hazard to structures and personal safety. In Grand County, rock falls have blocked roadways and railroads and have struck vehicles. In the Moab-Spanish Valley area, buildings on slopes below the cliffs of the southwestern valley margin, and the northeastern valley margin between Moab and the Colorado River, are particularly vulnerable to rock-fall hazards. As development advances higher onto alluvial fans and slopes below cliffs, the risk from falling rocks increases.

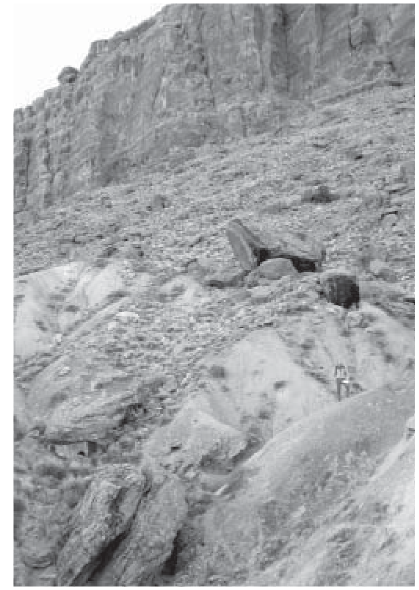

Figure 8. Rock-fall-hazard area along valley margin west of Moab, characterized by high cliff (source area) and abundant boulders on slope below cliff (runout or "shadow" zone). The rock-fall hazard in areas such as this is relatively high. Note that local topography (for example, hills and ravines) in the runout zone can trap rock-fall boulders and limit their runout distance; boulders generally travel farther downslope where slopes are smooth.

Rock falls are the principal mass-movement hazard in Moab-Spanish Valley. In general, the potential for other types of mass movement, such as rotational slumps and deep-seated landslides, is low (see Landslides section).

Hazard-Reduction Measures

Buildings are best located outside areas susceptible to rock falls, but methods are available for reducing rock-fall hazards. These methods include rock stabilization; removal or break-up of source rocks; and construction of deflection berms, slope benches, and rock-catch fences that may prevent, stop, or at least slow moving rocks. Structures may also be strengthened to withstand impact. Other techniques for reducing landslide hazards including rock falls are described by Kockelman (1986).

Figure 9. Example of moderate rock-fall-hazard area, where Sand Flats Road traverses Navajo Sandstone "slick rock" southeast of downtown Moab. Rock falls occasionally occur in these areas, but the relative lack of rock-fall sources and the generally limited travel distance of rock-fall boulders results in a lower hazard than in other rock-fall-hazard areas (see figure 8).

Scope of Recommended Site Investigations

Site investigations in rock-fall hazard areas should define rock-fall source areas and estimate rock runout paths and distances. Rock-fall sources may be cliffs, outcrops, or individual clasts on a slope. Rock size, shape, depth of burial, and slope geometry should be considered in defining sources as well as hazard areas. A preliminary estimate of runout distance can be made by measuring the "shadow angle" below the base of the rock-fall source (Evans and Hungr, 1993). Computer models are available to help evaluate rock-fall hazards (for example, CRSP [Jones and others, 2000]; ROCKFALL [Hungr and Evans, 1988, 1989]), but physical evidence such as extent of clast accumulations below sources, topography, damaged vegetation, and natural barriers can also be used to define rock-fall hazard areas.

SHALLOW GROUND WATER

In Moab-Spanish Valley, shallow ground water (water at depths below the ground surface of 10 feet [3 m] or less) is present in an unconfined aquifer in the unconsolidated deposits that cover the valley floor from the Colorado River to the Grand County-San Juan County line (plate 3) (Hecker and others, 1988). Shallow zones of perched ground water may also exist locally in the valley-fill deposits. The unconfined aquifer in Moab-Spanish Valley consists of alluvial, alluvial-fan, and eolian deposits of varying thickness. Maximum valley-fill thickness ranges from less than 155 feet (47 m) near the confluence of Pack and Mill Creeks (Harden and others, 1985) to possibly greater than 450 feet (137 m) in the northwestern part of the valley (Doelling and others, 2002). Sumsion (1971) indicates the average thickness of the saturated alluvium is 70 feet (21 m).

Surface and subsurface sources recharge the unconfined aquifer in Moab-Spanish Valley. Primary surface recharge is from snowmelt and rainfall that becomes stream flow in Mill and Pack Creeks, which then infiltrates the ground. Mill Creek is the largest source of surface recharge, providing water to the northwestern part of the valley (Blanchard, 1990). Pack Creek also provides surface recharge to the unconfined aquifer, mostly in southern Spanish Valley in San Juan County (Steiger and Susong, 1997). Irrigation waters may also contribute to recharge. Major subsurface recharge is from fractured-rock aquifers on the northeastern side of the valley.

Plate 3 shows the areal extent of shallow ground water in Moab-Spanish Valley. We delineated the shallow-ground-water area by contouring the depth to the water table as reported on drillers' logs of water wells. The map represents an "average" ground-water level taken from data collected during various seasons and years. Ground-water levels may fluctuate several feet, locally tens of feet, in response to seasonal and long-term climatic conditions. Also, local shallow water tables may be induced by landscape irrigation, water-line breaks, and septic-tank soil-absorption systems.

The most significant hazard associated with shallow ground water is the flooding of subsurface facilities such as

basements, utility lines, and septic-tank soil-absorption drain fields. Shallow ground water can increase the potential for corrosion of subsurface concrete walls and slabs, and structures extending below the water table may experience water damage to foundations and building contents. Landfills and waste dumps may become inundated and contaminate aquifers. Underground utilities may also experience water damage. Septic-tank soil-absorption drain fields can become flooded, which may cause ground-water contamination as well as system failure. Wetting of collapsible or expansive soils by ground water may cause settlement or expansion and damage to foundations and structures. Roads and airport runways may heave or settle when collapsible and expansive soils become saturated at shallow depths. Shallow ground water may cause sinkholes by soil piping or the dissolution of gypsum or soluble salts.

Shallow ground water can become contaminated by leaking underground or above-ground storage tanks. Pollutants will flow with the ground water and possibly impact deeper aquifers, and the contaminated water and associated vapors may seep into wells and basements.

Hazard-Reduction Measures

Avoidance is one method of reducing shallow ground-water problems. However, much of Moab-Spanish Valley's population and development are already in areas of shallow ground water. Construction techniques such as drainage systems, sump pumps, and waterproofing and other protective measures may reduce or eliminate the adverse effects of shallow ground water. Slab-on-grade buildings with no basements are an alternative construction design used in areas having a shallow water table. Pile foundations can be used to increase foundation stability. Adding fill can raise building grades, and pumping can lower the water table. Hazard-reduction measures should be based on the shallowest anticipated water level, taking into account both climatic and development-induced conditions.

Septic-tank soil-absorption drain fields may fail when inundated by ground water. To reduce the potential for drain-field failures, State of Utah regulations require that drain lines be at least 2 feet (0.6 m) above the highest seasonal ground-water table (Utah Division of Water Quality, 2000).

Scope of Recommended Site Investigations

Site-specific studies are recommended for all types of construction involving subsurface facilities in areas where the water table is or may rise to within 10 feet (3 m) of the ground surface (plate 3). Site-specific studies should identify the highest water level recorded or evident in sediments, as well as the present and highest expected level. Data on long-term water-level fluctuations in nearby wells over time can be obtained to define a range of seasonal and annual water-table fluctuations. Water-table measurements during known wet periods, such as 1983-85, can be used to approximate highest levels. Studies need to also consider potential development-induced changes to ground-water levels; septic-tank soil-absorption systems may raise water levels to near the level of drain lines, and excess landscape irrigation may also significantly raise ground-water levels.

Shallow-ground-water hazards can be addressed in the soil-foundation report for a site. The report should contain recommendations for stabilizing or lowering the water table, if necessary, and design of waterproofing or other hazard-reduction strategies. Such studies must also address soil conditions including the potential for collapse, piping, dissolution, or swelling, and the potential for ground-water contamination by soil-absorption systems.

Because of seasonal and long-term fluctuations of the water table, the accompanying maps are not intended to replace site-specific data. Ground-water information is available from drillers' logs in the urbanized areas of northern Moab-Spanish Valley, but is sparse in the southeastern end of the valley near the Grand County-San Juan County line.

FRACTURED ROCK

Dissolution of salt in the diapir beneath Moab-Spanish Valley and accompanying collapse caused extensive fracturing and displacement of much of the overlying rock (figure 10). Fractured rock is exposed along the base of the cliffs bordering Moab-Spanish Valley to the northeast and southwest; Doelling and others (2002) refer to these areas as the northeast- and southwest-valley-margin deformation belts. Doelling and others (2002) mapped numerous faults within these deformation belts; while these faults share hazard characteristics with other types of fractures, and may be subject to small subsidence-related displacements, they lack geologic evidence that would indicate they present a significant hazard from surface fault rupture related to earthquakes (see Earthquake Hazards and Subsidence discussions below).

Fractures increase secondary permeability and weaken the rock. Problems associated with development in zones of fractured rock are increased potential for contamination of ground water (such as with effluent from individual wastewater disposal systems) and unstable conditions in road cuts and tunnels. Fractures enable effluent to travel long distances without proper filtering of pathogens, which can result in contamination of shallow unconfined aquifers. Excavations and cuts in fractured rock are susceptible to failure and may generate rock falls.

Hazard-Reduction Measures

In fractured rock, use of individual wastewater disposal systems should be limited to areas having at least 4 feet (1.2 m) of natural soil present between drain lines and underlying fractured rock, as required by the Utah Division of Water Quality (2000). Hazard-reduction measures for potential rock falls in road cuts in fractured rock include installing rock catch fences, covering cuts with wire mesh, and stabilizing rock faces with rock bolts and surficial coatings. Road cuts and tunnels in fractured rock should be designed and constructed under the direction of a geotechnical engineer experienced in rock construction and rock-slope stability.

Scope of Recommended Site Investigations

Site investigations in areas of fractured rock (plate 4) should include geotechnical and hydrologic evaluations to

Figure 10. *Highly fractured Navajo Sandstone exposed at the northwestern end of Moab-Spanish Valley, at the intersection of Utah Hwy. 279 (foreground) and U.S. Hwy. 191 (at base of slope). Fractured rock such as this poses a variety of problems for development.*

identify the extent and nature of fractures, evidence for subsidence, stability of cut-slope materials, and potential for ground-water contamination. For foundations, assessment of stability should be included in the soil-foundation investigation. For roads and road cuts, geotechnical investigations should address subgrade and cut-slope stability. If potential sources of contamination are included in development plans, the potential for contamination must be determined through hydrogeologic studies to determine ground-water flow direction and recharge.

UNMAPPED HAZARDS

In addition to those discussed above, other geologic hazards may exist in Moab-Spanish Valley that could affect development, including: (1) earthquakes, (2) subsidence caused by salt dissolution, (3) landslides, and (4) indoor radon. Where these hazards are likely to occur is difficult to predict except in a very gross sense. Although plate 4 shows the trace of the Moab fault and the generalized area of potential valley-floor subsidence, we otherwise do not delineate hazard areas for these additional geologic hazards on the plates that accompany this report. However, these hazards should be considered in the design and construction of new development in Moab-Spanish Valley as appropriate.

Historically, earthquake activity has been low in the area. Subsidence in late Quaternary time is evident along the Colorado River in northwestern Moab-Spanish Valley and elsewhere in the valley. Naturally occurring landslides are scarce in the Moab-Spanish Valley area, but landslide triggering could be a concern in areas of hillside development. Uranium, which is the source of radon, is found in rocks in the Moab-Spanish Valley area, and readings indicate that elevated levels of indoor radon are present locally.

Earthquake Hazards

The Moab-Spanish Valley area is one of low historical earthquake activity. In general, earthquakes in the area are infrequent and of small to moderate magnitude (Wong and Humphrey, 1989; Wong and others, 1996). If a significant earthquake were to occur in the Moab-Spanish Valley area, potential geologic hazards would include ground shaking and possibly surface fault rupture, liquefaction, landslides, and rock falls. As discussed below, however, the possibility of any of these potential earthquake hazards causing appreciable damage is low.

Ground shaking could result from an earthquake generated by movement on a mapped fault, or from an earthquake not necessarily attributable to a mapped fault (background, or random earthquake). The general area around Moab-Spanish Valley has a number of faults that have possibly been active during Quaternary time (Hecker, 1993; Black and others, 2003); these faults are considered the most likely to undergo future movement. However, Quaternary movement on all but one of these fault zones has been shown to be the result of deformation associated with buried salt deposits (Colman and others, 1986; Oviatt, 1988; Olig and others, 1996), either diapirism (the upward movement of salt due to

its low density) or collapse due to salt dissolution. Because these faults extend only to relatively shallow depths in the crust, they are not considered capable of producing significant earthquakes or strong ground shaking. The one Quaternary fault zone in the area that is associated with regional crustal stresses rather than salt movement, the Uncompahgre fault zone, is about 30 miles (50 km) northeast of Moab-Spanish Valley. Based on this distance and an estimate of maximum earthquake magnitude, Wong and others (1996) concluded that earthquakes generated by this fault zone would produce an insignificant ground-shaking hazard to the Moab area.

Most earthquakes on the Colorado Plateau (including Moab-Spanish Valley) cannot be attributed to movement on known faults (Wong and Humphrey, 1989; Wong and others, 1996). Although the maximum magnitude of these background earthquakes could approach M 6.5, historical earthquakes in the Moab-Spanish Valley area have been much smaller. Wong and Humphrey (1989) summarized the seismicity of the area during the eight-year period following installation in July 1979 of a regional seismograph network in the Canyonlands region of southeastern Utah. During this period, the largest recorded earthquake was M_L 3.3, and the most seismically active area near Moab-Spanish Valley was in the vicinity of the Cane Creek potash mine, about 7 miles (11 km) southwest of Moab. However, most of the earthquakes recorded in the mine area were less than M_L 1.0, and may have been related to mining-induced subsidence (Wong and Humphrey, 1989). This general pattern of seismicity has continued to the present (University of Utah Seismograph Stations, unpublished data). Regionally, only a few earthquakes have been recorded that have been of M 5 or larger; four of these were in northern Arizona, and one was in the San Rafael Swell (1988, M_L 5.3) (Wong and others, 1996).

Earthquake ground motions are typically reported in units of acceleration as a fraction of the force (acceleration) of gravity (g). In general, the greater the acceleration or "g" force, the stronger the ground shaking and the more damaging the earthquake. Locally, ground motions can be amplified (more severe shaking) or deamplified (less severe shaking) depending on specific rock and soil conditions.

Probabilistic ground motions have been calculated for the uranium mill tailings site at the northwestern end of Moab-Spanish Valley relative to various earthquake return periods (the elapsed time between earthquakes of a given size). At return periods of 500, 1,000, 5,000, and 10,000 years, the mean peak ground accelerations are 0.05, 0.07, 0.14, and 0.18 g, respectively (Wong and others, 1996; Woodward-Clyde Federal Services, 1996). Probabilistic ground motions for the Moab-Spanish Valley area are also shown on national seismic-hazard maps developed by Frankel and others (1996, 2002), available online at <geohazards.cr.usgs.gov/eq/index.html>. These maps give probabilistic ground motions for rock sites (*International Building Code* [IBC] site class B; International Code Council, 2000a) in terms of peak ground acceleration and 0.2-, 0.3-, and 1.0-second-period spectral accelerations having 10, 5, and 2 percent probabilities of exceedance in 50 years (corresponding to return periods of approximately 500, 1,000, and 2,500 years, respectively). The different values are used by engineers for earthquake-resistant design of structures, based in part on the height and intended use of the structure as well as specific code requirements. Table 1 summarizes probabilistic accelerations derived from the national seismic-hazard maps applicable to rock sites near Moab; these values are given solely for the purpose of illustrating the generally low levels of expected ground motions. For building design, values from similar seismic-hazard maps in the IBC must be used, with a correction based on the particular geologic conditions at the site (site class).

Even the highest probabilistic ground motions for the Moab-Spanish Valley area, which have the lowest probability of occurrence in any given year, would likely only cause slight to moderate damage to well-built structures. To ensure that structures are well built relative to earthquake ground shaking, all new structures should be designed and built in accordance with the seismic provisions in the IBC and *International Residential Code* (IRC; International Code Council, 2000b), as appropriate. For the site classes anticipated in the Moab-Spanish Valley area, most construction will likely fall under IBC Seismic Design Category B, although some construction on sandstone bedrock may fall under Seismic Design Category A, and some critical facilities may fall under Seismic Design Category C.

The closest major fault with possible activity during Quaternary time is the Moab fault, exposed at the northern end of Moab-Spanish Valley (plate 4). Prior to detailed geologic mapping by H.H. Doelling and colleagues at the Utah Geological Survey, the northern trace of the fault was depicted as splitting at the northwestern end of the valley and then extending along both the northeastern and southwestern valley margins (for example, Hecker, 1993). The new mapping shows that the Moab fault trends down the middle of the valley, and is concealed beneath unfaulted Quaternary valley-fill deposits (Doelling and others, 2002). Surface rupture along the fault is possible, but in Moab-Spanish Valley where the fault is buried by Quaternary deposits, the likely location of such a rupture is difficult to predict. No evidence has been

Table 1. *Probabilistic ground-motion values (in g) generally applicable to rock sites near Moab, Utah.*

	10% PE in 50 yr	**5% PE in 50 yr**	**2% PE in 50 yr**
PGA	0.05	0.07	0.11
0.2 sec SA	0.10	0.15	0.24
0.3 sec SA	0.08	0.12	0.18
1.0 sec SA	0.03	0.04	0.06

Abbreviations: PE, probability of exceedance; PGA, peak ground acceleration; SA, spectral acceleration; sec, second; yr, years.

Ground-motion values determined from national seismic-hazard maps (Frankel and others, 1996) using latitude/longitude computations available online at <geohazards.cr.usgs.gov/eq/index.html>, and representing general values for ground shaking on rock (IBC site class B) at latitude 38 35′ N., longitude 109 32′30″ W. Ground motions at any specific site will vary from these values because of site-specific rock and soil conditions. Values for use in design must be derived from IBC seismic-hazard maps and corrected for geologic site conditions (site class) as required in the IBC seismic provisions.

found to indicate that late Quaternary valley-fill deposits have been cut by the fault. Also, geomorphic relations along the fault indicate very low rates of activity, and bedrock-scarp retreat rates indicate the fault has not moved significantly for at least 1.2 million years (Olig and others, 1996). Therefore, the surface-fault-rupture hazard along the Moab fault during an earthquake appears to be low. The hazard associated with ground shaking produced by movement on the Moab fault is also low. Subsurface and map data (Woodward-Clyde Consultants, 1986; Morgan, 1993; Cooksley Geophysics, 1995; Woodward-Clyde Federal Services, 1996; Doelling and others, 2002) indicate the fault soles into salt deposits at a relatively shallow depth, and therefore is not capable of producing significant earthquakes (Olig and others, 1996; Woodward-Clyde Federal Services, 1996).

Other faults in Moab-Spanish Valley active during Quaternary time are faults in the valley-margin deformation belts. These faults formed as a result of structural collapse in response to dissolution of salt in the diapir beneath Moab-Spanish Valley (Doelling and others, 2002). Although collapse of Moab-Spanish Valley occurred mostly in Quaternary time (Doelling and others, 2002), no evidence exists for significant displacements along the valley-margin faults in late Quaternary time. Therefore, the surface-fault-rupture hazard along these faults during an earthquake appears to be low. Also, the valley-margin faults likely sole into salt deposits at a shallow depth and, like the Moab fault, are not considered capable of producing significant earthquakes.

Areas having shallow ground water (plate 3) and sandy soils are most susceptible to liquefaction during strong earthquake ground shaking. However, liquefaction potential is low even in these susceptible areas in Moab-Spanish Valley because of the low probability of occurrence of earthquakes large enough to cause liquefaction (about M 5; Kuribayashi and Tatsuoka, 1975; Youd, 1977). Woodward-Clyde Federal Services (1996) evaluated an extreme scenario to determine liquefaction potential at the uranium mill tailings site at the northwestern end of the valley, involving the simultaneous occurrence of shallow ground water associated with incipient flooding of the Colorado River and a M 5.5 earthquake. Although liquefaction is predicted under this scenario, the combined probability of incipient flooding and the earthquake is one in 1,250,000 (Woodward-Clyde Federal Services, 1996).

Earthquakes can trigger translational or rotational landslides, but these types of landslides generally are triggered by earthquakes of about magnitude 4.5-5.0 or greater (Keefer, 1984). Because earthquakes in the area typically have magnitudes less than this (see discussion above), the likelihood of earthquake-induced landsliding is low. Earthquake-triggered rock falls are more likely, and would be in the areas shown on plate 3 and discussed above under Rock Fall.

Subsidence

Ultimately, the existence of Moab-Spanish Valley is attributed to dissolution of salt in the salt diapir that underlies the valley by ground water moving from the La Sal Mountains toward the Colorado River. As the salt has dissolved, the overlying rock has collapsed or subsided, creating the valley. Much of the faulting and other deformation in the valley-margin deformation belts formed as a result of salt dissolution and associated subsidence (Doelling and others, 2002).

Several lines of geologic and geomorphic evidence point to broad subsidence of Moab-Spanish Valley during late Quaternary time. Harden and others (1985) attribute the downstream convergence of Pleistocene terraces along Mill Creek, and burial of Pleistocene terraces along Pack Creek, to aggrading conditions in a subsiding basin. Doelling and others (2002) arrived at the same conclusion to explain the disappearance of Mill Creek terraces in Moab Valley. Significant thicknesses of Quaternary basin fill suggest late Quaternary subsidence; Harden and others (1985) report Quaternary deposits greater than 200 feet (61 m) thick in parts of the Moab-Spanish Valley, and Doelling and others (2002) estimate that Quaternary basin fill in the northwestern part of the valley may exceed a thickness of 450 feet (137 m). Finally, the existence of the broad, low-lying Moab Slough area adjacent to the channel of the Colorado River, an unusual occurrence on the Colorado Plateau where erosion and channel incision predominate, indicates recent subsidence and sediment deposition in the northern part of the valley (Harden and others, 1985).

Evidence exists for localized collapse in bedrock along the northeastern margin of Moab-Spanish Valley. Weir and others (1994) identified 33 breccia pipes in Navajo Sandstone within the present study area, and Doelling (2000) identified a similar "collapse feature" in the Entrada Sandstone near the main entrance to Arches National Park. These generally oval-shaped pipes of angular rock fragments have diameters ranging from about 100 to 1,500 feet (30-450 m) and have dropped downward from 30 to over 1,400 feet (10-440 m) (Weir and others, 1994). Although the origin of the breccia pipes remains uncertain, Weir and others (1994) hypothesize that they resulted from continuous collapse of rock caused by dissolution of deeply buried salt and limestone by ground water heated by igneous intrusions of the La Sal Mountains.

Woodward-Clyde Federal Services (1996) estimated Quaternary subsidence rates at the northwestern end of Moab-Spanish Valley of 0.08 to 0.2 millimeters per year (3-8 in/1,000 yr) based on thicknesses of basin-fill sediments, and late Pleistocene rates of 0.4 to 1 millimeter per year (16-40 in/1,000 yr) based on stream incision rates, stratigraphic correlation, and soil development. Woodward-Clyde Federal Services (1996) acknowledge that the estimated subsidence rates, in particular the late Pleistocene rates, are conservative (high) due to poor constraints on ages of deposits and incision rates.

Subsidence due to dissolution of salt at depth appears to be an ongoing process in Moab-Spanish Valley that needs further evaluation. Faults mapped within the valley-margin deformation belts lack evidence demonstrating late Quaternary movement, so the hazard from surface faulting in these areas appears to be low. However, continued subsidence could affect development in a number of ways, including tilting or damage to structures due to differential settlement, lateral earth pressures, ground cracks or displacements in fractured rock, or ground collapse (sinkhole formation). In general, subsidence due to salt dissolution beneath Moab-Spanish Valley is likely characterized by small, incremental displacements over a broad area (Woodward-Clyde Federal Services, 1996), and so the overall hazard is probably low. Also,

the absence of sinkholes in Moab-Spanish Valley indicates that the hazard associated with local subsidence or collapse related to underground solution cavities is also low.

Landslides

Geologic evidence shows that, under natural conditions, slopes in the Moab-Spanish Valley area are generally not susceptible to landsliding characterized by deep-seated, rotational or translational movement of soil or rock masses. Only one such landslide deposit is mapped in the study area, a mass of Moab Member of the Curtis Formation on the north side of U.S. Highway 191 near Arches National Park (figure 11); Doelling and others (2002) believe this landslide moved during late or latest middle Pleistocene time. Some of the faults in cliffs along the southern margin of the valley may represent scarps of large-scale late Pleistocene landslides, but strong evidence to support this hypothesis is lacking.

We consider landsliding (exclusive of rock falls and debris flows; see discussions above) to be unlikely under present conditions unless water is introduced or slopes are altered. Landslides would be most likely in highly fractured rock, in the Paradox Formation cap rock, and in clay-rich strata of the Chinle and Kayenta Formations where they locally dip toward valleys or canyons, particularly where these units are exposed in the valley-margin deformation belts (Doelling and others, 2002).

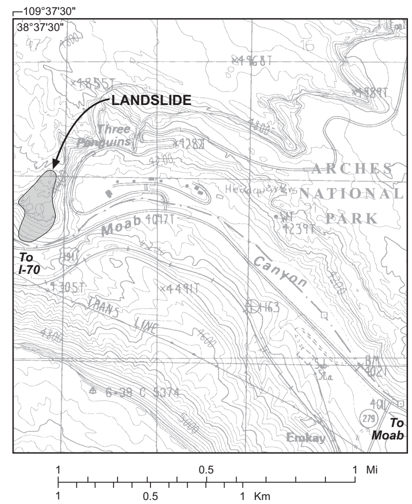

Figure 11. The only landslide deposit mapped in the study area is a mass of Moab Member of the Curtis Formation on the north side of U.S. Hwy. 191 near Arches National Park, in the extreme northwest corner of the study area (modified from Doelling and others, 2002). This landslide moved probably during late or latest middle Pleistocene time.

Design and construction of new development on hillsides should take into account the potential effects of the proposed development on slope stability, such as removing material in cut slopes, adding material by placing fill, and raising local ground-water levels through landscape irrigation or the use of septic-tank soil-absorption systems. Hillside development must adhere to standards set forth in city and county codes and ordinances; where grading or hillside-development permits are required or where construction limitations may apply (generally on slopes greater than 15 percent in the city of Moab, and greater than 30 percent in Grand County), pre-development studies should include geologic and geotechnical evaluations of slope stability and the potential for landsliding following the guidelines presented in Hylland (1996).

Indoor Radon

Radon is an odorless, tasteless, colorless, naturally occurring radioactive gas produced from the radioactive decay of uranium. Uranium, and thus radon, is found in almost all rock and soil in very small concentrations. Because radon is an inert gas, it is very mobile. It can move with air or can be dissolved in water and travel through openings in soil and rock. When present near the ground surface or beneath well-drained, porous, and permeable soil, radon gas can migrate into buildings. Certain types of water usage (such as showering) can release radon gas from well water into the air where it can be inhaled. When inhaled over a long period of time, radon decay products are a significant cause of lung cancer.

Granite, metamorphic rocks, black shales, and some volcanic rocks may be enriched in uranium; these rocks, and the soils derived from them, are the most common sources of radon gas (Sprinkel and Solomon, 1990). Other sources of radon are uranium mines and tailings from uranium mills. In the Moab-Spanish Valley area, uranium occurrences have been documented in mines and prospects in the Honaker Trail, Cutler, and Chinle Formations (Black, 1993; Doelling and others, 2002), and therefore these geologic units are potential radon sources. Also, the Moenkopi Formation has documented uranium occurrences elsewhere in Utah (Black, 1993), and the intrusive igneous rocks of the La Sal Mountains contain uranium (data in Nelson and Davidson, 1998). Streams draining the La Sal Mountains (Mill and Pack Creeks) and areas to the northwest (Courthouse Wash) transport sediment derived from these source rocks into Moab-Spanish Valley, and much of the valley floor is covered by these alluvial deposits.

Near-surface geologic conditions affect the ability of radon to migrate upward from source rocks to the ground surface. For example, most of the alluvium from Mill and Pack Creeks is coarse grained (boulders, cobbles, gravel, and sand), and radon moves readily to the surface in such permeable deposits. However, shallow ground water traps radon and can reduce radon emissions to the ground surface; areas of shallow ground water (<10 feet [3 m]) cover much of Moab-Spanish Valley (plate 3). Faults and zones of highly fractured rock, such as the valley-margin deformation belts, act as pathways for the movement of radon gas. A statewide evaluation of geologic factors that influence indoor-radon levels found the Moab-Spanish Valley area to have a low to moderate radon-hazard potential (Black, 1993).

In addition to geologic conditions, other factors affect indoor-radon concentrations, including the type of structure, methods of construction, and occupant lifestyle. The greatest radon concentrations are commonly in basements and crawl spaces where radon can enter from surrounding soil. Cracks in foundations, leaky seals around pipes that pass through foundations, floor drains, and the water supply are the most common pathways for radon to enter a home.

With the trend toward more energy-efficient construction, newer buildings generally have less air circulation than older buildings and may trap radon gas that enters the structure. However, less radon will be trapped if windows are frequently open. Older buildings may be draftier and allow radon gas to escape more easily than newer buildings, but may also allow more radon to continuously enter through foundation cracks and poorly sealed basements.

Radon concentration is measured in picocuries per liter of air (pCi/L). Most buildings in the United States contain small amounts of radon; however, these concentrations are typically less than 3 pCi/L (Nero and others, 1986). The average indoor-radon concentration is about 1 pCi/L (Sextro, 1988). Long-term exposure to these levels is considered a low health risk to the general population; higher concentrations pose greater risk. The U.S. Environmental Protection Agency (EPA) has established an action level of 4 pCi/L; if short-term (less than 90 days) testing indicates radon levels in excess of 4 pCi/L, follow-up testing should be conducted and remedial measures undertaken as appropriate. A 1988 statewide indoor-radon survey by the Utah Bureau of Radiation Control reported two test results from the Moab area that were 0.7 and 5.6 pCi/L (Sprinkel and Solomon, 1990); the specific locations of these tests are unknown (Barry Solomon, UGS, verbal communication, 2003). More recent unpublished test results on file with the Utah Division of Radiation Control indicate generally low levels of indoor radon in the Moab-Spanish Valley area. Out of 18 long-term (greater than 90 days) tests, only one documented a radon level above 4 pCi/L; a test result of 4.4 pCi/L was obtained from a house in the southwestern part of Moab, in an area underlain by Pack Creek alluvium.

Homeowners should consider testing for indoor-radon concentrations, particularly if the residents are smokers (radioactive isotopes formed from radon decay attach to smoke particles which are then inhaled and increase the risk of lung cancer). Short-term (20-30 days) radon test kits are readily available from most home-improvement stores. For the most accurate assessment of long-term radon exposure, a year-long test should be conducted. One-year test kits are not readily available, but a list of vendors certified to sell them can be obtained from the Utah Division of Radiation Control in Salt Lake City (appendix B). The longer test periods are the most diagnostic of the long-term indoor-radon exposure level because changes in atmospheric pressure, temperature, and moisture can affect radon concentrations.

High indoor-radon levels can be reduced by a variety of methods. Short-term measures with minimum expense include discouraging smoking indoors and spending less time in areas with high radon concentrations such as basements. Increasing ventilation by opening windows or turning on fans may also reduce radon concentrations. Long-term measures include sealing openings in the foundation to prevent radon entry, and ventilating the structure to remove radon-contaminated indoor air and venting it outdoors. Sub-slab suction is a soil ventilation method that can be very effective in removing radon from soil gas before it enters a structure. The sub-slab suction method uses pipes inserted through the floor slab into a layer of crushed rock between the foundation and soil. A fan removes radon-contaminated soil gas from beneath the slab and forces it into the pipes, which release the radon outdoors (U.S. EPA, 1992).

If tests in existing buildings indicate areas of high indoor-radon concentration (greater than 4 piC/L), the reason for the high concentrations should be evaluated. Depending on these results, builders of new homes in those areas should consider incorporating radon-resistant design following the guidelines given in appendix F of the IRC (International Code Council, 2000b). Similar to methods used to retrofit existing buildings, such designs may (1) prevent radon from entering structures by sealing cracks and openings around pipes penetrating the basement floor and walls, and (2) intercept the radon before it enters the house by using sub-slab ventilation (Osborne, 1988). Detailed descriptions of these construction methods are available from the U.S. Environmental Protection Agency.

USES OF THE HAZARD MAPS IN LAND-USE PLANNING

Plates 1 through 4 can be used in a variety of ways by homeowners and other residents, developers, and local governments. The maps can be used as general information to show what hazards may occur and where. In this way, homeowners and residents can assess their exposure to hazards and take whatever action they deem appropriate. The maps may be used in real-estate disclosure so that sellers of homes in hazard areas can disclose to buyers the possible existence of hazards. Also, local governments may use the maps to show where site-specific hazard studies are needed prior to development.

Plates 1 and 2 depict some of the non-life-threatening, soil-related hazards and may be used to alert developers and home builders of potential problems. Hazard studies are most effective when conducted prior to construction to define hazards and guide appropriate design of structures and landscapes. Maps depicting life-threatening hazards (plates 2, 3, and 4) may be used for emergency-response planning, or more comprehensive land-use planning to protect life safety and reduce damages. All of the maps may be adopted in local-government ordinances to show areas where site-specific investigations addressing the particular hazard are required prior to development. These site-specific studies should, in addition to evaluating the hazards, include recommendations for hazard-reduction measures. To be effective, such ordinances must stipulate that the studies be prepared by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) and be reviewed by qualified professionals acting on behalf of government.

Because of the relatively small scale of the maps, some small hazard areas may not be shown. We therefore recommend complete hazard studies even outside the mapped hazard areas for all critical facilities (category II and III structures as defined in the IBC, table 1604.5, p. 297 [International Code Council, 2000a], including hospitals, schools, fire stations, high-occupancy buildings, water-treatment facilities, and facilities containing hazardous materials [IBC class E, H, and I structures]).

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GLOSSARY

Alluvial fan – A generally low, cone-shaped deposit formed by deposition from a stream issuing from mountains as it flows onto a lowland.

Alluvial-fan flooding – Flooding and sediment deposition, including debris flows, on an alluvial-fan surface by overland (sheet) flow or flow in channels branching outward from a canyon mouth. See also *alluvial fan*, *debris flow*.

Alluvium – General term for unconsolidated sediments (clay, sand, gravel) deposited by a stream.

Aquifer – A permeable body of rock or sediment that conducts ground water and can yield significant quantities of water to wells and springs.

Bedding – The arrangement of a sedimentary rock in beds or layers of varying thickness and character.

Breccia pipe – A cylindrical chimney filled with coarse, angular rock fragments held together by a mineral cement or in a fine-grained matrix; may be formed by collapse of rock material.

Cap rock – An impervious concentration of evaporite minerals and other rocks that overlies a buried salt body.

Collapsible soil – Soil that has considerable strength in its dry, natural state but that settles significantly due to hydrocompaction when wetted. Typically associated with geologically young alluvial fans, debris-flow deposits, and loess.

Colluvium – General term applied to any loose, unconsolidated mass of soil material, usually at the foot of a slope or cliff, and brought there chiefly by gravity.

Colorado Plateau physiographic province – Area of generally flat-lying sedimentary rocks in plateaus, mesas, and canyons in southeastern Utah and parts of Arizona, Colorado, and New Mexico.

Debris flow – Slurry of rock, soil, organic matter, and water that flows down channels and onto alluvial fans.

Diapir – Dome or anticlinal (arch-shaped) fold containing a core of salt or shale, where the overlying rocks have been ruptured by the squeezing-out of the plastic core material.

Dip – The angle that a bedding plane makes with the horizontal.

Dissolution – The conversion of rock from solid to liquid state.

Earthquake – Sudden motion or trembling in the Earth's crust as stored elastic energy is released by fracture and movement of rocks along a fault.

Eolian – Pertaining to erosion and deposition accomplished by the wind, and the geologic features formed by wind action.

Erosion – Removal and transport of soil or rock from a land surface, usually through chemical or mechanical means.

Evaporite – A mineral or rock (halite and gypsum, for example) formed by precipitation from a saline solution, typically by evaporation but also by other mechanisms.

Expansive soil/rock – Soil or rock that swells when wetted and contracts when dried. Associated with high clay content, particularly sodium-rich clay.

Fault – A break in the Earth's crust along which movement occurs.

Flood plain – An area adjoining a body of water or natural stream that has been or may be covered by floodwater.

Formation (geologic) – A rock unit consisting of distinctive features/rock types that distinguish it from units above and below.

Gabion – A container of corrosion-resistant wire that holds coarse rock aggregate, and is used to reduce erosion or improve slope stability.

Ground shaking – The shaking or vibration of the ground during an earthquake.

Gypsiferous soil – Soil containing appreciable amounts of gypsum. Gypsiferous soil is subject to subsidence and collapse due to dissolution of the gypsum.

Gypsum – Common evaporite mineral composed of hydrated calcium sulfate.

Hydrocompaction – See Collapsible soil.

Landslide – General term referring to any type of slope failure, but usage here refers chiefly to large-scale rotational slumps and slow-moving earth flows.

Liquefaction – Sudden large decrease in shear strength of a saturated cohesionless soil (generally sand or silt) caused by collapse of soil structure and temporary increase in pore water pressure during earthquake ground shaking. Liquefaction may induce ground failure, including lateral spreads and flow-type landslides.

Loess – A fine-grained blanket deposit of wind-blown (eolian) silt with minor clay and fine sand.

Permeability – Capacity of a porous rock or soil for transmitting a fluid.

Picocurie – Unit of measure of radioactivity. Picocuries per liter (pCi/L) is a common unit used to measure the concentration of radon in air.

Piping – Subsurface erosion by movement of ground water forming a void or "pipe."

Radon – Radioactive gas that occurs naturally through the decay of uranium.

Riprap – A layer of large fragments of broken rock used to prevent erosion by waves or currents.

Rock fall – The relatively free falling or precipitous movement of a rock from a slope by rolling, falling, toppling, or bouncing. The rock-fall runout zone is the area below a rock-fall source which is at risk from falling rocks.

Scarp – A steep slope or face breaking the general continuity of the land by separating surfaces lying at different levels (for example, where there is vertical movement along a fault, or at the head of a landslide).

Subsidence – Permanent lowering of the normal level of the ground surface by any of a number of processes, including dissolution of buried salt.

Surface faulting (surface fault rupture) – Propagation of an earthquake-generating fault rupture to the ground surface, displacing the surface and forming a scarp.

Talus – Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep, rocky slope.

Weathering – A group of processes involving physical disintegration and chemical decomposition that breaks down rock and produces soil.

APPENDIX A

GEOLOGIC TIME SCALE

(after Palmer and Geissman, 1999)

Subdivisions of Geologic Time			Apparent Ages (millions of years before present)
Era	Period	Epoch	
CENOZOIC	Quaternary	(Recent) Holocene	0.01
		Pleistocene	1.8
	Tertiary	Pliocene	5
		Miocene	24
		Oligocene	34
		Eocene	55
		Paleocene	65
MESOZOIC	Cretaceous		144
	Jurassic		206
	Triassic		248
PALEOZOIC	Cretaceous		290
	Pennsylvanian (Upper Carboniferous)		323
	Mississippian (Lower Carboniferous)		354
	Devonian		417
	Silurian		443
	Ordovician		490
	Cambrian		543
Precambrian			

APPENDIX B

AGENCIES PROVIDING INFORMATION ON GEOLOGIC HAZARDS AND RELATED ISSUES

LOCAL

City of Moab Planning Department
115 West 200 South
Moab, Utah 84532
(435) 259-5129
moabcity.org

Information on planning, zoning, and community development issues.

City of Moab and Grand County Building Department
125 East Center Street
Moab, Utah 84532
(435) 259-1343
grandcountyutah.net

Information on current county development and building regulations.

STATE

Utah Department of Health
Southeastern Utah District Health Department
28 South 100 East
P.O. Box 800
Price, Utah 84501
(435) 637-3671
hlunix.hl.state.ut.us/lhd/html/southeastern_utah_district_hea.html

Information on current Health Department regulations concerning wastewater disposal and systems.

Utah Division of Emergency Services and Homeland Security
Rm. 1110, State Office Bldg.
Salt Lake City, Utah 84114
(801) 538-3400
des.utah.gov

Information concerning emergency response, preparedness, and mitigation. Source of information on FEMA National Flood Insurance Program.

Utah Division of Radiation Control
168 North 1950 West
Building #2, Room 212
P.O. Box 144850
Salt Lake City, Utah 84114-4850
(801) 536-4250
www.deq.state.ut.us/EQRAD/drc_hmpg.htm

Information on indoor-radon testing and mitigation.

Utah Division of Water Rights
1594 W. North Temple Suite 220
P.O. Box 146300
Salt Lake City, Utah 84114-6300
(801) 538-7240
waterrights.utah.gov

Regulations concerning appropriation and distribution of water in the state of Utah. Technical publications concerning local and regional water resources. Publications contain information on water source, amount, and quality in Utah.

Utah Geological Survey
1594 W. North Temple, Suite 3110
P.O. Box 146100
Salt Lake City, Utah 84114-6100
(801) 537-3300
geology.utah.gov

Geologic information concerning geologic hazards, ground water, geologic mapping, fossils, and economic geology. Geologic Hazards Program conducts local and regional geologic-hazards studies. Topographic and geologic maps, and publications on geologic hazards and other geology topics available through the Natural Resources Map and Bookstore; (801) 537-3320, 1-888-UTAH MAP, mapstore.utah.gov.

FEDERAL

U.S. Bureau of Land Management
Moab District Office
82 East Dogwood
Moab, Utah 84532
(435) 259-2100
blm.gov/nhp

Ownership and management of federal lands; knowledge of geology, water resources, and vegetation on lands under their jurisdiction.

U.S. Environmental Protection Agency – Region 8
Mail Code (8P-AR)
999 18th Street, Suite 300
Denver, Colorado 80202-2466
(303) 312-6031; 1-800-227-8917
www.epa.gov/region08/air/iaq/radon/radon.html

General information on indoor radon and testing for indoor-radon levels.

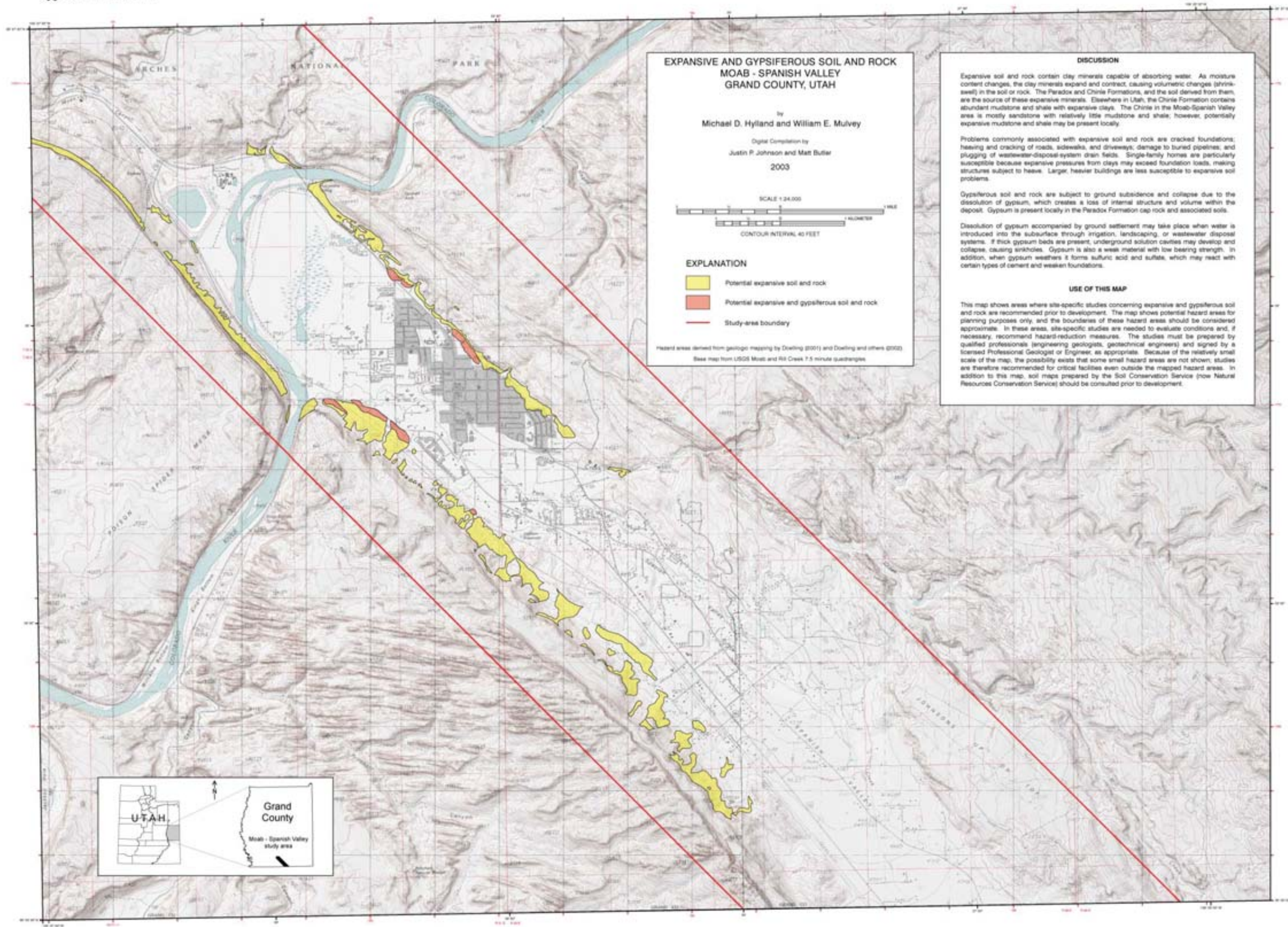
U.S. Geological Survey
Salt Lake Information Office
2329 W. Orton Circle
West Valley City, Utah 84119
(801) 908-5000
usgs.gov
ut.water.usgs.gov

General geologic information, data on surface and ground water, and USGS publications available.

U.S. Natural Resources Conservation Service (formerly Soil Conservation Service)
Price Service Center
350 North 400 East
Price, Utah 84501
(435) 637-0041
nrcs.usda.gov

Regional and local soil surveys. Surveys contain information on soil type, description, engineering properties, and agricultural uses.

PLATE 1
SPECIAL STUDY 107
UTAH GEOLOGICAL SURVEY



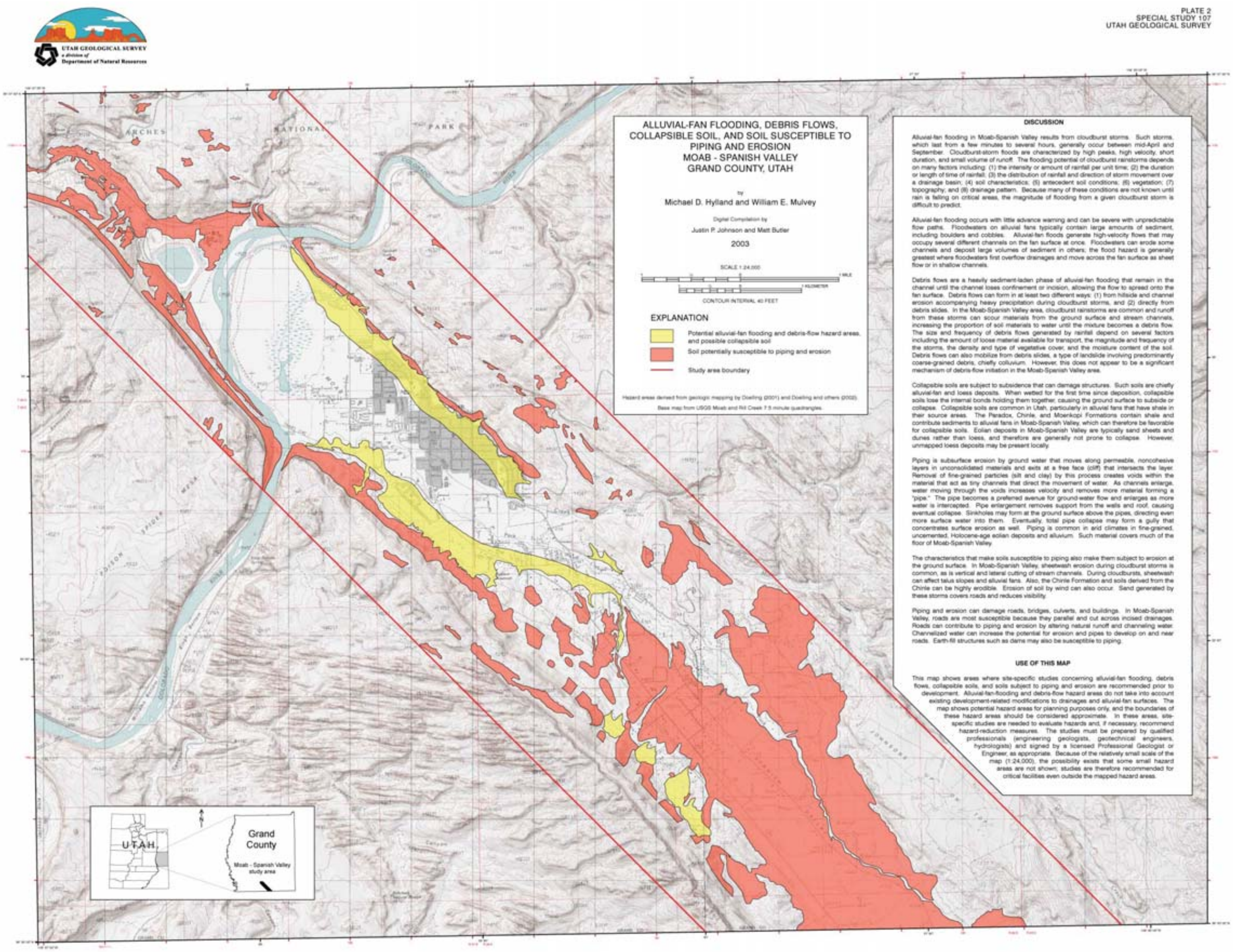
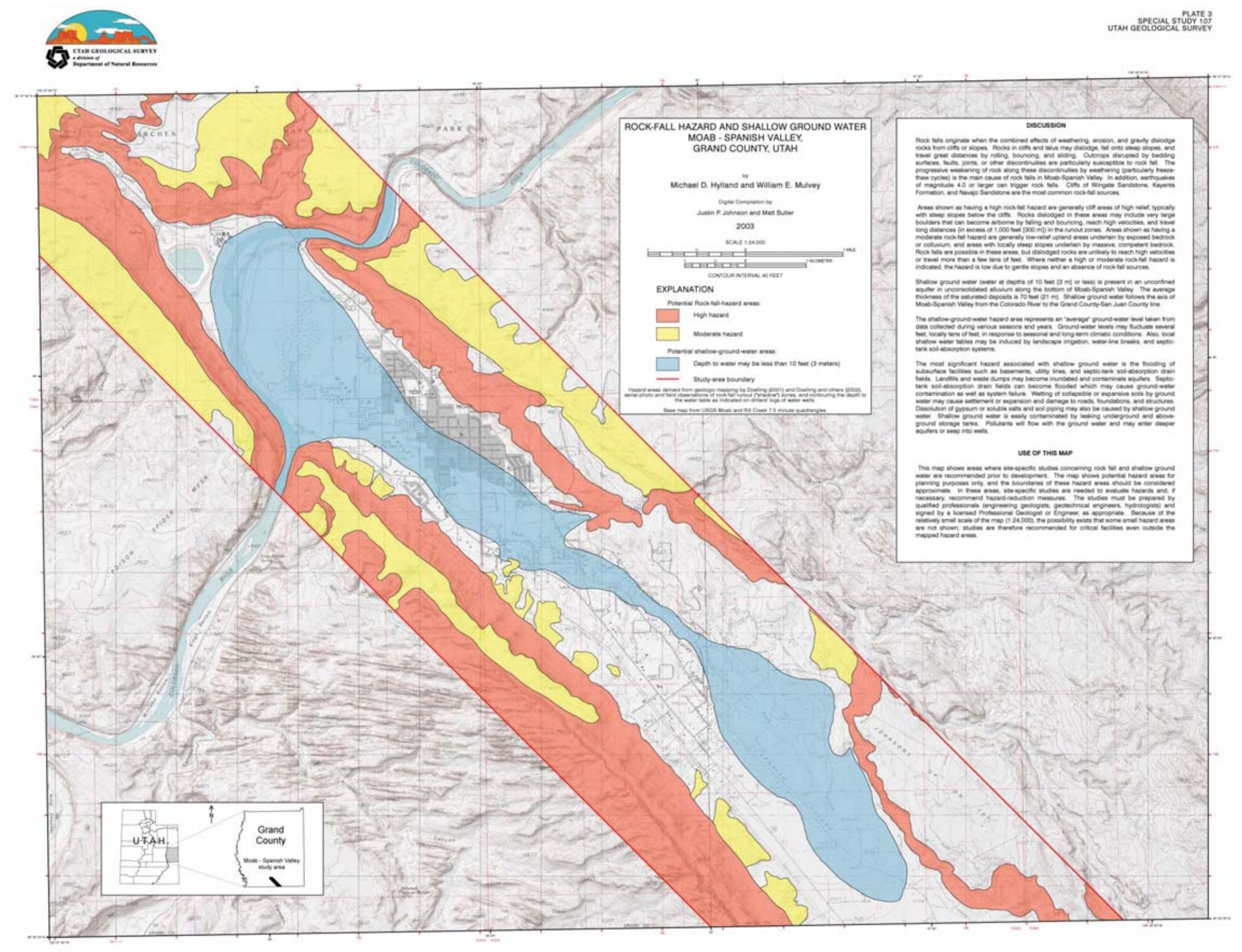
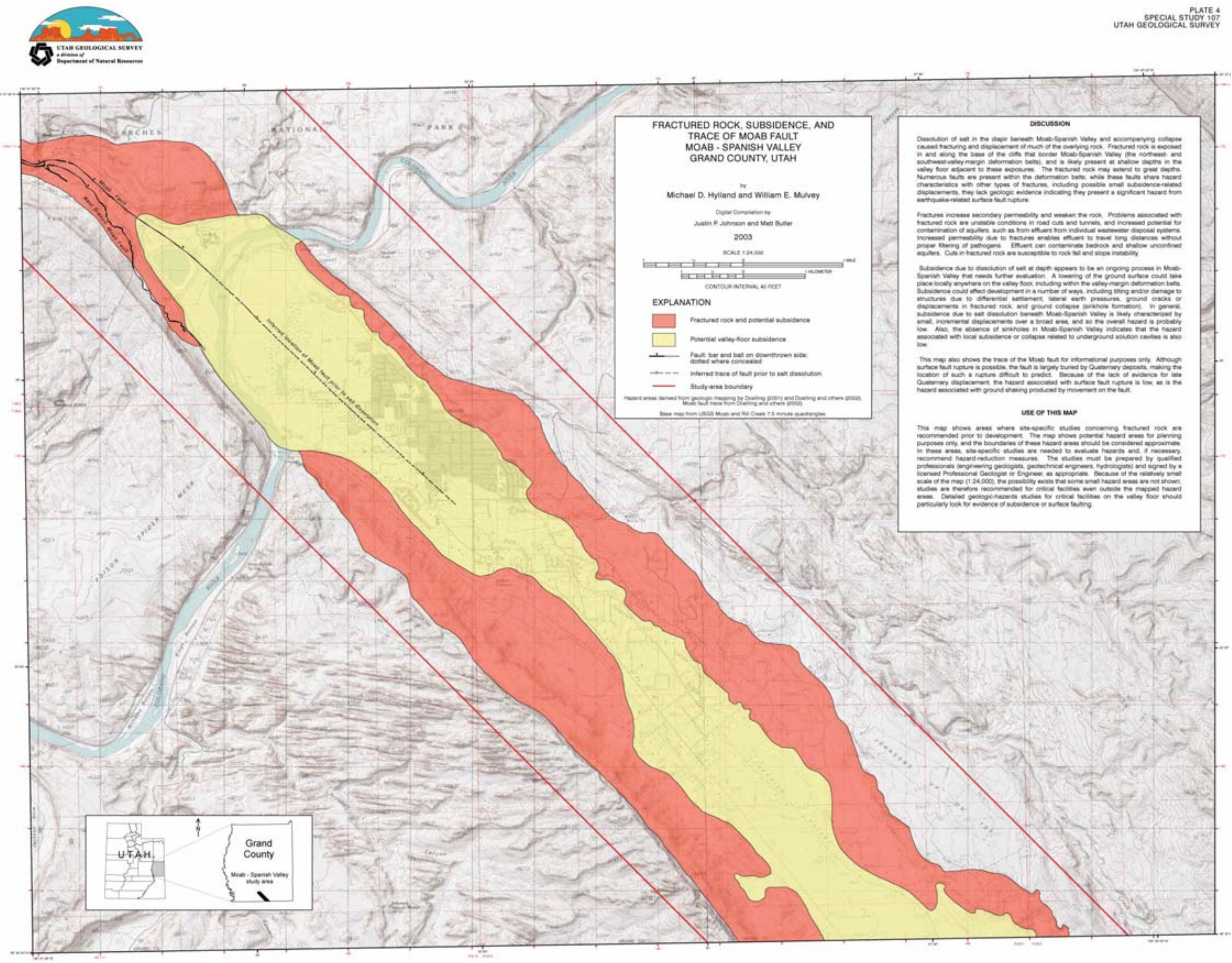


PLATE 2
SPECIAL STUDY 107
UTAH GEOLOGICAL SURVEY
UTAH GEOLOGICAL SURVEY
a division of
Department of Natural Resources
ALLUVIAL-FAN FLOODING, DEBRIS FLOWS, COLLAPSIBLE SOIL, AND SOIL SUSCEPTIBLE TO PIPING AND EROSION
MOAB - SPANISH VALLEY
GRAND COUNTY, UTAH
by
Michael D. Hylland and William E. Mulvey
Digital Compilation by
Justin P. Johnson and Matt Butler
2003
SCALE 1:24,000
CONTOUR INTERVAL 40 FEET
EXPLANATION
Potential alluvial-fan flooding and debris-flow hazard areas, and possible collapsible soil
Soil potentially susceptible to piping and erosion
Study area boundary
Hazard areas derived from geologic mapping by Doelling (2001) and Doelling and others (2002).
Base map from USGS Moab and Rill Creek 7.5 minute quadrangles.
DISCUSSION
Alluvial-fan flooding in Moab-Spanish Valley results from cloudburst storms. Such storms, which last from a few minutes to several hours, generally occur between mid-April and September. Cloudburst-storm floods are characterized by high peaks, high velocity, short duration, and small volume of runoff. The flooding potential of cloudburst rainstorms depends on many factors including: (1) the intensity or amount of rainfall per unit time; (2) the duration or length of time of rainfall; (3) the distribution of rainfall and direction of storm movement over a drainage basin; (4) soil characteristics; (5) antecedent soil conditions; (6) vegetation; (7) topography; and (8) drainage pattern. Because many of these conditions are not known until rain is falling on critical areas, the magnitude of flooding from a given cloudburst storm is difficult to predict.
Alluvial-fan flooding occurs with little advance warning and can be severe with unpredictable flow paths. Floodwaters on alluvial fans typically contain large amounts of sediment, including boulders and cobbles. Alluvial-fan floods generate high-velocity flows that may occupy several different channels on the fan surface at once. Floodwaters can erode some channels and deposit large volumes of sediment in others; the flood hazard is generally greatest where floodwaters first overflow drainages and move across the fan surface as sheet flow or in shallow channels.
Debris flows are a heavily sediment-laden phase of alluvial-fan flooding that remain in the channel until the channel loses confinement or incision, allowing the flow to spread onto the fan surface. Debris flows can form in at least two different ways: (1) from hillside and channel erosion accompanying heavy precipitation during cloudburst storms, and (2) directly from debris slides. In the Moab-Spanish Valley area, cloudburst rainstorms are common and runoff from these storms can scour materials from the ground surface and stream channels, increasing the proportion of soil materials to water until the mixture becomes a debris flow. The size and frequency of debris flows generated by rainfall depend on several factors including the amount of loose material available for transport, the magnitude and frequency of the storms, the density and type of vegetative cover, and the moisture content of the soil. Debris flows can also mobilize from debris slides, a type of landslide involving predominantly coarse-grained debris, chiefly colluvium. However, this does not appear to be a significant mechanism of debris-flow initiation in the Moab-Spanish Valley area.
Collapsible soils are subject to subsidence that can damage structures. Such soils are chiefly alluvial-fan and loess deposits. When wetted for the first time since deposition, collapsible soils lose the internal bonds holding them together, causing the ground surface to subside or collapse. Collapsible soils are common in Utah, particularly in alluvial fans that have shale in their source areas. The Paradox, Chinle, and Moenkopi Formations contain shale and contribute sediments to alluvial fans in Moab-Spanish Valley, which can therefore be favorable for collapsible soils. Eolian deposits in Moab-Spanish Valley are typically sand sheets and dunes rather than loess, and therefore are generally not prone to collapse. However, unmapped loess deposits may be present locally.
Piping is subsurface erosion by ground water that moves along permeable, noncohesive layers in unconsolidated materials and exits at a free face (cliff) that intersects the layer. Removal of fine-grained particles (silt and clay) by this process creates voids within the material that act as tiny channels that direct the movement of water. As channels enlarge, water moving through the voids increases velocity and removes more material forming a "pipe." The pipe becomes a preferred avenue for ground-water flow and enlarges as more water is intercepted. Pipe enlargement removes support from the walls and roof, causing eventual collapse. Sinkholes may form at the ground surface above the pipes, directing even more surface water into them. Eventually, total pipe collapse may form a gully that concentrates surface erosion as well. Piping is common in arid climates in fine-grained, uncemented, Holocene-age eolian deposits and alluvium. Such material covers much of the floor of Moab-Spanish Valley.
The characteristics that make soils susceptible to piping also make them subject to erosion at the ground surface. In Moab-Spanish Valley, sheetwash erosion during cloudburst storms is common, as is vertical and lateral cutting of stream channels. During cloudbursts, sheetwash can affect talus slopes and alluvial fans. Also, the Chinle Formation and soils derived from the Chinle can be highly erodible. Erosion of soil by wind can also occur. Sand generated by these storms covers roads and reduces visibility.
Piping and erosion can damage roads, bridges, culverts, and buildings. In Moab-Spanish Valley, roads are most susceptible because they parallel and cut across incised drainages. Roads can contribute to piping and erosion by altering natural runoff and channeling water. Channelized water can increase the potential for erosion and pipes to develop on and near roads. Earth-fill structures such as dams may also be susceptible to piping.
USE OF THIS MAP
This map shows areas where site-specific studies concerning alluvial-fan flooding, debris flows, collapsible soils, and soils subject to piping and erosion are recommended prior to development. Alluvial-fan-flooding and debris-flow hazard areas do not take into account existing development-related modifications to drainages and alluvial-fan surfaces. The map shows potential hazard areas for planning purposes only, and the boundaries of these hazard areas should be considered approximate. In these areas, site-specific studies are needed to evaluate hazards and, if necessary, recommend hazard-reduction measures. The studies must be prepared by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) and signed by a licensed Professional Geologist or Engineer, as appropriate. Because of the relatively small scale of the map (1:24,000), the possibility exists that some small hazard areas are not shown; studies are therefore recommended for critical facilities even outside the mapped hazard areas.
ARCHES
NATIONAL
PARK
UTAH
Grand
County
Moab - Spanish Valley study area



UTAH GEOLOGICAL SURVEY
a division of
Department of Natural Resources
PLATE 3
SPECIAL STUDY 107
UTAH GEOLOGICAL SURVEY
ROCK-FALL HAZARD AND SHALLOW GROUND WATER
MOAB - SPANISH VALLEY,
GRAND COUNTY, UTAH
by
Michael D. Hylland and William E. Mulvey
Digital Compilation by
Justin P. Johnson and Matt Butler
2003
SCALE 1:24,000
CONTOUR INTERVAL 40 FEET
EXPLANATION
Potential Rock-fall-hazard areas:
High hazard
Moderate hazard
Potential shallow-ground-water areas:
Depth to water may be less than 10 feet (3 meters)
Study-area boundary
Hazard areas derived from geologic mapping by Doelling (2001) and Doelling and others (2002), aerial-photo and field observations of rock-fall runout ("shadow") zones, and contouring the depth to the water table as indicated on drillers' logs of water wells.
Base map from USGS Moab and Rill Creek 7.5 minute quadrangles.
DISCUSSION
Rock falls originate when the combined effects of weathering, erosion, and gravity dislodge rocks from cliffs or slopes. Rocks in cliffs and talus may dislodge, fall onto steep slopes, and travel great distances by rolling, bouncing, and sliding. Outcrops disrupted by bedding surfaces, faults, joints, or other discontinuities are particularly susceptible to rock fall. The progressive weakening of rock along these discontinuities by weathering (particularly freeze-thaw cycles) is the main cause of rock falls in Moab-Spanish Valley. In addition, earthquakes of magnitude 4.0 or larger can trigger rock falls. Cliffs of Wingate Sandstone, Kayenta Formation, and Navajo Sandstone are the most common rock-fall sources.
Areas shown as having a high rock-fall hazard are generally cliff areas of high relief, typically with steep slopes below the cliffs. Rocks dislodged in these areas may include very large boulders that can become airborne by falling and bouncing, reach high velocities, and travel long distances (in excess of 1,000 feet [300 m]) in the runout zones. Areas shown as having a moderate rock-fall hazard are generally low-relief upland areas underlain by exposed bedrock or colluvium, and areas with locally steep slopes underlain by massive, competent bedrock. Rock falls are possible in these areas, but dislodged rocks are unlikely to reach high velocities or travel more than a few tens of feet. Where neither a high or moderate rock-fall hazard is indicated, the hazard is low due to gentle slopes and an absence of rock-fall sources.
Shallow ground water (water at depths of 10 feet [3 m] or less) is present in an unconfined aquifer in unconsolidated alluvium along the bottom of Moab-Spanish Valley. The average thickness of the saturated deposits is 70 feet (21 m). Shallow ground water follows the axis of Moab-Spanish Valley from the Colorado River to the Grand County-San Juan County line.
The shallow-ground-water hazard area represents an "average" ground-water level taken from data collected during various seasons and years. Ground-water levels may fluctuate several feet, locally tens of feet, in response to seasonal and long-term climatic conditions. Also, local shallow water tables may be induced by landscape irrigation, water-line breaks, and septic-tank soil-absorption systems.
The most significant hazard associated with shallow ground water is the flooding of subsurface facilities such as basements, utility lines, and septic-tank soil-absorption drain fields. Landfills and waste dumps may become inundated and contaminate aquifers. Septic-tank soil-absorption drain fields can become flooded which may cause ground-water contamination as well as system failure. Wetting of collapsible or expansive soils by ground water may cause settlement or expansion and damage to roads, foundations, and structures. Dissolution of gypsum or soluble salts and soil piping may also be caused by shallow ground water. Shallow ground water is easily contaminated by leaking underground and above-ground storage tanks. Pollutants will flow with the ground water and may enter deeper aquifers or seep into wells.
USE OF THIS MAP
This map shows areas where site-specific studies concerning rock fall and shallow ground water are recommended prior to development. The map shows potential hazard areas for planning purposes only, and the boundaries of these hazard areas should be considered approximate. In these areas, site-specific studies are needed to evaluate hazards and, if necessary, recommend hazard-reduction measures. The studies must be prepared by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) and signed by a licensed Professional Geologist or Engineer, as appropriate. Because of the relatively small scale of the map (1:24,000), the possibility exists that some small hazard areas are not shown; studies are therefore recommended for critical facilities even outside the mapped hazard areas.
UTAH
Grand County
Moab - Spanish Valley study area



UTAH GEOLOGICAL SURVEY
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Department of Natural Resources
PLATE 4
SPECIAL STUDY 107
UTAH GEOLOGICAL SURVEY
FRACTURED ROCK, SUBSIDENCE, AND
TRACE OF MOAB FAULT
MOAB - SPANISH VALLEY
GRAND COUNTY, UTAH
by
Michael D. Hylland and William E. Mulvey
Digital Compilation by
Justin P. Johnson and Matt Butler
2003
SCALE 1:24,000
1 MILE
1 KILOMETER
CONTOUR INTERVAL 40 FEET
EXPLANATION
Fractured rock and potential subsidence
Potential valley-floor subsidence
Fault: bar and ball on downthrown side; dotted where concealed
Inferred trace of fault prior to salt dissolution
Study-area boundary
Hazard areas derived from geologic mapping by Doelling (2001) and Doelling and others (2002). Moab fault trace from Doelling and others (2002).
Base map from USGS Moab and Rill Creek 7.5 minute quadrangles.
DISCUSSION
Dissolution of salt in the diapir beneath Moab-Spanish Valley and accompanying collapse caused fracturing and displacement of much of the overlying rock. Fractured rock is exposed in and along the base of the cliffs that border Moab-Spanish Valley (the northeast- and southwest-valley-margin deformation belts), and is likely present at shallow depths in the valley floor adjacent to these exposures. The fractured rock may extend to great depths. Numerous faults are present within the deformation belts; while these faults share hazard characteristics with other types of fractures, including possible small subsidence-related displacements, they lack geologic evidence indicating they present a significant hazard from earthquake-related surface fault rupture.
Fractures increase secondary permeability and weaken the rock. Problems associated with fractured rock are unstable conditions in road cuts and tunnels, and increased potential for contamination of aquifers, such as from effluent from individual wastewater disposal systems. Increased permeability due to fractures enables effluent to travel long distances without proper filtering of pathogens. Effluent can contaminate bedrock and shallow unconfined aquifers. Cuts in fractured rock are susceptible to rock fall and slope instability.
Subsidence due to dissolution of salt at depth appears to be an ongoing process in Moab-Spanish Valley that needs further evaluation. A lowering of the ground surface could take place locally anywhere on the valley floor, including within the valley-margin deformation belts. Subsidence could affect development in a number of ways, including tilting and/or damage to structures due to differential settlement, lateral earth pressures, ground cracks or displacements in fractured rock, and ground collapse (sinkhole formation). In general, subsidence due to salt dissolution beneath Moab-Spanish Valley is likely characterized by small, incremental displacements over a broad area, and so the overall hazard is probably low. Also, the absence of sinkholes in Moab-Spanish Valley indicates that the hazard associated with local subsidence or collapse related to underground solution cavities is also low.
This map also shows the trace of the Moab fault for informational purposes only. Although surface fault rupture is possible, the fault is largely buried by Quaternary deposits, making the location of such a rupture difficult to predict. Because of the lack of evidence for late Quaternary displacement, the hazard associated with surface fault rupture is low, as is the hazard associated with ground shaking produced by movement on the fault.
USE OF THIS MAP
This map shows areas where site-specific studies concerning fractured rock are recommended prior to development. The map shows potential hazard areas for planning purposes only, and the boundaries of these hazard areas should be considered approximate. In these areas, site-specific studies are needed to evaluate hazards and, if necessary, recommend hazard-reduction measures. The studies must be prepared by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) and signed by a licensed Professional Geologist or Engineer, as appropriate. Because of the relatively small scale of the map (1:24,000), the possibility exists that some small hazard areas are not shown; studies are therefore recommended for critical facilities even outside the mapped hazard areas. Detailed geologic-hazards studies for critical facilities on the valley floor should particularly look for evidence of subsidence or surface faulting.
UTAH
Grand County
Moab - Spanish Valley study area
N
ARCHES
NATIONAL
PARK

State of Utah

Department of Community and Economic Development
Division of State History
Utah State Historical Society

Michael O. Leavitt, Governor
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300 Rio Grande
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(801) 533-3500 FAX: 533-3503 TDD: 533-3502
ushs@history.state.ut.us http://history.utah.org

March 25, 1999

Kenneth L. Wintch, Staff Archaeologist
Utah School and Institutional State Trust
Lands Administration
675 East 500 South, Suite 500
Salt Lake City UT 84102

RE: USU/CEU Moab Branch Campus Development Parcel, Grand County

In Reply Please Refer to Case No. 99-0314

Dear Kenny:

The Utah State Historic Preservation Office received the above referenced report on March 3, 1999. After consideration of the report, the USHPO concurs with the determination that sites; [42GR 2916-19 and 2930] are not eligible for the National Register of Historic Places. We, therefore, also concur with the TLA's determination of **No Historic Property**.

This information is provided on request to assist Trust Lands with its state law responsibilities as specified in U.A.C. 9-8-404. If you have questions, please contact me at (801) 533-3555. My email address is: jdykman@state.ut.us

As ever,

James L. Dykmann
Compliance Archaeologist

JLD:99-0314 Lands/NPx5/NEx5

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Preserving and Sharing Utah's Past for the Present and Future

State of Utah

School and Institutional
TRUST LANDS ADMINISTRATION

Michael O. Leavitt, Governor
David T. Terry, Director

675 East 500 South, Suite 500
Salt Lake City, Utah 84102-2818
801-538-5100
801-355-0922 (Fax)
http://www.trustlands.com

March 1, 1999

Mr. James L. Dykmann,
Compliance Archaeologist
State Historic Preservation Office
300 Rio Grande
Salt Lake City, Utah 84101

RE: USU/CEU Moab Branch Campus Development Parcel, Grand County
(No SHPO case no. as yet); finding of ***No Historic Properties***

Dear Jim:

This letter is in regard to the subject action by the School and Institutional Trust Lands Administration, in compliance with accordance with *U.C.A.* 9-8-404 and *U.A.C. R850-60*. The subject action is a proposed development of 375.5 acres of trust land located on the south side of Moab in southern Grand County. Please note the attached report (Wolfe and Montgomery 1999) and IMACS site forms for newly-recorded sites 42Gr2916 through Gr2920 with attached SHPO Cover Page. Please be aware that I am submitting these data both on behalf of Montgomery Archaeological Consultants (in fulfillment of their permit responsibility) and to aid in consultation with your office regarding this case. Please respond to my attention at your convenience.

The subject project is depicted in Figure 1 of the attached report, and described elsewhere in that report. All five of the sites they identified (and recorded for the first time) have been recommended to me as *not eligible* for the National Register, and I concur. Accordingly, the School and Institutional Trust Lands Administration has determined that archaeological sites 42Gr2916, 2917, 2918, 2919 and 2930 are *not eligible*; further, this agency finds that since no other potential historic properties are located in the subject project's area of potential effects, that the proposed university branch campus development will effect ***No Historic Properties.*** Please concur at your earliest convenience. Thanks very much in advance for your time in reviewing this matter. Please contact me at 538-5168 should you need additional information or assistance regarding this case.

Sincerely,

Kenneth L. Wintch
Staff Archaeologist

Attachments

CULTURAL RESOURCE INVENTORY OF THE USU/CEU
MOAB BRANCH CAMPUS DEVELOPMENT PARCEL
GRAND COUNTY, UTAH

by

Michael S. Wolfe
and
Keith Montgomery

Prepared For:

State of Utah
School and Institutional
Trust Lands Administration

Prepared By:

Montgomery Archaeological Consultants
P.O. Box 147
Moab, Utah 84532

February 4, 1999

United States Department of Interior (FLPMA)
Permit No. 98-UT-60122

State of Utah Antiquities Project (Survey)
Permit No. U-99-MQ-0035s

ABSTRACT

A cultural resource inventory was conducted in January, 1999, for the USU/CEU Moab Branch Development Parcel located south of the town of Moab, Grand County, Utah. The archaeological survey was carried out by Montgomery Archaeological Consultants for the State of Utah School and Institutional Trust Lands Administration (TLA). The inventory parcel consists of approximately 375.5 acres. The legal description is Township 26 South, Range 22 East, Sections 17 and 18.

The inventory resulted in the documentation of five new archaeological sites (42Gr2916 to 42Gr2920), and 6 isolated finds of artifacts (IF-A through IF-F). All the prehistoric sites are limited activity lithic scatters of unknown temporal affiliations. These four sites are considered not eligible for consideration to the NRHP. Sites 42Gr2916 and 42Gr2918 are situated on a narrow bench along steep northeast facing colluvial slopes associated with large boulders. Both of these sites are lithic reduction stations lacking cultural deposits in the shallow boulder alcoves. However, the sites have been visited during modern times, evidenced by small enclosures of dry-laid walls and historic graffiti. The other two lithic scatters (42Gr2919 and 2920) are situated at the base of the colluvial slopes on shallow residual and eolian terraces. These sites also contain limited cultural materials (e.g. lithic reduction stations), lacking potential for buried diagnostic artifacts or features. The recordation of these sites have exhausted their research potential. These prehistoric cultural resources are not unique to the area and are found throughout the valley, representing short-term lithic reduction stations by mainly hunter-gathering groups.

Site 42Gr2917 is a historic temporary camp probably related to early 20th century ranging activities in Grand County. The site consists of a tent platform (level area with rock alignment) and a small scatter. Based on the historic items, the occupation dates between 1911 and 1914. The site occurs on a residual/colluvium bench and lacks potential for additional features or buried cultural remains. It is assessed as not eligible to the NRHP due to its lack of additional research potential which would contribute important information to the historic themes of the area.

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INTRODUCTION

A cultural resource inventory was conducted in January, 1999, for the USU/CEU Moab Branch Development Parcel located south of the town of Moab, Grand County, Utah. The archaeological survey was carried out by Montgomery Archaeological Consultants for the State of Utah School and Institutional Trust Lands Administration (TLA).

The objective of the inventory was to locate, document, and evaluate any cultural resources and paleontological localities within the project area. The inventory was implemented in accord with various historic preservation laws and regulations, including the National Historic Preservation Act of 1966 (as amended), the Archaeological Resource Preservation Act of 1974, the Archaeological Resources Protection Act of 1979 (as amended), the American Indian Religious Freedom Act of 1978, and the Utah State Antiquities Act of 1973 (amended 1990).

The fieldwork was performed by Keith R. Montgomery, Michael "Red" Wolfe, Joe Pachak and Mark Beeson from January 25, 1999, through January 28,1999, under the auspices of U.S.D.I. (FLPMA) Permit No. 98-UT-60122 and State of Utah Antiquities Project (Survey) No. U-99-MQ-0035s, issued to Montgomery Archaeological Consultants, Moab, Utah.

Prior to the survey, a records search for previous projects and documented cultural resources was completed by Chris Horting (TLA Archaeologist) on January 6, 1999, at the Division of State History. File searches were also performed by Michael "Red" Wolfe on January 26, and February 3,1999, at the BLM Grand Resource Area Office (Moab District). These record consultations indicate that numerous inventories have been completed in the vicinity of the project area, although only four surveys have occurred in the immediate project area. In T 26S, R 22E, S. 17 and 18, three projects have been completed. In 1980 a survey for MAPCO's Rocky Mountain Liquid Hydrocarbon Pipeline was completed by Woodward-Clyde Consultants (Schroedl 1980). In 1987, an inventory was performed by Abajo Archaeology for the Utah Department of Transportation US 191 right-of-way project (Westfall 1987). In 1995, an inventory was performed for an expansion of a wastewater collection system in Spanish Valley (DeFrancia 1995). In 1998, Alpine Archaeology inventoried Mid-American Pipeline Company's Rocky Mountain Expansion pipeline right-of-way (Horn et al. 1998). No archaeological sites have been documented in the immediate project area as a result of these inventories.

Also a paleontological file search was completed by Martha Hayden at the Utah Geological Survey on February 1, 1999. Known fossils in the area include petrified wood from the Chinle Formation (T26S, R22E, S.17 SE, SW) and mollusk fossils from the same geologic formation (T22S, R22E, S.18 SW, NW, NW). These fossil localities are considered not significant.

DESCRIPTION OF PROJECT AREA

The project area is located just south of the town of Moab, Grand County, Utah (Figure 1). The inventory parcel consists of approximately 375.5 acres. The legal description is Township 26 South, Range 22 East, Section 17: 34, 35, 36, tracts A, B; and Section 18: lots 5 (NW1/4 SE1/4), 6 (NE1/4 SE1/4), SE1/4 SE1/4, S1/2 NE1/4, SE1/4 NW1/4).

In general, the inventory area is situated in the Salt Anticline of the Paradox Basin of the northern Colorado Plateau (Stokes 1986). Specifically, it is located along the west side of Spanish Valley, a long northwest-southeast trending valley formed by the structural collapse of underlying salt domes. The project area lies primarily along the base of the northwest-southeast trending cliffs which form the southeast walls of the valley. These cliffs are formed by the Triassic age Navajo Sandstone, Kayenta Sandstone, Wingate Sandstone, and Chinle Formation Most of the project area consists of a relatively active transport slope scattered with numerous small to medium sandstone boulders, and dissected by a few entrenched intermittent drainages. Lower down, as one moves away from the bottom of the steep slopes, pockets of residual and aeolian soil are found. Pack Creek is the primary watercourse in the area and carries runoff from the La Sal Mountains down to Spanish Valley, merging with Mill Creek at the town of Moab, thereafter flowing into the Colorado River.

The elevation of the project area ranges from 4280 to 5200 feet although the majority of the survey area lies below 4600 feet. The project area occurs within the Upper Sonoran Lifezone, dominated by a blackbrush and sagebrush-juniper vegetation community. Associated plant taxa include sand sagebrush, shadscale, rabbitbrush, Russian thistle, winterfat, Indian ricegrass, broom snakeweed, Mormon tea, narrowleaf yucca, prickly pear cactus as well as other low, hearty, desert shrub plants. Historic impact, sheep overgrazing in particular, has altered most of the native rangeland, resulting in the secondary appearance of cheatgrass brome, which now dominates most of the area. Modern impacts to the landscape include US-191, roads, fence lines, and two buried pipelines.

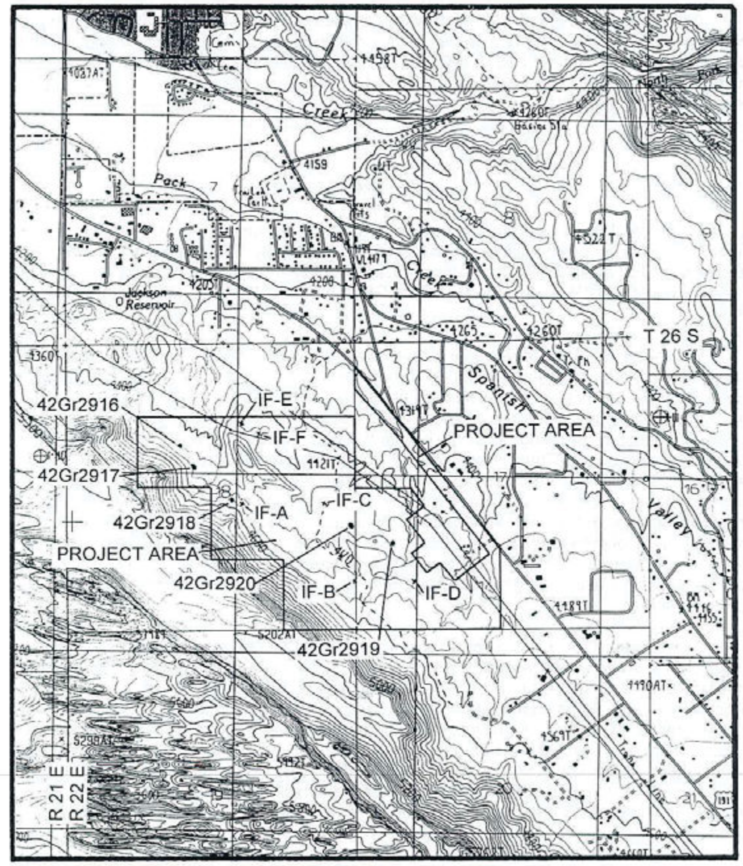

Figure 1. Moab Branch Campus Development Inventory Area Showing Cultural Resources, Grand County, Utah. USGS 7.5' Moab, UT 1985. Scale 1:24000.

Cultural-Historical Overview

Various cultural overviews have been presented for the study area, including a recent Class I study providing information on the Grand Resource Area (Horn, Reed, and Chandler 1994). The cultural-chronological stages presented for this area consist of the Paleoindian, Archaic, Anasazi, Numic, and Euro-American stages. The earliest inhabitants of the region were representative of the Paleoindian stage (ca. 12,000-8,000 B.P.). This prehistoric stage represents an adaptation to terminal Pleistocene environments, characterized by the exploitation of big game fauna. In northern San Juan County, both Folsom and Clovis peoples have been identified primarily by occasional fluted points recovered by local collectors (Copeland and Fike 1988). In the 1950s, the "Moab Complex" was coined by Alice Hunt, based on the discovery of diagnostic Paleoindian points and tool assemblages found in an area extending from between the Green and Colorado Rivers to the south slope of the La Sal Mountains (Pierson 1981:28). Paleoindian points have also been documented to the south in Lisbon Valley (Black et al. 1982; Davis and Westfall 1990). Elsewhere, several early Paleoindian open campsites containing Clovis or Folsom assemblages have been investigated along the terraces of the Green River and San Juan River, probable migratory corridors for late Pleistocene fauna (Davis 1985; Davis and Brown 1986).

The Archaic stage (ca. 8,000 B.P.-1,500 B.P.) is characterized by peoples depending on a foraging subsistence strategy incorporating a wide spectrum of faunal and floral resources. The various artifact assemblages identified in the area indicate cultural and technological similarities, and relationships with various cultural units including the northern Colorado Plateau Archaic, La Sal Complex, Uncompahgre Complex, and Oshara Tradition (Horn, Reed, and Chandler 1994). Adaptive strategies of Archaic peoples in the area include exploitation of desert grassland and wooded upland resources, and increased spatial and seasonal variability of key resources. This was accomplished through the development of transhumance patterns keyed to the availability of targeted natural resources. Archaic sites which have been documented in the area occur in a variety of topographic settings including mesa tops, spur ridges, creek terraces, and canyon edges (Fetterman and Honeycutt 1983:68). They are represented by lithic reduction stations with evidence of tool manufacture, tool use, and vegetal processing. Rock shelters with Archaic cultural deposits have been identified in the side canyons of Mill and Kane Creeks indicative of semi-permanent camps. Only a limited number of presumably Archaic component sites have been tested in the area. Along the east bank of Mill Creek several shelters, Moonshine Cave, Sheep Camp, and Cist Cave were tested by Pendergast (1961) who found a split-twig figurine fragment in Moonshine Cave. Similar figures have been analyzed in the Green River area where they are associated with the late Archaic period, as well as at Cowboy Cave where they date around 3500 B.P. (Jennings 1980:94). Sites attributed to the Late Archaic or Basketmaker II periods in the area include the Orchard Pithouse site within the Moab city limits (Louthan 1990), and an isolated burden basket found along the rim of the Spanish Valley (Howard 1990).

The adoption and eventual intensification of agriculture, along with population increase and the formation of settled villages, are important processes which characterize the transition from the Archaic to the Formative stage. The introduction of the bow and arrow and pottery also accompany this change in lifeways. This fundamental shift from a hunting and gathering lifeway to one based on agriculture is manifested on the Colorado Plateau by the Anasazi and Fremont cultural groups. The Moab area appears to represent a hinterland of the Northern San Juan Anasazi and Fremont cultural spheres although the archaeological data is far from comprehensive in delineating the geographical and temporal range of Formative groups in the study area, or the ways traditions influenced or blended with one another. In southeastern Utah, the Anasazi tradition dates between approximately 500 BC and A.D. 1300, divided into the Basketmaker II, Basketmaker III, Pueblo I, Pueblo II, and Pueblo III periods (Horn, Chandler, and Reed 1994). The majority of sites yielding Anasazi ceramics in the area consist of artifact scatters lacking associated architecture. The absence of key elements of the Anasazi tradition in the study area has been recognized for some time. Pierson (1981), for example, writing about Formative stage sites in the Moab area, accounted for the degree of archaeological variation by defining a cultural unit termed the La Sal Mountain Anasazi, a regional variant of the Anasazi tradition. The Gateway Tradition (500 B.C. and A.D. 1250) has been defined by Reed (1984) in the area charactered by such traits as: limited reliance upon corn horticulture; procurement through trade of small quantities of Anasazi, and much less frequently, Fremont ceramics; apparent lack of ceramic production; possible habitation of pitstructures, at least late in the tradition; construction of granaries and storage cists in rockshelter; and rock art with both Anasazi and Fremont influence.

The Protohistoric/Historic Aboriginal stage is represented by the incursion of Numic speaking groups (Ute and Paiute), who were essentially seminomadic hunter and gatherers adapted to a lifeway of transhumance. Archaeological evidence indicates that the Utes appeared in east-central Utah at approximately A.D. 1100 or shortly thereafter (Horn, Reed, and Chandler 1994:130). The archaeological remains of the Numic-speaking Ute consist primarily of lithic scatters with low quantities of crude brownware ceramics, rock art, and occasional wickiups. Diagnostic artifacts found on Protohistoric sites in the area include Desert side-notched, Cottonwood triangular, and small corner-notched arrow points, and possibly Shoshonean knives. According to early Spanish chronicles, the Utes (some with horses) were reported in the region in the early 1600s and Escalante encountered Tabeguache Utes along the Dolores River east of the La Sal Mountains in the 1770's. Although the early Utes were primarily hunter and gatherers, there are accounts of agriculture in the Moab area shortly before their removal to the reservation in 1881 (Tanner 1976:19). Historical accounts by the Elk Mountain missionaries in 1855 report that Utes living in Spanish Valley were engaged in flood water farming, raising crops of corn, squash, and beans (Tanner 1976:54). In the 1880s, Utes in Utah and Colorado were forcibly relocated to the Uintah Reservation (White River band), and to the Ouray Reservation (Uncompahgre band).

In 1855, Mormon settlers established the Elk Mountain Mission in northern Spanish Valley and were met with Ute hostility resulting in abandonment of the fort and retreat to Salt Lake City (Tanner 1976). The area was resettled in the 1870s when the cattle outfits, succeeded by farmers, established small home sites throughout the region. The next important economic development followed the discovery of various minerals. Gold mines were active for a short time in the La Sal Mountains in the 1880s. During the 1930s, a series of Civilian Conservation Corps (CCC) camps of young men from various areas of the United states were established in the Moab area. Camps were established in Dry Valley, Dalton Well, and Indian Creek with temporary camps located near the work sites (Pierson 1981). Projects of the CCC included bridge construction and erosion control which are still evident throughout the region. The more important boom to the area was the uranium boom which began in the late 1940s. Numerous mines opened in the Moab area and the population increased dramatically.

SURVEY METHODOLOGY

An intensive pedestrian survey was performed for this project, which is considered 100% coverage. Pedestrian transects were made by crew members spaced no more than 10 meters apart. Along the cliffs and steep slopes binoculars were employed to inspect for rock art and other cultural resources. At total of 375.5 acres was inventoried, all located on property under the jurisdiction of State of Utah, Trust Lands Administration.

Cultural resources were recorded as either an archaeological site or isolated find of artifact. Archaeological sites were defined as spatially definable areas with features and/or ten or more artifacts. Sites were documented by the archaeologists walking transects across the site, spaced no more than 3 meters apart, and marking the locations of cultural materials with pinflags. This procedure allowed clear definition of site boundaries and artifact concentrations. At the completion of the surface inspection, a Brunton compass mounted on a tripod was employed to point-provenience diagnostic artifacts and other relevant features in reference to the site datum. Site datums consisting of a rebar with an aluminum cap stamped with the temporary site number were placed at the newly-found sites. Archaeological sites were plotted on a 7.5' USGS quadrangle, and photographed with site data entered on an Intermountain Antiquities Computer System (IMACS, 1990 version) inventory form (Appendix A). Isolated finds are defined as individual artifacts or light scatter of items, which lack sufficient material culture to warrant IMACS forms, or to derive interpretation of human behavior in a cultural and temporal context. All isolated artifacts were plotted on a 7.5' USGS map and described in this report.

INVENTORY RESULTS

The inventory of the CEU/CSU Moab Branch Campus Development Parcel resulted in the documentation of five new archaeological sites (42Gr2916 to 42Gr2920). Four of these are prehistoric sites (42Gr2916, 42Gr2918, 42Gr2919 and 42Gr2920), and one is a historic site (42Gr2917). In addition, six isolated finds of artifacts (IF-A through IF-F) were documented. No paleontological sites were found during the inventory.

Archaeological Sites

Smithsonian Site No.: 42Gr2916
Temporary Site No.: 35 RW-1
Legal Description: T26S, R22E, S. 18
NRHP Eligibility: Not Eligible
Description: This site is a sparse lithic scatter associated with a large boulder, situated on a relatively steep slope on the west side of Spanish Valley (Figure 1). The site occurs within a blackbrush community, and measures 29 NE-SW by 23 m NW-SE (Figure 2). The cultural materials consist of approximately 6 pieces of chert debitage and a prepared quartzite core. No features or cultural fill was observed in the interior of the shallow boulders.

There are two recently constructed (modern) dry-laid single course sandstone walls inside the boulders which enclose a 3 by 3 meter space, approximately 1 meter high. The informal walls consist of 30 untrimmed sandstone rocks of varying sizes. Also some potting has occurred inside this boulder evidenced by a 60 by 60 cm vandal hole. Modern graffiti (pecking) occurs on the south side and inside the boulder. The site lacks potential for subsurface features and cultural materials.

Smithsonian Site No.: 42Gr2917
Temporary Site No.: 35 RW-2
Legal Description: T26S, R22E, S. 18
NRHP Eligibility: Not Eligible
Description: This is a temporary camp most likely related to the early 1900s cattle/sheep industry in Grand County. The site is situated on a narrow bench along the west side of Spanish Valley (Figure 1). It measures about 27 meters north-south by 14 meters east-west (Figure 3). The historic artifacts occur mainly in the center of the site and include early sanitary milk cans (1911-1915), a green beverage base manufactured by Owens Bottle Company (1911-1929), sanitary food cans, a flat-sided tobacco can, and clear glass fragments. Located on the south end of the site is evidence of a prepared tent platform with rock alignments and rock tent supports. The site lies on residual rock soil with no potential for additional features or buried cultural materials.

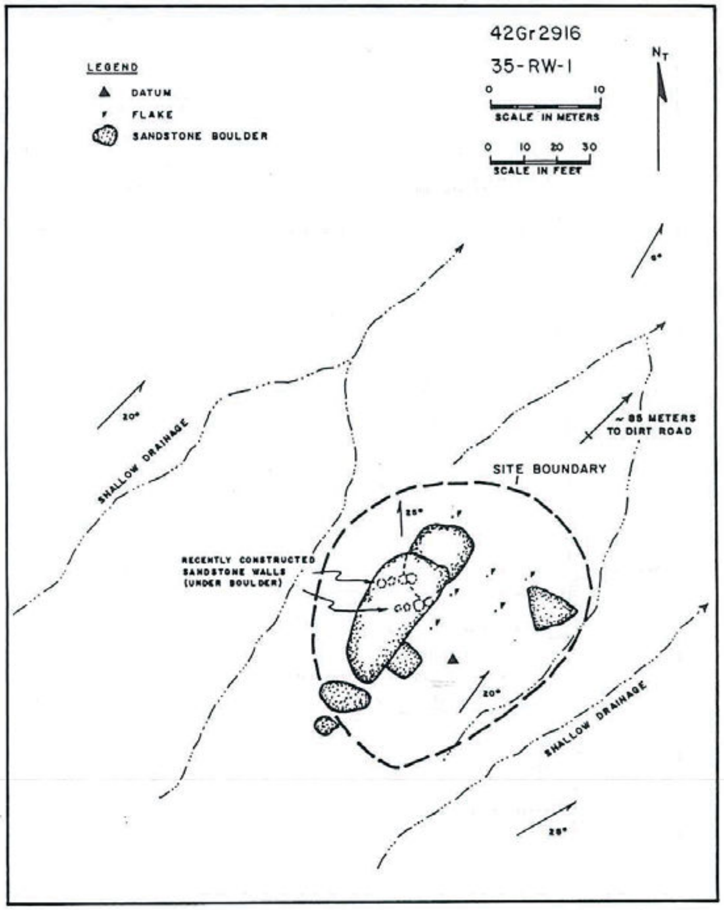

Figure 2. Site 42Gr2916.

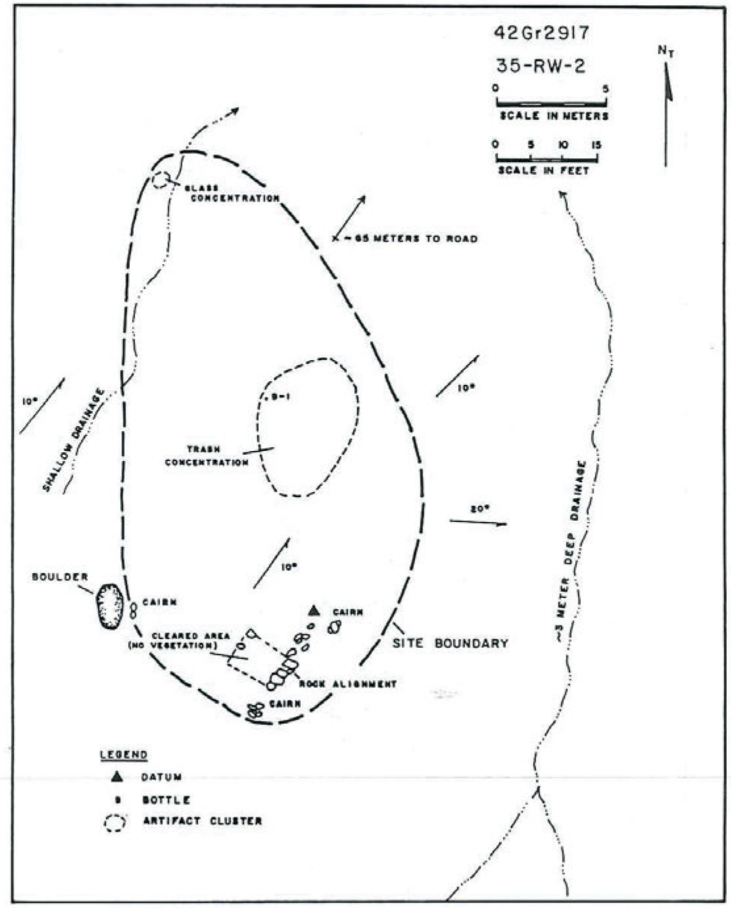

Figure 3. Site 42Gr2917.

Smithsonian Site No.: 42Gr2918
Temporary Site No.: 35 RW-3
Legal Description: T26S, R22E, S. 18.
NRHP Eligibility: Not Eligible

Description: This is a low density dispersed lithic scatter of unknown temporal affiliation. The site is situated around several large boulders on a small colluvial bench along the southwest edge of Spanish Valley (Figure 1). The site measures approximately 36 meters east-west by 27 meters north-south (Figure 4). The cultural material occurs adjacent to one boulder and in along the top of the slope on the north side of the site. Cultural materials consist of 41 flakes and a mano fragment. No features or cultural fill was observed around or inside of the shallow boulders.

There are two modern dry-laid single course sandstone walls constructed between two of the boulders. Overall, the site has been disturbed by vandals and erosion, lacking potential for additional prehistoric diagnostic artifacts or cultural remains.

Smithsonian Site No.: 42Gr2919
Temporary Site No.: 35 RW-4
Legal Description: T26S, R22E, S. 17
NRHP Eligibility: Not Eligible

Description: This is a low density lithic scatter of unknown temporal affiliation situated on a shallow aeolian bench along the west side of Spanish Valley (Figure 1). The artifacts occur within a 36 meters north-south by 24 meters east-west area (Figure 5). The cultural materials include approximately 22 chalcedony flakes of mainly secondary reduction. The only diagnostic artifact is a prepared core. No temporally diagnostic tools or features were found. The site represents a limited activity lithic reduction locality.

Smithsonian Site No.: 42Gr2920
Temporary Site No.: 35 RW-5
Legal Description: T26S, R22E, S. 18
NRHP Eligibility: Not Eligible

Description: This is a low density lithic scatter of unknown temporal affiliation situated in a flat shallow sandy area (Figure 1). The site measures approximately 70 meters northwest-southeast by 34 meters northeast-southwest (Figure 6). The cultural materials include approximately 32 mainly secondary chalcedony and chert flakes, concentrated in the southeast portion of the site. Diagnostic artifacts consist of a sandstone metate fragment and a utilized flake. The site lacks cultural features or potential for buried cultural remains.

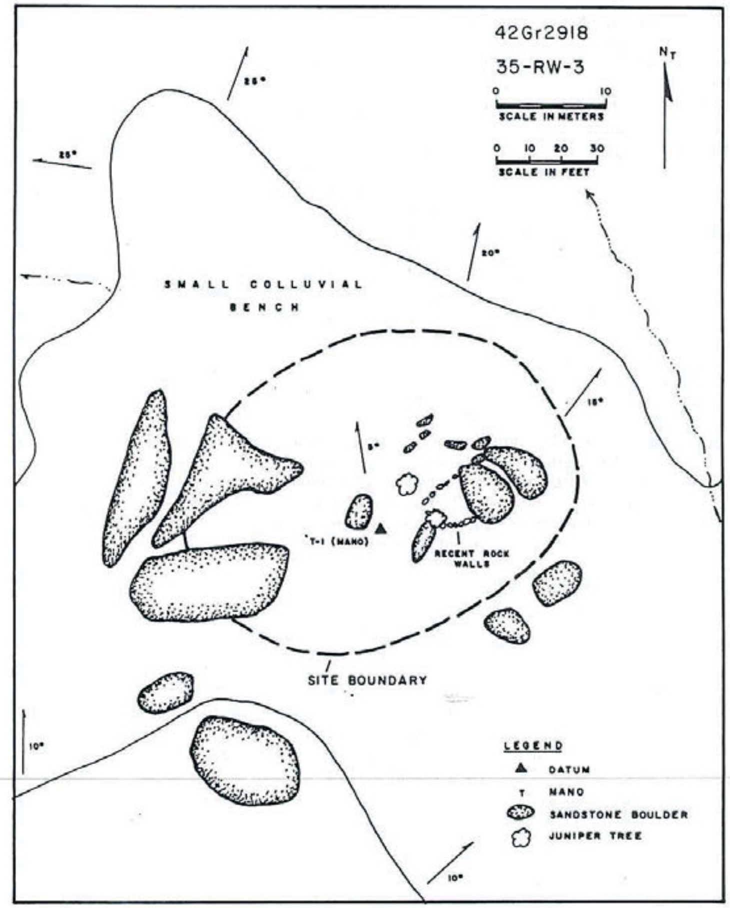

Figure 4. Site 42Gr2918.

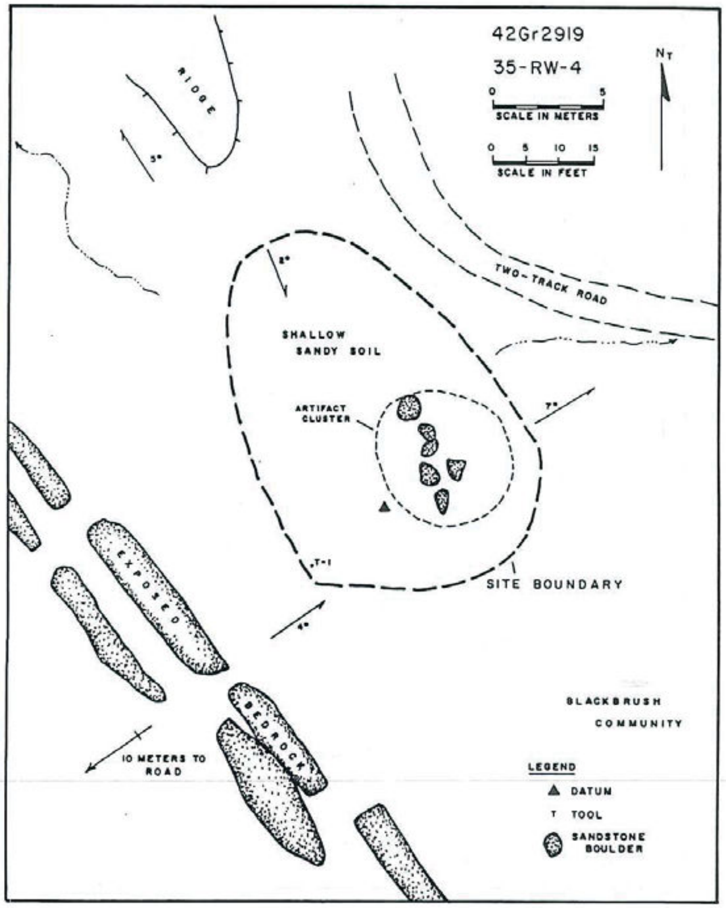

Figure 5. Site 42Gr2919.

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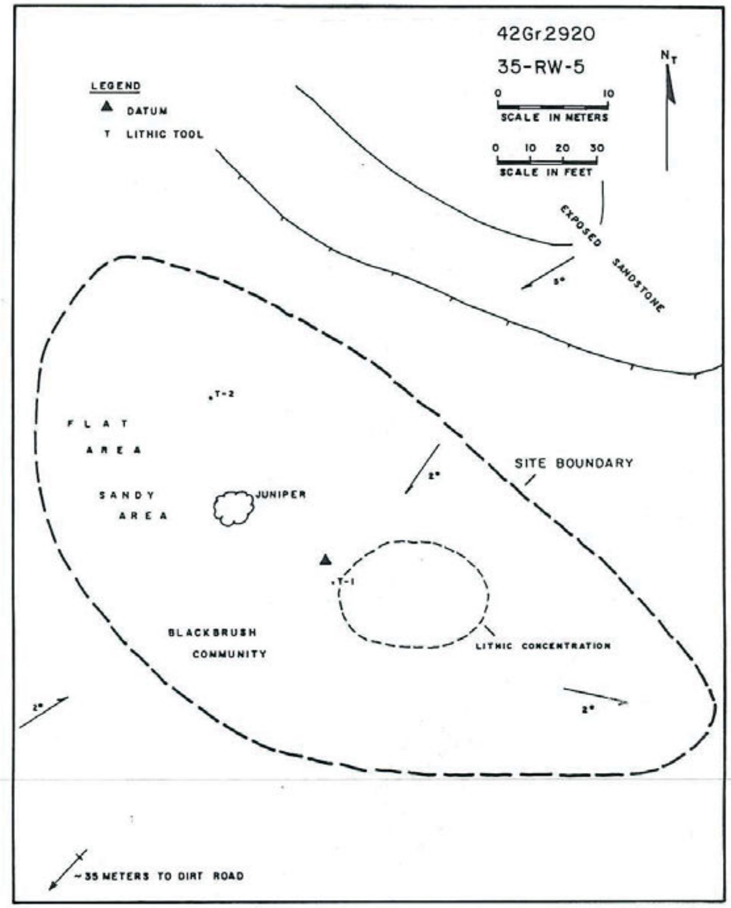

Figure 6. Site 42Gr2920.

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Isolated Finds of Artifacts

Isolated Find A (IF-A) is situated in T26S, 22E, S.18 NW 1/4, NW 1/4, SE 1/4; UTM 628040E-4266820N (Figure 1). It is a white chalcedony secondary flake.

Isolated Find B (IF-B) is situated in T26S, 22E, S.18 NE 1/4, SE 1/4, SE 1/4; UTM 628660E-4266400N (Figure 1). It is an untypable projectile point base fragment of red chert (22 x 14 x 3 mm).

Isolated Find C (IF-C) is situated in T26S, 22E, S. 18 NE 1/4, NE 1/4, SE 1/4; UTM 628500E-4266840N (Figure 1). It consists of a secondary flake of white, semi-opaque chert, with a small amount of cortex.

Isolated Find D (IF-D) is situated in T26S, R22E, S. 17 NE 1/4, SW 1/4, SW 1/4; UTM 628950E-4266410N (Figure 1). It is a partial Elko corner-notched projectile point (30 x 19 x 3 mm) of a dark gray/green, medium grain chert. It exhibits even and regular flaking, straight blade margins, a slight concave base, and is asymmetrical lenticular in cross section. The distance between the corner notches is 11mm. These notches are broad and fairly shallow.

Isolated Find E (IF-E) is situated in T26S,R22E, S.18 NW 1/4, SW 1/4, N/E ; UTM 628020E-4267300N (Figure 1). It is a projectile point fragment (24 x 11 x 2 mm) of mottled gray and white chert with orange flecks. It exhibits even and regular flaking, has slightly convex blade margins, and is symmetrically lenticular in cross-section. It is missing the base and the tip.

Isolated Find F (IF-F) is situated in T26S, R22E, S. 18; NE 1/4 SW 1/4, NE 1/4; UTM 628130E-4267240N (Figure 1). It is a white chalcedony projectile point tip (28 x 22 x 3 mm). It has slightly convex blade margins and is plano-convex in cross-section.

NATIONAL REGISTER OF HISTORIC PLACES EVALUATION

The National Register Criteria for Evaluation of Significance and procedures for nominating cultural resources to the National Register of Historic Places (NRHP) are outlined in 36 CFR 60.4 as follows:

> The quality of significance in American history, architecture, archaeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, material, workmanship, feeling, and association, and that they:
>
> a)...are associated with events that have made a significant contribution to the broad patterns of our history; or

> b)...are associated with the lives of persons significant to our past; or
>
> c)...embody the distinctive characteristics of a type, period, or method of construction; or that represents the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> d)...have yielded or may be likely to yield information important in prehistory or history.

The inventory resulted in the documentation of five new archaeological sites (42Gr2916 to 42Gr2920), and 6 isolated finds of artifacts (IF-A through IF-F). All the prehistoric sites are limited activity lithic scatters of unknown temporal affiliations. These four sites are considered not eligible for consideration to the NRHP. Sites 42Gr2916 and 42Gr2918 are situated on narrow bench along steep northeast facing colluvial slopes associated with large boulders. Both of these sites are lithic reduction stations lacking cultural deposits in the shallow boulder alcoves. However, the sites have been visited during modern times evidenced by small enclosures of dry-laid walls and historic graffiti. The other two lithic scatters (42Gr2919 and 2920) are situated at the base of the colluvial slopes on shallow residual and eolian terraces. These sites also contain limited cultural materials (e.g. lithic reduction stations), lacking potential for buried diagnositic artifacts or features. The recordation of these sites have exhausted their research potential. These prehistoric cultural resources are not unique to the area and are found throughout the valley representing short-term lithic reduction stations by mainly hunter-gathering groups.

Site 42Gr2917 is a historic temporary camp probably related to early 20th century ranging activities in Grand County. The site consists of a tent platform (level area with rock alignment) and a small scatter. Based on the historic items, the occupation dates between 1911 and 1914. The site occurs on a residual/colluvium bench and lacks potential for additional features or buried cultural remains. It is assessed as not eligible to the NRHP due to its lack of additional research potential which would contribute important information to the historic themes of the area.

The isolated finds of artifacts are considered not eligible for inclusion to the NRHP. The research potential of these cultural resources have been exhausted by the documentation in this report.

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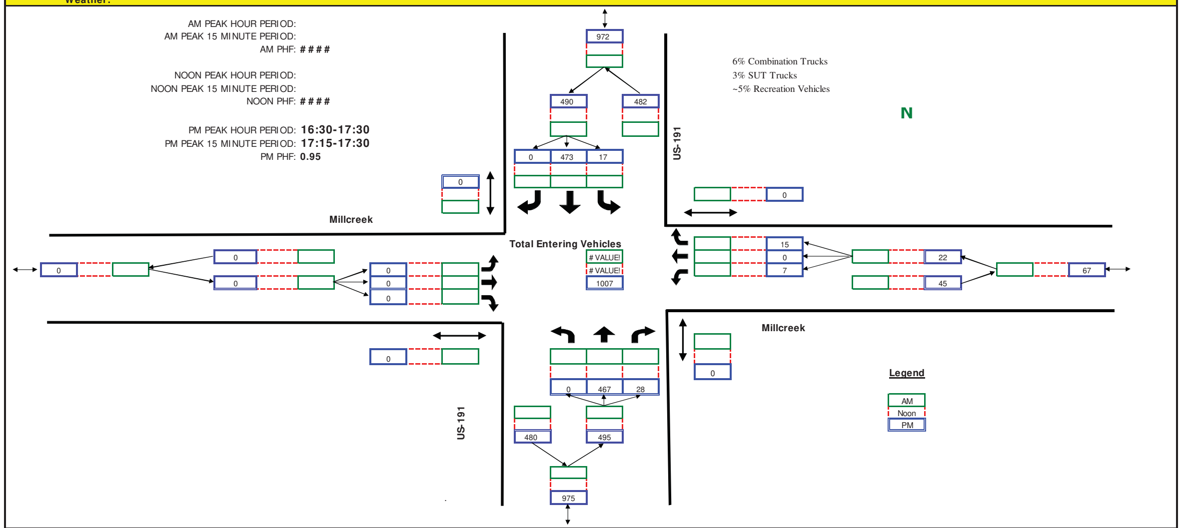
TrafficCounts

2364 North 1450 East
Lehi, UT 84043
801.636.0891

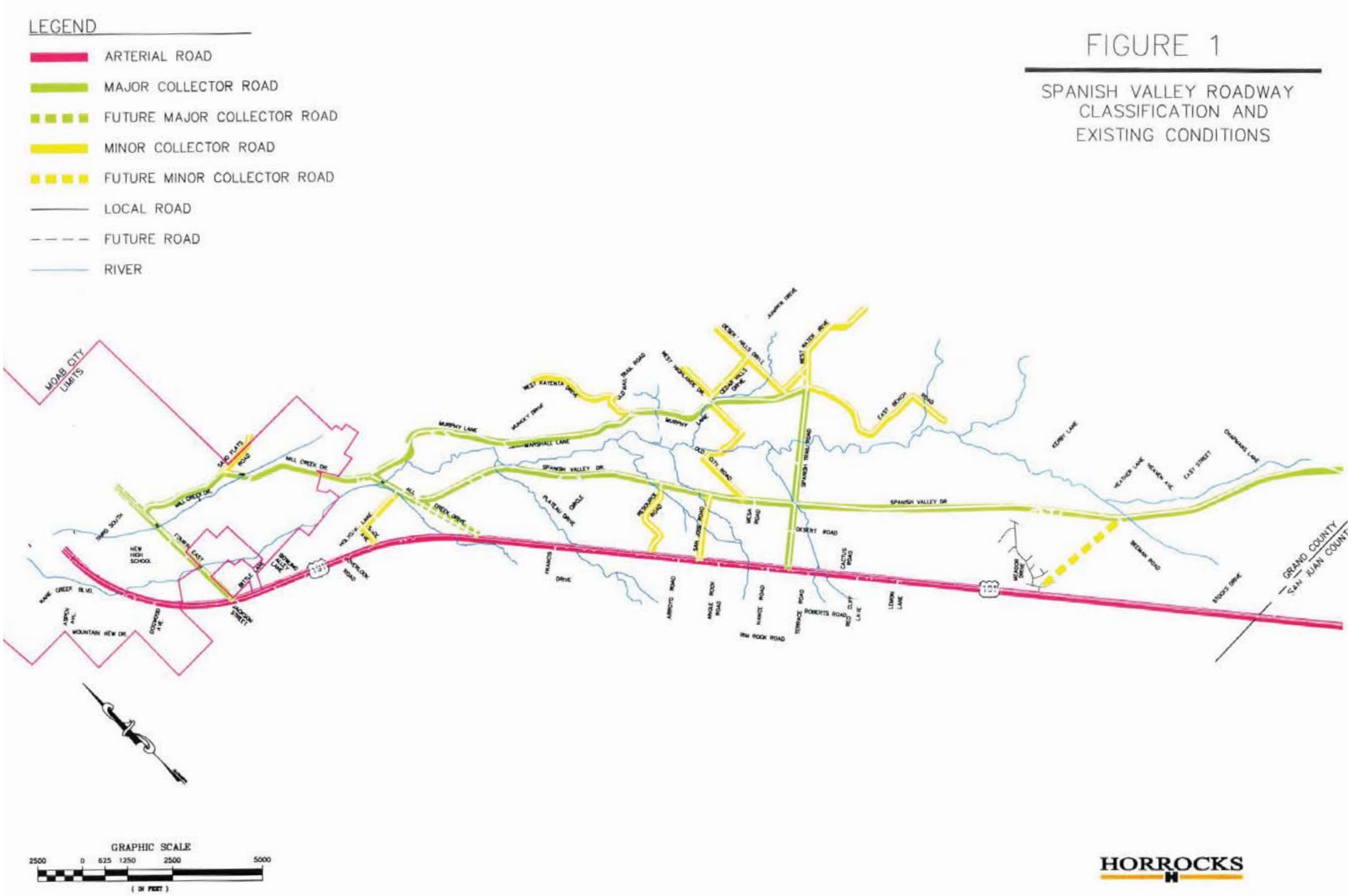
Intersection Turning Movement Summary

Intersection: US-191 / Millcreek
North/South: US-191
East/West: Millcreek
Jurisdiction: Moab, UT
Project Title:
Project No: P362
Weather:

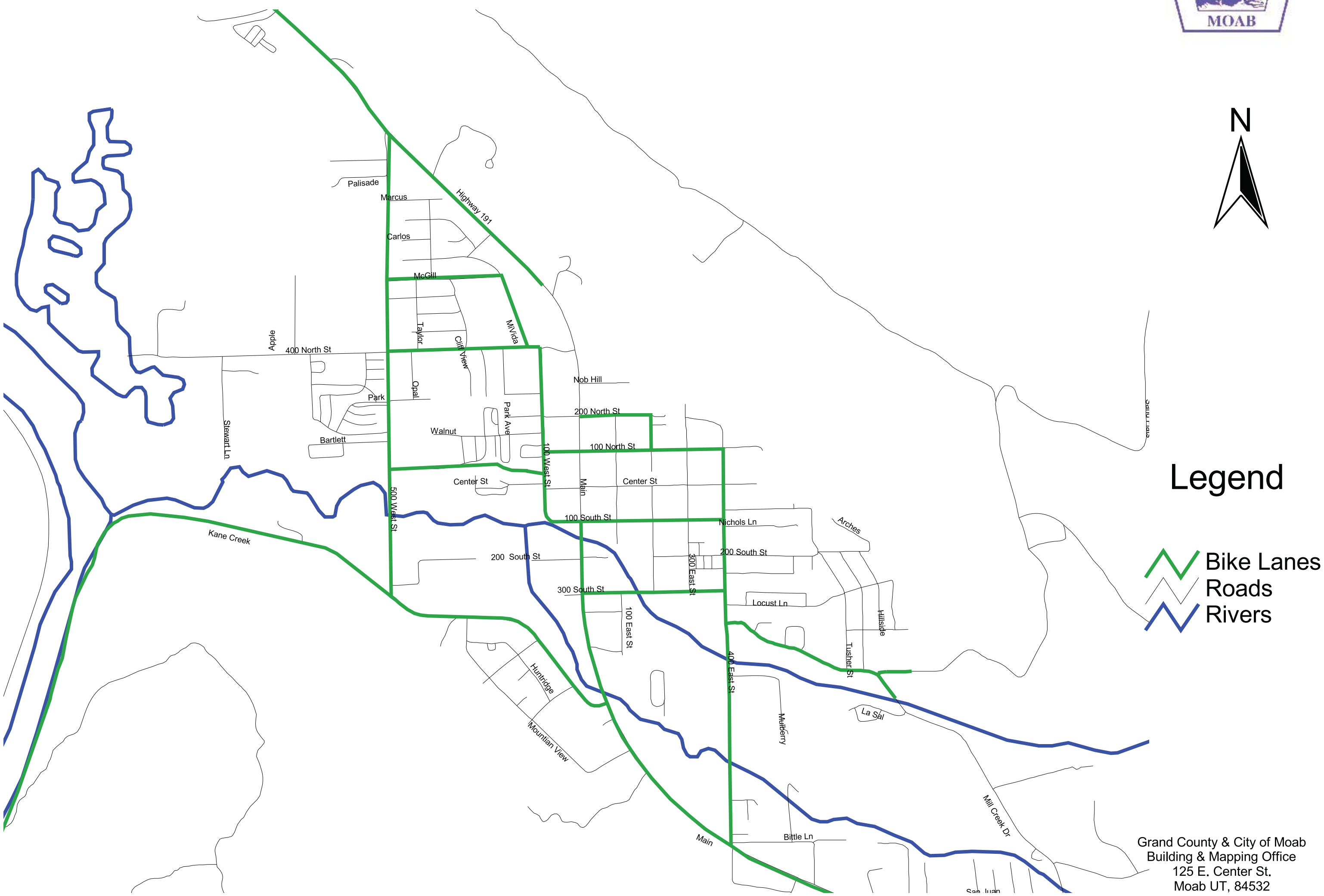
Date: 7-12-11, Tue
Day of Week Adjustment: 100.0%
Month of Year Adjustment: 100.0%
Adjustment Station #:
Growth Rate: 0.0%
Number of Years: 0



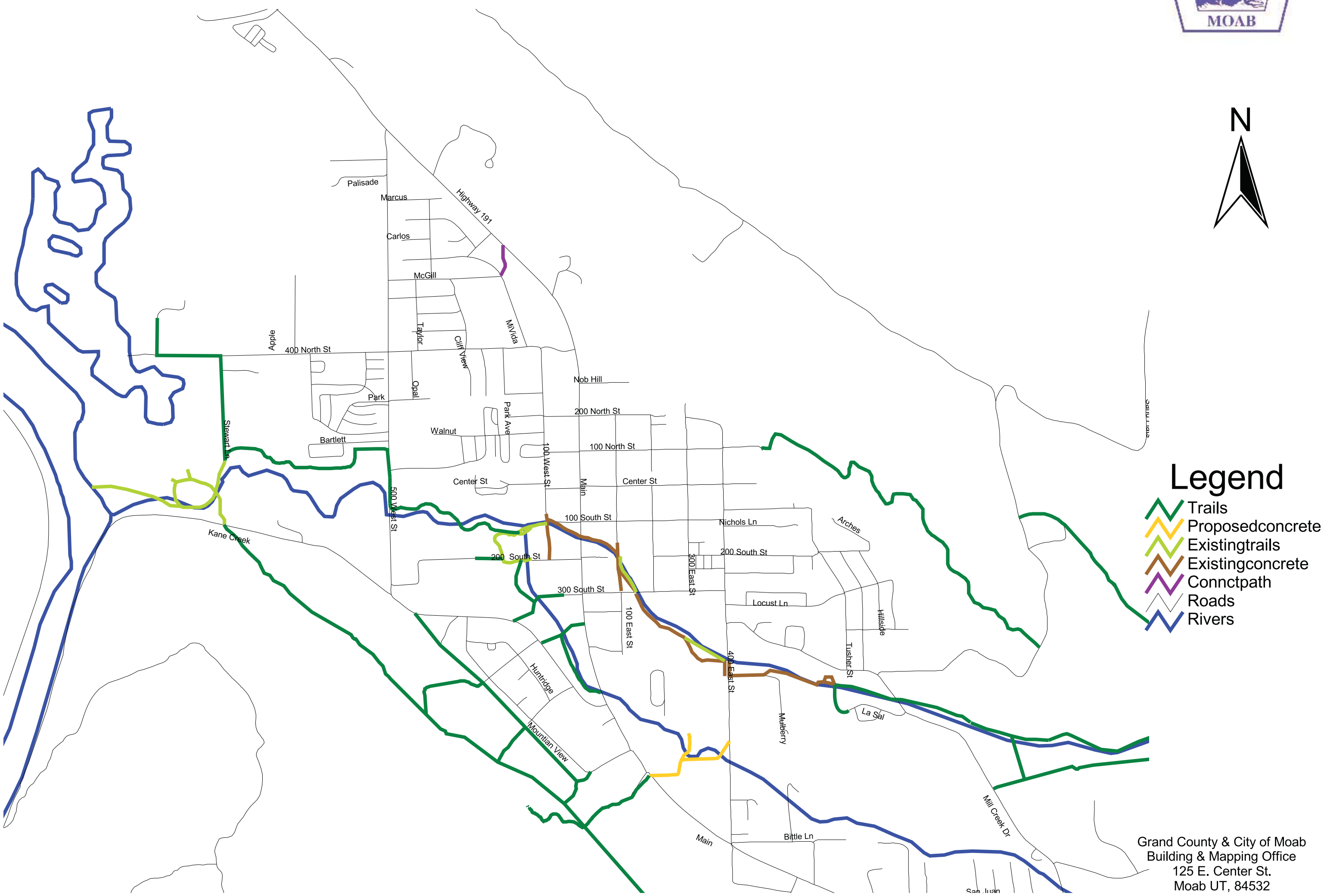
RAW COUNT SUMMARIES	US-191 Northbound				US-191 Southbound				Millcreek Eastbound				Millcreek Westbound				
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
AM PERIOD COUNTS																	
Period	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	TOTAL
7:00-7:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15-7:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30-7:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45-8:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00-8:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15-8:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30-8:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45-9:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOON PERIOD COUNTS																	
Period	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	TOTAL
11:00-11:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:15-11:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:30-11:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:45-12:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:00-12:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:15-12:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:30-12:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:45-13:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PM PERIOD COUNTS																	
Period	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	TOTAL
16:00-16:15	0	94	3	0	3	110	0	0	0	0	0	0	1	0	3	0	214
16:15-16:30	0	88	3	0	4	98	0	0	0	0	0	0	2	0	5	0	200
16:30-16:45	0	119	7	0	7	120	0	0	0	0	0	0	2	0	2	0	257
16:45-17:00	0	115	6	0	1	111	0	0	0	0	0	0	1	0	2	0	236
17:00-17:15	0	108	9	0	3	125	0	0	0	0	0	0	3	0	2	0	250
17:15-17:30	0	125	6	0	6	117	0	0	0	0	0	0	1	0	9	0	264
17:30-17:45	0	128	1	0	5	114	0	0	0	0	0	0	1	0	3	0	252
17:45-18:00	0	112	5	0	4	114	0	0	0	0	0	0	2	0	0	0	237


LEGEND
ARTERIAL ROAD
MAJOR COLLECTOR ROAD
FUTURE MAJOR COLLECTOR ROAD
MINOR COLLECTOR ROAD
FUTURE MINOR COLLECTOR ROAD
LOCAL ROAD
FUTURE ROAD
RIVER
FIGURE 1
SPANISH VALLEY ROADWAY
CLASSIFICATION AND
EXISTING CONDITIONS
MOAB CITY LIMITS
SPANISH VALLEY DR
GRAND COUNTY
SAN JUAN COUNTY
GRAPHIC SCALE
2500 0 625 1250 2500 5000
(IN FEET)
HORROCKS

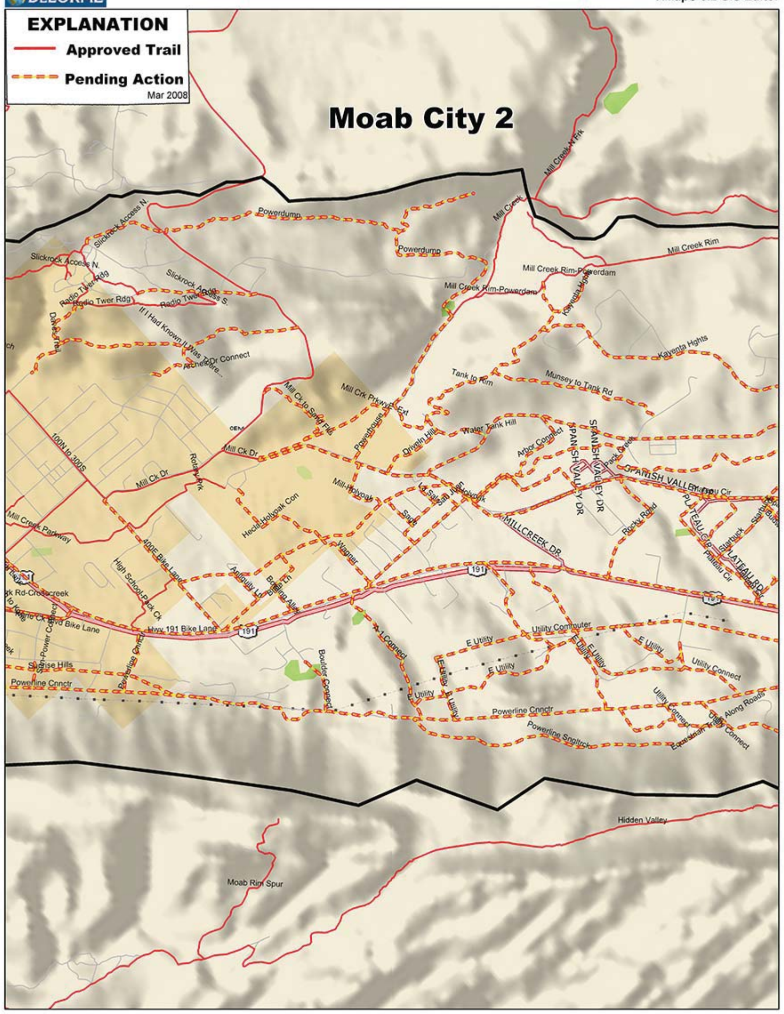
Bike Lanes


N
Legend
Bike Lanes
Roads
Rivers
Highway 191
Palisade
Marcus
Carlos
McGill
Mi Vida
Taylor
Cliff View
Apple
400 North St
Opal
Park
Park Ave
Walnut
Bartlett
Stewart Ln
Nob Hill
200 North St
100 North St
100 West St
Center St
Main
Center St
500 West St
100 South St
Nichols Ln
Arches
Kane Creek
200 South St
200 South St
300 East St
300 South St
Locust Ln
Hillside
100 East St
Tusher St
400 East St
Huntridge
La Sal
Mulberry
Mountain View
Mill Creek Dr
Main
Bittle Ln
San Juan
Grand County & City of Moab
Building & Mapping Office
125 E. Center St.
Moab UT, 84532

Paths and Trails



DeLorme XMap® 5.2 GIS Editor



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MN (11.3° E)

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Conceptual LEED NC checklist

LEED-NC

LEED-NC v3 2009 Project Checklist

LEED 2009 for NEW CONSTRUCTION and MAJOR RENOVATIONS

Conceptual Approximation of LEED Scoring Targets

UTAH STATE UNIVERSITY - MOAB CAMPUS COMPLEX Phase 1		EDA Architects, Inc.	LEED v3 2009 _v1_ Aug 5, 2011

Estimated Score: 76 = Gold / Owner's Target: Gold min. 60
[Note: Credits in 'Likely' category = 13, putting Platinum within range]

NOTES: Assumptions forming the basis of this preliminary scoring are listed in the 'Notes' column.
EDA Architects is anticipated to file LEED documentation not specifically required to be responsibility of specialty consultants. Documentation responsibilities are to be refined as project emerges.

Certified 40-49 points Silver 50-59 points Gold 60-79 points
Platinum 80 points / above

NOTE THAT Complex is analyzed preliminarily as a single building. Actual LEED application would not allow this at present. Project would need to be submitted either as three separate buildings, or as a 'Campus' project, adapting rules from earlier version of 'Application Guide for Multi-Building and Campus Projects'

Yes	Likely	Doubt-ful	No	Sustainable Sites		26 Points Possible	Attainment Certainty	Challenges / Strategies	Documentation Responsibility	Notes
Y				Prereq 1	Construction Activity Pollution Prevention	Required				
1				Credit 1	Site Selection	1				
			5	Credit 2	Development Density & Community Connectivity	5				
			1	Credit 3	Brownfield Redevelopment	1				
			6	Credit 4.1	**Alternative Transportation,** Public Transportation Access	6				
1				Credit 4.2	**Alternative Transportation,** Bicycle Storage & Changing Rooms	1				
	3			Credit 4.3	**Alternative Transportation,** Low-Emitting and Fuel-Efficient Vehicles	3				
	2			Credit 4.4	**Alternative Transportation,** Parking Capacity	2		Likely to need more parking than zoning requires		Need to have clear what zoning will require, and then provide fewer; co-location may be useful
1				Credit 5.1	**Site Development,** Protect or Restore Habitat	1				
1				Credit 5.2	**Site Development,** Maximize Open Space	1				Depends on building layout, 'LEED Project' delineation
1				Credit 6.1	**Stormwater Design,** Quantity Control	1				
1				Credit 6.2	**Stormwater Design,** Quality Control	1				
1				Credit 7.1	**Heat Island Effect,** Non-Roof	1				
1				Credit 7.2	**Heat Island Effect,** Roof	1				
1				Credit 8	Light Pollution Reduction	1		Honor 'dark sky' constraints		REGIONAL PRIORITY CREDIT OPPORTUNITY; Will require rigorous consensus approach to site lighting
9	5		12	subtotals						

Yes	Likely	Doubt-ful	No	Water Efficiency		10 Points Possible	Attainment Certainty	Challenges / Strategies	Documentation Responsibility	Notes
Y				Prereq 1	Water Use Reduction	Required				Requires min. 20% improvement for building water use over 'baseline,' excluding irrigation
2	2			Credit 1	Water Efficient Landscaping	2-4				REGIONAL PRIORITY CREDIT OPPORTUNITY (Op. 2 No Potable Water Use or Irrigation); Will require unity of concept from beginning
2				Credit 2	Innovative Wastewater Technologies	2		On-site treatment, dramatic reduction of discharge to sewer		
4				Credit 3	Water Use Reduction	2-4				REGIONAL PRIORITY CREDIT OPPORTUNITY (40% Reduction)
8	2			subtotals						

Yes	Likely	Doubtful	No	Energy & Atmosphere		35 Points Possible	Attainment Certainty	Challenges / Strategies	Documentation Responsibility	Notes
Y				Prereq 1	Fundamental Commissioning of Building Energy Systems	Required				Suggest extending 'basis-of-design' and 'owner's project requirements' to articulation of architectural systems and performance expectations
Y				Prereq 2	Minimum Energy Performance	Required				
Y				Prereq 3	Fundamental Refrigerant Management	Required				
15	4			Credit 1	Optimize Energy Performance *ESTIMATED*	1 to 19		Strive to make envelope as self-sufficient as possible; use natural ventilation/operable windows; Consider transpired walls, heat recovery w/ ground sourced heat pumps		REGIONAL PRIORITY CREDIT OPPORTUNITY (Min. 30% > 90.1-2007)
7				Credit 2	On-Site Renewable Energy	1 to 7		Solar-thermal and PV, both; PV on carports		Review Prism Solar availability for carports
2				Credit 3	Enhanced Commissioning	2				
2				Credit 4	Enhanced Refrigerant Management	2				
3				Credit 5	Measurement & Verification	3				
2				Credit 6	Green Power	2				
31	4			subtotals						

Yes	Likely	Doubtful	No	Materials & Resources		14 Points Possible	Attainment Certainty	Challenges / Strategies	Documentation Responsibility	Notes
Y				Prereq 1	Storage & Collection of Recyclables	Required				
			3	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1-3		N.A.		
			1	Credit 1.2	**Building Reuse**, Maintain Existing Interior Nonstructural Elements	1		N.A.		
		2		Credit 2	Construction Waste Management	1-2		Probably no local services		
		2		Credit 3	Materials Reuse	1-2				
2				Credit 4	Recycled Content	1-2				
2				Credit 5	Regional Materials	1-2				
	1			Credit 6	Rapidly Renewable Materials	1				
1				Credit 7	Certified Wood	1				
5	1	4	4	subtotals						

Yes	Likely	Doubtful	No	Indoor Environmental Quality		15 Points Possible	Attainment Certainty	Challenges / Strategies	Documentation Responsibility	Notes
Y				Prereq 1	Minimum Indoor Air Quality Performance	Required				
Y				Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required		State law		
1				Credit 1	Outdoor Air Delivery Monitoring	1				
	1			Credit 2	Increased Ventilation	1		May conflict with energy efficiency objectives		
1				Credit 3.1	**Construction IAQ Management Plan**, During Construction	1				
1				Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1				
1				Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1				

1				Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1				
1				Credit 4.3	**Low-Emitting Materials**, Flooring Systems	1				
1				Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1				
1				Credit 5	**Indoor Chemical & Pollutant Source Control**	1				
1				Credit 6.1	**Controllability of Systems**, Lighting	1				
1				Credit 6.2	**Controllability of Systems**, Thermal Comfort	1				
1				Credit 7.1	**Thermal Comfort**, Design	1				
1				Credit 7.2	**Thermal Comfort**, Verification	1				
1				Credit 8.1	**Daylight & Views**, Daylight	1				
1				Credit 8.2	**Daylight & Views**, Views	1				
14	1			**subtotals**						
Yes	Likely	Doubtful	No		**Innovation & Design Process**	**6 Points Possible**	**Attainment Certainty**	**Challenges / Strategies**	**Documentation Responsibility**	**Notes**
1				Credit 1.1	**Innovation in Design: 'Educational Program': Building Process, Story and Performance as Ongoing Educational Tool**	1		**Consider using 'dashboard' and well-placed informational signage in complex**		**At minimum, well-designed fixed signage with walking tour brochures, web page. Top end of scale uses interactive website and information kiosk with interactive display. Suggest creatively linking environmental message with ecological context.**
1				Credit 1.2	**Innovation in Design: Exemplary Performance - Comprehensive Transportation Plan**	1		**Comprensive Transportation Plan seeks to reduce single-occupancy vehicle dependence**		
1				Credit 1.3	**Innovation in Design: LEED-EBOM Mgmt Plans - Green Cleaning, Indoor Enviro. Quality Plans**	1				
1				Credit 1.4	**Innovation in Design: Exemplary Acoustical Environment (LEED-Schools)**	1				
1				Credit 1.5	**Innovation in Design: Comprehensive Envelope Commissioning**	1				
1				Credit 2	**LEED® Accredited Professional**	1				
6				**subtotals**						
Yes	Likely	Doubtful	No		**Regional Priority**	**4 Points Possible**	**Attainment Certainty**	**Challenges / Strategies**	**Documentation Responsibility**	**Notes**
				Credit 1	**Regional Priority**	1-4				
1				**SSc8**	**Light Pollution Reduction**	1		**Strict 'Dark-Sky' design in exterior lighting**		
1				**EAc1**	**Optimize Energy Performance - min. 36%> 90.1-07**	1		**Target 40% > 90.1-2007 energy cost savings**		
1				**WEc3**	**Water Use Reduction**	1		**Aggressive interior water use restraint**		
			1			1				
3			1	**subtotals**						
Yes	**Likely**	**Doubt-ful**	**No**							
76	13	4	17	**Project Totals (pre-certification estimates)**		**Certified 40-49 points Silver 50-59 points Gold 60-79 points Platinum 80 points or above**				

Conceptual LEED ND checklist

LEED for Neighborhood Development 2009
Ballot Draft - Project Scorecard

Project Name:

Yes	?	No			
		X	**Smart Location & Linkage**		**27** Points Possible
Y			Prereq 1	**Smart Location**	Required
Y			Prereq 2	**Imperiled Species and Ecological Communities**	Required
Y			Prereq 3	**Wetland and Water Body Conservation**	Required
Y			Prereq 4	**Agricultural Land Conservation**	Required
Y			Prereq 5	**Floodplain Avoidance**	Required
			Credit 1	**Preferred Locations**	10
			Credit 2	**Brownfield Redevelopment**	2
			Credit 3	**Locations with Reduced Automobile Dependence**	7
			Credit 4	**Bicycle Network and Storage**	1
			Credit 5	**Housing and Jobs Proximity**	3
			Credit 6	**Steep Slope Protection**	1
			Credit 7	**Site Design for Habitat or Wetland/Water Body Conservation**	1
			Credit 8	**Restoration of Habitat or Wetlands/Water Bodies**	1
			Credit 9	**Long-Term Conservation Management of Habitat or Wetlands/Water Bodies**	1

Yes	?	No			
26	8	10	**Neighborhood Pattern & Design**		**44** Points Possible
Y			Prereq 1	**Walkable Streets**	Required
Y			Prereq 2	**Compact Development**	Required
Y			Prereq 3	**Connected and Open Community**	Required
X			Credit 1	**Walkable Streets**	12
X			Credit 2	**Compact Development**	6
	X		Credit 3	**Mixed-Use Neighborhood Centers**	4
		X	Credit 4	**Mixed-Income Diverse Communities**	7
	X		Credit 5	**Reduced Parking Footprint**	1
	X		Credit 6	**Street Network**	2
	X		Credit 7	**Transit Facilities**	1
X			Credit 8	**Transportation Demand Management**	2
X			Credit 9	**Access to Civic & Public Spaces**	1
X			Credit 10	**Access to Recreation Facilities**	1
X			Credit 11	**Visitability and Universal Design**	1
X			Credit 12	**Community Outreach and Involvement**	2
		X	Credit 13	**Local Food Production**	1
		X	Credit 14	**Tree-Lined and Shaded Streets**	2
X			Credit 15	**Neighborhood Schools**	1

Yes	?	No			
18	10	2	**Green Infrastructure & Buildings**		**29** Points Possible
Y			Prereq 1	**Certified Green Building**	Required
Y			Prereq 2	**Minimum Building Energy Efficiency**	Required
Y			Prereq 3	**Minimum Building Water Efficiency**	Required
Y			Prereq 4	**Construction Activity Pollution Prevention**	Required
X			Credit 1	**Certified Green Buildings**	5
X			Credit 2	**Building Energy Efficiency**	2
X			Credit 3	**Building Water Efficiency**	1
X			Credit 4	**Water Efficient Landscaping**	1
		X	Credit 5	**Existing Building Use**	1
		X	Credit 6	**Historic Resource Preservation and Adaptive Reuse**	1
X			Credit 7	**Minimize Site Disturbance in Design and Construction**	1
X			Credit 8	**Stormwater Management**	4
X			Credit 9	**Heat Island Reduction**	1
	X		Credit 10	**Solar Orientation**	1
	X		Credit 11	**On-Site Renewable Energy Sources**	3
	X		Credit 12	**District Heating and Cooling**	2
X			Credit 13	**Infrastructure Energy Efficiency**	1
	X		Credit 14	**Wastewater Management**	2
	X		Credit 15	**Recycled Content in Infrastructure**	1
	X		Credit 16	**Solid Waste Management Infrastructure**	1
X			Credit 17	**Light Pollution Reduction**	1

Yes	?	No			
3	3		**Innovation & Design Process**		6 Points
X			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
X			Credit 1.2	**Innovation in Design**: Provide Specific Title	1
	X		Credit 1.3	**Innovation in Design**: Provide Specific Title	1
	X		Credit 1.4	**Innovation in Design**: Provide Specific Title	1
	X		Credit 1.5	**Innovation in Design**: Provide Specific Title	1
X			Credit 2	**LEED® Accredited Professional**	1

Yes	?	No			
2	3		**Regional Priority Credits**		4 Points
X			Credit 1.1	**Regional Priority Credit**: Region Defined	1
	X		Credit 1.2	**Regional Priority Credit**: Region Defined	1
	X		Credit 1.3	**Regional Priority Credit**: Region Defined	1
	X		Credit 1.4	**Regional Priority Credit**: Region Defined	1
49	24	39	**Project Totals** (Certification estimates)		110 Points

Certified: 40-49 points, **Silver:** 50-59 points, **Gold:** 60-79 points, **Platinum:** 80+ points

Conceptual Sustainable Sites checklist

Sustainable Site Score Card

Developed from the Sustainable Sites Initiative Guidelines and Performance Benchmarks 2009

Credit	Description	Possible Points		Points Earned	Low	High
Site Selection 21 Possible Points	Select locations to preserve existing resources and repair damaged systems					
Prerequisite 1.1	Limit Development of Soils designated as prime farmland, unique farmland, and farmland of statewide importance					
Prerequisite 1.2	Protect floodplain functions					
Prerequisite 1.3	Preserve wetlands					
Prerequisite 1.4	Preserve thereatened or endangered species and their homes					
Credit 1.5	Select brownfields or greyfields for redevelopment	5 to 10				
Credit 1.6	Select sites within existing communities	6				
Credit 1.7	Select sites that encourage non-motorized transportation and use of public transit	5			1	
			TOTAL	0	1	0

Credit	Description	Possible Points		Points Earned		
Pre-Design Assessment and Planning 4 Possible Points	Plan for sustainability from the onset of the project					
Prerequisite 2.1	Conduct a pre-design site assessment and explore opportunities for site sustainability					
Prerequisite 2.2	Use an integrated site development process					
Credit 2.3	Engage users and other stakeholders in site design	4			1	4
			TOTAL	0	1	4

Credit	Description	Possible Points		Points Earned		
Site Design - Water 44 Possible Points	Protect and restore processes and systems associated with a site's hydrology					
Prerequisite 3.1	Reduce potable water use for landscape irrigation by 50% from established baseline					
Credit 3.2	Reduce potable water use for landscape irrigation by 75 percent or more from established base line	2 to 5			2	5
Credit 3.3	Protect and restore riparian, wetland, and shoreline buffers	3 to 8				
Credit 3.4	Rehabilitate lost streams, wetlands, and shoreline	2 to 5				
Credit 3.5	Manage stormwater on site	5 to 10			5	10
Credit 3.6	Protect and enhance on-site water resources and receiving water quality	3 to 9				
Credit 3.7	Design rainwater/ stormwater features to provide a landscape amenity	1 to 3			1	3
Credit 3.8	Maintain water features to conserve water and other resources	1 to 4				
			TOTAL	0	8	18

Credit	Description	Possible Points		Points Earned		
Site Design - Soil and Vegetation 51 Possible Points	Protect and restore processes and systems associated with a site's soil and vegetation					
Prerequisite 4.1	Control and manage known invasive plants found on site					
Prerequisite 4.2	Use appropriate, non-invasive plants					
Prerequisite 4.3	Creat a soil management plan					
Credit 4.4	Minimize soil disturbance in design and construction	6			6	
Credit 4.5	Preserve all vegetation designated as special status	5			5	
Credit 4.6	Preserve or restore appropriate plant biomass on site	3 to 8			3	8
Credit 4.7	Use native plants	1 to 4			2	4
Credits 4.8	Preserve plant communities native to the ecoregion	2 to 6			2	6
Credit 4.9	Restore plant communities native to the ecoregion	1 to 5			1	5
Credit 4.10	Use vegetation to minimize building heating requirements	2 to 4			2	4
Credit 4.11	Use vegetation to minimize building cooling requirements	2 to 5			2	5
Credit 4.12	Reduce urban heat island effects	3 to 5			3	5
Credit 4.13	Reduce the risk of catastrophic wildfires	3				3
			TOTAL	0	26	40

Credit	Description	Possible Points		Points Earned		
Site Design - Materials Selection	Reuse/ recycle existing materials and support sustainable production practices					
Prerequisite 5.1	Elimiate the use of wood from threatened tree species					
Credit 5.2	Maintain on-site structures, hardscape, and landscape amenities	1 to 4				
Credit 5.3	Design for deconstruction and disassembly	1 to 3				
Credit 5.4	Reuse salvaged materials and plants	2 to 4				
Credit 5.5	Use recylced content materials	2 to 4			2	4
Credit 5.6	Use certified wood	1 to 4			1	4
Credit 5.7	Use regional materials	2 to 6			2	6
Credit 5.8	Use adhesives, sealants, paints, and coatings with reduced VOC emmisions	2				2
Credit 5.9	Support sustainable practices in plant production	3				3
Credit 5.10	Support sustainable practices in materials manufacturing	3 to 6			3	6
			TOTAL	0	8	25

Credit	Description	Possible Points		Points Earned		
Site Design - Human Health and Well-Being 32 Possible Points	Build storng communities and sense of stewardship					
Credit 6.1	Promote equitable site development	1 to 3			1	3
Credit 6.2	Promote equitable site users	1 to 4			1	4
Credit 6.3	Promote sustianable awareness and education	2 to 4			2	4
Credit 6.4	Protect and maintain cultural and historical places	2 to 4				2
Credit 6.5	Provide opportunities for oudoor physical activities	4 to 5			4	5
Credit 6.6	Provide opportunities for outdoor physcial activities	4 to 5			4	5
Credit 6.7	Provide views of vegetation and quiet outdoor spaces for mental restoration	3 to 4			3	4
Credit 6.8	Provide outdoor spaces for social interaction	3			3	3
Credit 6.9	Reduce light pollution	2			2	2
			TOTAL	0	20	32

Credit	Description	Possible Points		Points Earned		
Construction 21 Possible Points	Minimize effects of construction-related activities					
Prerequisite 7.1	Control and retain construction pollutants					
Prerequisite 7.2	Restore soils disturbed during construction					
Credit 7.3	Restore soils disturbed by previous development	2 to 8				2
Credit 7.4	Divert construction and demolition materials from disposal	3 to 5			3	5
Credit 7.5	Reuse or recycle vegetation, rocks, and soil generated during construction	3 to 5			3	5
Credit 7.6	Minimize genration of greenhouse gas emissions and exposure to localized air pollutants during construction	1 to 3			1	3
			TOTAL	0	7	15

Credit	Description	Possible Points		Points Earned		
Construction 21 Possible Points	Minimize effects of construction-related activities					
Prerequisite 8.1	Plan for sustainable site maintenance					
Prerequisite 8.2	Provide for storage and collection of recyclables					
Credit 8.3	Recylce organic matter generated during site operations and maintenance	2 to 6			2	6
Credit 8.4	Reduce outdoor energy consumption for all landscapes and exterior operations	1 to 4			1	4
Credit 8.5	Use renewable sources for landscape electricity needs	2 to 3			2	3
Credit 8.6	Minimize exposure to envrionmental tobacco smoke	1 to 2			1	2
Credit 8.7	Minimize generation of greenhouse gases and exposure to localized air pollutants during landscape maintenance activities	1 to 4			1	4
Credit 8.8	Reduce emissions and promote the use of fuel-efficient vehicles	4				4
			TOTAL	0	7	23

Credit	Description	Possible Points		Points Earned		
Monitor and Innovation 18 Possible Points	Reward exceptional performance and improve the body of knowledge on long-term sustiainability					
Credit 9.1	Monitor performance of sustainable design practices	10				10
Credit 9.2	Innovation in site design	8				8
			TOTAL	0	0	18
TOTAL CUMULATIVE POINTS				0	78	175

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN

PRELIMINARY WATER SYSTEM DEMANDS

ITEM NO. / TYPE OF USE	IRRIGATED AREA	TOTAL	UNIT	PEAK DAY SOURCE DEMAND						MINIMUM TANK STORAGE REQ'D				PEAK INSTANTANEOUS DEMAND		ANNUAL WATER RIGHT	
				UNIT DEMAND		TOTAL DAILY DEMAND				UNIT DEMAND		TOTAL DEMAND				UNIT DEMAND	TOTAL DEMAND
				WINTER	SUMMER	WINTER		SUMMER		WINTER	SUMMER	WINTER	SUMMER	WINTER	SUMMER		
CAMPUS - TOTAL BUILDOUT																	
I. POTABLE				(GPD)	(GPD)	(GPM)	(GPD)	(GPM)	(GPD)	(GAL)	(GAL)	(GAL)	(GAL)	(GPM)	(GPM)	(AC-FT)	(AC-FT)
		(b)		(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(FORMULAS)						(b)*(c)/1440	(b)*(c)	(b)*(d)/1440	(b)*(d)	(c)/2	(d)/2	(b)*(i)	(b)*(j)	10.8*((peak day/800)^0.64)		(calc.)	(b)*(o)
1. CAMPUS																	
STUDENTS - TRADITIONAL		2,400	FTE	20	20	33	48,000	33	48,000	10	10	24,000	24,000			0.011	26.9
STUDENTS - NONTRADITIONAL		150	FTE	20	20	2	3,000	2	3,000	10	10	1,500	1,500			0.011	1.7
FACULTY & STAFF		213	EMP	15	15	2	3,195	2	3,195	8	8	1,598	1,598			0.008	1.8
SUBTOTAL POTABLE						**38**	**54,195**	**38**	**54,195**			**27,098**	**27,098**	**160**	**160**		**30.4**
II. IRRIGATION	(ACRES/UNIT)			(GPD/AC)	(GPD/AC)	(GPM)	(GPD)	(GPM)	(GPD)	(GAL)	(GAL)	(GAL)	(GAL)	(GPM)	(GPM)	(AC-FT)	(AC-FT)
(FORMULAS)	(a)				UDDW	(a)*(b)*(c)/1440	(a)*(b)*(c)	(a)*(b)*(d)/1440	(g)*1440	(c)/2	(d)/2	(a)*(b)*(i)	(a)*(b)*(j)	(e)*2	(g)*2	3.39 ac-ft/ac	(b)*(o)
1. CAMPUS																	
IRRIGATED AREA		1.21	ACRE		8,850			7	10,709		4,425		5,354		15	3.39	4.1
SUBTOTAL IRRIGATION								**7**	**10,709**				**5,354**		**15**		**4.1**
TOTAL POTABLE AND IRRIGATION						**38**	**54,195**	**45**	**64,904**			**27,098**	**32,452**	**160**	**175**		**34.5**
III. FIRE FLOW / STORAGE RESERVES		(GPM)	(HOURS)									(GAL)	(GAL)				
1. FIRE FLOW (Assume 1500 gpm; 4 hrs)		**1,500**	**4**									**360,000**	**360,000**				
TOTAL						**38**	**54,195**	**45**	**64,904**			**387,098**	**392,452**	**160**	**175**		**34.5**
						(GPM)	(GPD)	(GPM)	(GPD)			(GAL)	(GAL)	(GPM)	(GPM)		(AC-FT)

NOTES:

1. PEAK DAY DOMESTIC DEMANDS WERE BASED ON STATE DRINKING WATER REGULATIONS.
2. PEAK DAY IRRIGATION DEMAND = 8,850 GPD/ACRE PER UTAH DIVISION OF WATER RIGHTS CONSUMPTIVE USE TABLES FOR MOAB, ELEVATION 3970'.
3. ANNUAL WATER SUPPLY REQUIREMENTS:
   DOMESTIC = 0.5 TIMES THE PEAK DAY DEMAND, ANNUALIZED.
   IRRIGATION = 3.39 A.F./ ACRE PER UTAH DIVISION OF WATER RIGHTS CONSUMPTIVE USE TABLES FOR MOAB, ELEVATION 3970' AND AMES IRRIGATION HANDBOOK.

12/16/2011 Campus STANTEC CONSULTING, INC.

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN

PRELIMINARY WATER SYSTEM DEMANDS

ITEM NO. TYPE OF USE	IRRIGATED AREA	TOTAL	UNIT	PEAK DAY SOURCE DEMAND						MINIMUM TANK STORAGE REQ'D				PEAK INSTANTANEOUS DEMAND		ANNUAL WATER RIGHT	
				UNIT DEMAND		TOTAL DAILY DEMAND				UNIT DEMAND		TOTAL DEMAND				UNIT DEMAND	TOTAL DEMAND
				WINTER	SUMMER	WINTER		SUMMER		WINTER	SUMMER	WINTER	SUMMER	WINTER	SUMMER		
SITLA LAND																	
I. POTABLE				(GPD)	(GPD)	(GPM)	(GPD)	(GPM)	(GPD)	(GAL)	(GAL)	(GAL)	(GAL)	(GPM)	(GPM)	(AC-FT)	(AC-FT)
		(b)		(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(FORMULAS)						(b)*(c)/1440	(b)*(c)	(b)*(d)/1440	(b)*(d)	(c)/2	(d)/2	(b)*(i)	(b)*(j)	10.8*((peak day/800)^0.64)		(calc.)	(b)*(o)
1. STUDENT HOUSING (6 CAP/UNIT)																	
STUDENT HOUSING 1		101	UNITS	1,200	1,200	84	121,200	84	121,200	600	600	60,600	60,600			0.672	67.9
STUDENT HOUSING 2		126	UNITS	1,200	1,200	105	151,200	105	151,200	600	600	75,600	75,600			0.672	84.7
STUDENT HOUSING 3		45	UNITS	1,200	1,200	38	54,000	38	54,000	600	600	27,000	27,000			0.672	30.2
2. MULTI-FAMILY (3 CAP/UNIT)																	
MULTI-FAMILY 1		212	UNITS	600	600	88	127,200	88	127,200	300	300	63,600	63,600			0.336	71.2
MULTI-FAMILY 2		204	UNITS	600	600	85	122,400	85	122,400	300	300	61,200	61,200			0.336	68.6
MULTI-FAMILY 3		28	UNITS	600	600	12	16,800	12	16,800	300	300	8,400	8,400			0.336	9.4
MULTI-FAMILY 4		12	UNITS	600	600	5	7,200	5	7,200	300	300	3,600	3,600			0.336	4.0
MULTI-FAMILY 5		8	UNITS	600	600	3	4,800	3	4,800	300	300	2,400	2,400			0.336	2.7
MULTI-FAMILY 6		20	UNITS	600	600	8	12,000	8	12,000	300	300	6,000	6,000			0.336	6.7
3. SINGLE FAMILY (2.4 CAP/UNIT)																	
SINGLE FAMILY 1		15	UNITS	480	480	5	7,200	5	7,200	240	240	3,600	3,600			0.269	4.0
SINGLE FAMILY 2		16	UNITS	480	480	5	7,680	5	7,680	240	240	3,840	3,840			0.269	4.3
SINGLE FAMILY 3		8	UNITS	480	480	3	3,840	3	3,840	240	240	1,920	1,920			0.269	2.2
SINGLE FAMILY 4		8	UNITS	480	480	3	3,840	3	3,840	240	240	1,920	1,920			0.269	2.2
SINGLE FAMILY 5		47	UNITS	480	480	16	22,560	16	22,560	240	240	11,280	11,280			0.269	12.6
SUBTOTAL POTABLE						**460**	**661,920**	**460**	**661,920**			**330,960**	**330,960**	**796**	**796**		**370.7**
II. IRRIGATION	(ACRES/AREA\)			(GPD/AC)	(GPD/AC)	(GPM)	(GPD)	(GPM)	(GPD)	(GAL)	(GAL)	(GAL)	(GAL)	(GPM)	(GPM)	(AC-FT)	(AC-FT)
(FORMULAS)	(a)				UDDW	(a)*(b)*(c)/1440	(a)*(b)*(c)	(a)*(d)/1440	(g)*1440	(c)/2	(d)/2	(a)*(b)*(i)	(a)*(j)	(e)*2	(g)*2	3.39 ac-ft/ac	(a)*(o)
1. STUDENT HOUSING (5% IRRG)																	
STUDENT HOUSING 1 (4.04 AC)	0.202		ACRE		8,850			1.2	1,788		4,425		894		2	0.684	0.1
STUDENT HOUSING 2 (5.02 AC)	0.251		ACRE		8,850			1.5	2,221		4,425		1,111		3	0.850	0.2
STUDENT HOUSING 3 (1.8 AC)	0.090		ACRE		8,850			0.6	797		4,425		398		1	0.305	0.0
2. MULTI-FAMILY (5% IRRIG)																	
MULTI-FAMILY 1 (10.6 AC)	0.530		ACRE		8,850			3.3	4,691		4,425		2,345		7	1.795	1.0
MULTI-FAMILY 2 (10.2 AC)	0.510		ACRE		8,850			3.1	4,514		4,425		2,257		6	1.727	0.9
MULTI-FAMILY 3 (1.4 AC)	0.070		ACRE		8,850			0.4	620		4,425		310		1	0.237	0.0
MULTI-FAMILY 4 (0.6 AC)	0.030		ACRE		8,850			0.2	266		4,425		133		0	0.102	0.0
MULTI-FAMILY 5 (0.4 AC)	0.020		ACRE		8,850			0.1	177		4,425		89		0	0.068	0.0
MULTI-FAMILY 6 (1.0 AC)	0.050		ACRE		8,850			0.3	443		4,425		221		1	0.169	0.0
3. SINGLE FAMILY (10% IRRIG)																	
SINGLE FAMILY 1 (3.8 AC)	0.38		ACRE		8,850			2.3	3,363		4,425		1,682		5	1.287	0.5
SINGLE FAMILY 2 (4.04 AC)	0.40		ACRE		8,850			2.5	3,575		4,425		1,788		5	1.368	0.6
SINGLE FAMILY 3 (2.08 AC)	0.21		ACRE		8,850			1.3	1,841		4,425		920		3	0.704	0.1
SINGLE FAMILY 4 (2.03 AC)	0.20		ACRE		8,850			1.2	1,797		4,425		898		2	0.688	0.1
SINGLE FAMILY 5 (11.7 AC)	1.17		ACRE		8,850			7.2	10,355		4,425		5,177		14	3.963	4.6
SUBTOTAL IRRIGATION								**25**	**36,444**				**18,222**		**51**		**8.2**
TOTAL POTABLE AND IRRIGATION						**460**	**661,920**	**485**	**698,364**			**330,960**	**349,182**	**796**	**846**		**379.0**
III. FIRE FLOW / STORAGE RESERVES		(GPM)	(HOURS)									(GAL)	(GAL)				
1. FIRE FLOW (Assume 1500 gpm; 4 hrs)		**1,500**	**4**									**360,000**	**360,000**				
TOTAL						**460**	**661,920**	**485**	**698,364**			**690,960**	**709,182**	**796**	**846**		**379.0**
						(GPM)	(GPD)	(GPM)	(GPD)			(GAL)	(GAL)	(GPM)	(GPM)		(AC-FT)

NOTES:
1. PEAK DAY DOMESTIC DEMANDS WERE BASED ON STATE DRINKING WATER REGULATIONS.
2. PEAK DAY IRRIGATION DEMAND = 8,850 GPD/ACRE PER UTAH DIVISION OF WATER RIGHTS CONSUMPTIVE USE TABLES FOR MOAB, ELEVATION 3970'.
3. ANNUAL WATER SUPPLY REQUIREMENTS:
   DOMESTIC = 0.5 TIMES THE PEAK DAY DEMAND, ANNUALIZED.
   IRRIGATION = 3.39 A.F./ ACRE PER UTAH DIVISION OF WATER RIGHTS CONSUMPTIVE USE TABLES FOR MOAB, ELEVATION 3970' AND AMES IRRIGATION HANDBOOK.

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
PRELIMINARY CAMPUS FIRE FLOW DEMAND

1	CONSTRUCTION TYPE (from EDA Architects)				TYPE IIB	Conservative
2	MAXIMUM BUILDING FOOTPRINT				15000	ft^2
3	MAXIMUM NUMBER OF FLOORS				5	
4	FIRE FLOW CALCULATION AREA *(PER IFC SECTION B104)*				75000	ft^2
5	MINIMUM REQUIRED FIRE FLOW AND DURATION *(PER IFC TABLE B105.1)*			FOR	5750 4	gpm hrs
6	ALLOWABLE REDUCTION BASED ON FIRE SPRINKLERS *(PER IFC SECTION B105.2)*				75	%
6	MINIMUM FIRE FLOW = *(PER IFC SECTION B105.2)*	5750	gpm *	25%	1437.5	gpm
7	MINIMUM FIRE FLOW ALLOWED *(PER IFC SECTION B105.2)*				1500	gpm
8	PROJECT FIRE FLOW = THE GREATER OF LINE 6 AND LINE 7				**1500** **4**	**gpm** **hrs**

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
SITLA FIRE FLOW DEMAND

1	CONSTRUCTION TYPE (ASSUMED)				TYPE IIB	Conservative
2	MAXIMUM BUILDING FOOTPRINT				10000	ft^2
3	MAXIMUM NUMBER OF FLOORS				4	
4	FIRE FLOW CALCULATION AREA *(PER IFC SECTION B104)*				40000	ft^2
5	MINIMUM REQUIRED FIRE FLOW AND DURATION *(PER IFC TABLE B105.1)*			FOR	4250 4	gpm hrs
6	ALLOWABLE REDUCTION BASED ON FIRE SPRINKLERS *(PER IFC SECTION B105.2)*				75	%
6	MINIMUM FIRE FLOW = *(PER IFC SECTION B105.2)*	4250	gpm *	25%	1062.5	gpm
7	MINIMUM FIRE FLOW ALLOWED *(PER IFC SECTION B105.2)*				1500	gpm
8	PROJECT FIRE FLOW = THE GREATER OF LINE 6 AND LINE 7				**1500** **4**	**gpm** **hrs**

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
IRRIGATION DEMANDS FOR AVERAGE ELEVATIONS OF 4000' (MOAB UTAH)

AVERAGE GROWING SEASON: Feb 15 to Nov 1		256	Days (Conservative)
PEAK DAY CONSUMPTIVE USE (C.U.)[1]			
Peak Consumptive Use (Turf Grass)	=	5.44	in/month
	=	0.18	in/day
x 1.30 Peaking Factor	=	0.23	in/day
SEASONAL CONSUMPTIVE USE (C.U.)[1]			
30.0 inches/year * 1.0	=	29.95	in/yr
SEASONAL GROSS REQUIREMENTS			
SEASONAL CONSUMPTIVE USE (C.U.) =		29.95	in/yr
Less soil moisture (silt loam 1.75 in/ft*1ft effective root zone)[2]	-	1.5	in/yr
Less rainfall average (during irrigation season)	-	6.63	in/yr
NET SEASONAL CONSUMPTIVE USE (C.U.)	=	21.82	in/yr
GROSS IRRIGATION REQUIREMENTS			
Assumed Efficiency = 70%			
Seasonal:			
Net C.U./Efficiency			
21.82 in/yr / 70%	=	31.17	in/yr
IF NO RAIN OCCURS			
(net seasonal + rainfall avg) / 70%	=	40.64	in/yr
40.64 in/yr/ 12	=	**3.39**	**ac-ft/acre**
Peak Day			
Peak C.U. / Efficiency			
0.23 inches/day / 70%	=	0.33	in/day
gpm/ac Conversion			
0.33 (43560 ft2/ac*7.48 gal/ft3)/(12 in/ft*1440 min/day)	=	6.15	gpm/ac
gpd/ac Conversion			
6.15 gpm / ac * 1440 min / day	=	**8850**	gpd/ac (Peak Day Demand)

[1] Data taken from the *Utah Division of Water Rights Consumptive Use Tables* for Moab, Elevation 3970' (http://nrwrt1.nr.state.ut.us/techinfo/consumpt/default.htm).
[2] Ref: Ames Irrigation Handbook - Third Edition 1967

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
PRELIMINARY SANITARY SEWER FLOW

TYPE OF USE	NO. OF UNITS	UNIT	AVE. DAY DEMAND/UNIT	ANNUAL AVERAGE DAILY FLOW RATE			MAXIMUM DESIGN FLOW RATE (PEAKING FACTOR = 4)		
				FLOW/ UNIT	TOTAL FLOW		FLOW/ UNIT	TOTAL FLOW	
CAMPUS - TOTAL BUILDOUT			(GPD)	(GPD)	(GPM)	(GPD)	(GPD)	(GPM)	(GPD)
	(a)		(b)	(c)	(d)	(e)	(i)	(j)	(k)
(FORMULAS)				(b)	(a)*(c)/1440	(d)*1440	(c)*4	(a)*(i)/1440	(j)*1440
1. CAMPUS									
STUDENTS - TRADITIONAL	2,400	FTE	10	10	17	24,000	40	67	96,000
STUDENTS - NONTRADITIONAL	150	FTE	10	10	1	1,500	40	4	6,000
FACULTY & STAFF	213	EMP	8	8	1	1,598	30	4	6,390
TOTAL					**19**	**27,098**		**75**	**108,390**

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
PRELIMINARY SANITARY SEWER FLOW

TYPE OF USE	NO. OF UNITS	UNIT	AVE. DAY DEMAND/UNIT	ANNUAL AVERAGE DAILY FLOW RATE			MAXIMUM DESIGN FLOW RATE (PEAKING FACTOR = 4)		
				FLOW/ UNIT	TOTAL FLOW		FLOW/ UNIT	TOTAL FLOW	
SITLA LAND			(GPD)	(GPD)	(GPM)	(GPD)	(GPD)	(GPM)	(GPD)
	(a)		(b)	(c)	(d)	(e)	(i)	(j)	(k)
(FORMULAS)				(b)	(a)*(c)/1440	(d)*1440	(c)*4	(a)*(i)/1440	(j)*1440
1. STUDENT HOUSING (6 CAP/UNIT)									
STUDENT HOUSING 1	101	UNITS	600	600	42	60,600	2,400	168	242,400
STUDENT HOUSING 2	126	UNITS	600	600	53	75,600	2,400	210	302,400
STUDENT HOUSING 3	45	UNITS	600	600	19	27,000	2,400	75	108,000
2. MULTI-FAMILY (3 CAP/UNIT)									
MULTI-FAMILY 1	212	UNITS	300	300	44	63,600	1,200	177	254,400
MULTI-FAMILY 2	204	UNITS	300	300	43	61,200	1,200	170	244,800
MULTI-FAMILY 3	28	UNITS	300	300	6	8,400	1,200	23	33,600
MULTI-FAMILY 4	12	UNITS	300	300	3	3,600	1,200	10	14,400
MULTI-FAMILY 5	8	UNITS	300	300	2	2,400	1,200	7	9,600
MULTI-FAMILY 6	20	UNITS	300	300	4	6,000	1,200	17	24,000
3. SINGLE FAMILY (2.4 CAP/UNIT)									
SINGLE FAMILY 1	15	UNITS	240	240	3	3,600	960	10	14,400
SINGLE FAMILY 2	16	UNITS	240	240	3	3,840	960	11	15,360
SINGLE FAMILY 3	8	UNITS	240	240	1	1,920	960	5	7,680
SINGLE FAMILY 4	8	UNITS	240	240	1	1,920	960	5	7,680
SINGLE FAMILY 5	47	UNITS	240	240	8	11,280	960	31	45,120
TOTAL					**230**	**330,960**		**919**	**1,323,840**

Utilities Reference Data - Storm Water

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
DETENTION BASIN 1 - PRELIMINARY SIZING

Total Area	Area sq. ft.	C	CA		
				Weighted "C"	0.66
Roof Area	130,680	0.9	117,612	Total Acres	10.00
Paved Area	130,680	0.90	117,612	Allowable Q cfs/acre	0.2
Landscaped Area	174,240	0.3	52,272	Allowed Release Rate Q cfs	2.00
Totals	435,600	N/A	287,496	Total Release Rate cfs	2.00

100 Year Storm Information

(4) Interval (min.)	Precipitation (inches/hr)	(1) Precipitation (inches)	(2) CA/12 (cu.ft./inch)	(3) (1)X(2) Accum. Sto. (cu.ft.)	(5) Maximum Release Rate (cu.ft./min.)	(6) (4)X(5) Accum. Rel. (cu.ft.)	(7) (3)-(6) Req'd. Sto. (cu.ft.)
15	3.36	0.84	23,958	20,125	120.0	1,800	18,325
30	2.26	1.13	23,958	27,073	120.0	3,600	23,473
60	1.40	1.40	23,958	33,541	120.0	7,200	26,341
360	0.32	1.92	23,958	45,999	120.0	43,200	2,799
720	0.18	2.16	23,958	51,749	120.0	86,400	0
1440	0.12	2.79	23,958	66,814	120.0	172,800	0

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
DETENTION BASIN 3 - PRELIMINARY SIZING

Total Area	Area sq. ft.	C	CA		
				Weighted "C"	0.52
Roof Area	32,670	0.9	29,403	Total Acres	4.06
Paved Area	32,670	0.90	29,403	Allowable Q cfs/acre	0.2
Landscaped Area	111,422	0.3	33,427	Allowed Release Rate Q cfs	0.81
Totals	176,762	N/A	92,233	Total Release Rate cfs	0.81

100 Year Storm Information

(4) Interval (min.)	Precipitation (inches/hr)	(1) Precipitation (inches)	(2) CA/12 (cu.ft./inch)	(3) (1)X(2) Accum. Sto. (cu.ft.)	(5) Maximum Release Rate (cu.ft./min.)	(6) (4)X(5) Accum. Rel. (cu.ft.)	(7) (3)-(6) Req'd. Sto. (cu.ft.)
15	3.36	0.84	7,686	6,456	48.7	730	5,726
30	2.26	1.13	7,686	8,685	48.7	1,461	7,224
60	1.40	1.40	7,686	10,760	48.7	2,922	7,839
360	0.32	1.92	7,686	14,757	48.7	17,530	0
720	0.18	2.16	7,686	16,602	48.7	35,060	0
1440	0.12	2.79	7,686	21,435	48.7	70,120	0

UTAH STATE UNIVERSITY FUTURE MOAB CAMPUS MASTER PLAN
DETENTION BASIN 2 - PRELIMINARY SIZING

Total Area	Area sq. ft.	C	CA		
				Weighted "C"	0.67
Roof Area	108,900	0.9	98,010	Total Acres	8.18
Paved Area	108,900	0.90	98,010	Allowable Q cfs/acre	0.2
Landscaped Area	138,500	0.3	41,550	Allowed Release Rate Q cfs	1.64
Totals	356,300	N/A	237,570	Total Release Rate cfs	1.64

100 Year Storm Information

(4) Interval (min.)	Precipitation (inches/hr)	(1) Precipitation (inches)	(2) CA/12 (cu.ft./inch)	(3) (1)X(2) Accum. Sto. (cu.ft.)	(5) Maximum Release Rate (cu.ft./min.)	(6) (4)X(5) Accum. Rel. (cu.ft.)	(7) (3)-(6) Req'd. Sto. (cu.ft.)
15	3.36	0.84	19,798	16,630	98.2	1,472	15,158
30	2.26	1.13	19,798	22,371	98.2	2,945	19,427
60	1.40	1.40	19,798	27,717	98.2	5,889	21,827
360	0.32	1.92	19,798	38,011	98.2	35,336	2,676
720	0.18	2.16	19,798	42,763	98.2	70,671	0
1440	0.12	2.79	19,798	55,211	98.2	141,342	0

RUSLE2 Related Attributes

Canyonlands Area, Utah - Parts of Grand and San Juan Counties

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
62:							
Nepalto	83	A	.24	5	66.0	23.0	11.0
88:							
Thoroughfare	83	B	.28	5	71.3	16.7	12.0
99:							
Ustic Torriorthents	35	C	.24	3	80.8	9.2	10.0
Lithic Torriorthents	25	D	.24	1	70.9	16.6	12.5
Rock outcrop	20	---	---	---	---	---	---

RUSLE2 Related Attributes

This report summarizes those soil attributes used by the Revised Universal Soil Loss Equation Version 2 (RUSLE2) for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. Soil property data for each map unit component include the hydrologic soil group, erosion factors Kf for the surface horizon, erosion factor T, and the representative percentage of sand, silt, and clay in the surface horizon.

Map Unit Description (Brief, Generated)

Canyonlands Area, Utah - Parts of Grand and San Juan Counties

[Minor map unit components are excluded from this report]

Map unit: 62 - Nepalto very stony sandy loam, 2 to 8 percent slopes

Component: Nepalto (83%)

The Nepalto component makes up 83 percent of the map unit. Slopes are 2 to 8 percent. This component is on canyons, talus cones. The parent material consists of alluvium derived from sandstone. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R035XY139UT Desert Stony Loam (blackbrush) ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Map unit: 88 - Thoroughfare fine sandy loam,2 to 8 percent slopes

Component: Thoroughfare (83%)

The Thoroughfare component makes up 83 percent of the map unit. Slopes are 2 to 8 percent. This component is on stream terraces, alluvial flats. The parent material consists of alluvium derived from sandstone and shale. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is moderate. Shrink-swell potential is low. This soil is occasionally flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R035XY118UT Desert Sandy Loam (fourwing Saltbush) ecological site. Nonirrigated land capability classification is 7e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Map unit: 99 - Ustic Torriorthents-Lithic Torriorthents, warm-Rock outcrop complex, 10 to 80 percent slopes

Component: Ustic Torriorthents (35%)

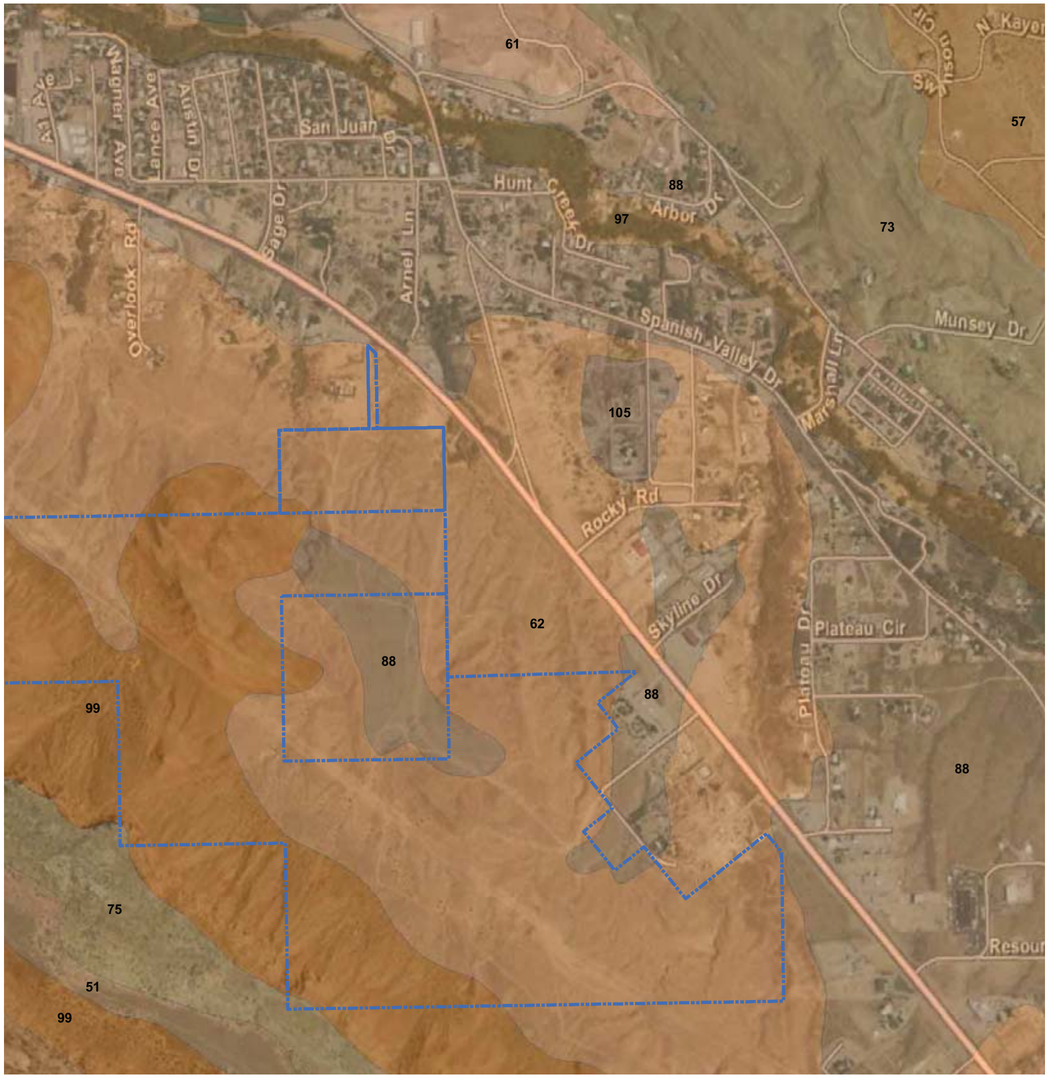
The Ustic Torriorthents component makes up 35 percent of the map unit. Slopes are 10 to 80 percent. This component is on talus cones on escarpments. The parent material consists of colluvium derived from sandstone and shale. Depth to a root restrictive layer, bedrock, paralithic, is 20 to 79 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R035XY018UT Talus Slope (blackbrush-Shadscale) ecological site. Nonirrigated land capability classification is 7e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Component: Lithic Torriorthents (25%)

The Lithic Torriorthents component makes up 25 percent of the map unit. Slopes are 30 to 50 percent. This component is on escarpments, ledges. The parent material consists of alluvium derived from sandstone and shale and/or residuum weathered from sandstone and shale. Depth to a root restrictive layer, bedrock, lithic, is 4 to 20 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches is very low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 0 percent. This component is in the R035XY133UT Desert Shallow Sandy Loam (blackbrush) ecological site. Nonirrigated land capability classification is 7s. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Component: Rock outcrop (20%)

Generated brief soil descriptions are created for major soil components. The Rock outcrop is a miscellaneous area.



NOAA Atlas 14, Volume 1, Version 5
Location name: Moab, Utah, US*
Coordinates: 38.5428, -109.5262
Elevation: 4451ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval(years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.109 (0.095-0.128)	0.139 (0.126-0.166)	0.188 (0.171-0.228)	0.235 (0.217-0.288)	0.306 (0.285-0.386)	0.370 (0.344-0.478)	0.445 (0.415-0.599)	0.534 (0.496-0.749)	0.671 (0.617-1.00)	0.795 (0.726-1.26)
10-min	0.166 (0.145-0.194)	0.212 (0.192-0.252)	0.286 (0.260-0.347)	0.358 (0.330-0.439)	0.467 (0.433-0.588)	0.563 (0.524-0.728)	0.678 (0.632-0.912)	0.812 (0.754-1.14)	1.02 (0.939-1.52)	1.21 (1.10-1.91)
15-min	0.205 (0.180-0.241)	0.262 (0.238-0.313)	0.355 (0.322-0.430)	0.443 (0.409-0.544)	0.578 (0.537-0.729)	0.698 (0.650-0.902)	0.841 (0.783-1.13)	1.01 (0.935-1.41)	1.27 (1.16-1.89)	1.50 (1.37-2.37)
30-min	0.277 (0.243-0.324)	0.353 (0.321-0.421)	0.478 (0.434-0.579)	0.597 (0.551-0.733)	0.779 (0.723-0.982)	0.940 (0.875-1.22)	1.13 (1.06-1.52)	1.36 (1.26-1.90)	1.71 (1.57-2.54)	2.02 (1.84-3.19)
60-min	0.342 (0.300-0.402)	0.437 (0.397-0.521)	0.591 (0.537-0.716)	0.739 (0.682-0.908)	0.964 (0.895-1.22)	1.16 (1.08-1.50)	1.40 (1.31-1.88)	1.68 (1.56-2.35)	2.11 (1.94-3.15)	2.50 (2.28-3.95)
2-hr	0.426 (0.382-0.496)	0.539 (0.474-0.621)	0.725 (0.641-0.836)	0.897 (0.787-1.03)	1.20 (1.03-1.36)	1.47 (1.23-1.68)	1.80 (1.47-2.09)	2.21 (1.74-2.59)	2.87 (2.17-3.45)	3.50 (2.56-4.29)
3-hr	0.475 (0.425-0.536)	0.595 (0.528-0.676)	0.777 (0.693-0.873)	0.950 (0.838-1.07)	1.23 (1.08-1.39)	1.50 (1.29-1.70)	1.84 (1.54-2.11)	2.24 (1.84-2.61)	2.91 (2.30-3.49)	3.54 (2.70-4.34)
6-hr	0.593 (0.541-0.656)	0.737 (0.668-0.816)	0.940 (0.857-1.03)	1.12 (1.01-1.23)	1.40 (1.25-1.55)	1.64 (1.45-1.82)	1.93 (1.68-2.17)	2.34 (2.00-2.65)	3.02 (2.50-3.52)	3.65 (2.96-4.38)
12-hr	0.734 (0.669-0.807)	0.913 (0.834-1.01)	1.14 (1.04-1.26)	1.34 (1.22-1.47)	1.63 (1.47-1.81)	1.88 (1.68-2.07)	2.15 (1.90-2.39)	2.46 (2.15-2.76)	3.13 (2.68-3.56)	3.76 (3.17-4.42)
24-hr	0.922 (0.847-1.01)	1.15 (1.06-1.26)	1.46 (1.33-1.59)	1.72 (1.55-1.90)	2.11 (1.86-2.37)	2.43 (2.09-2.79)	2.79 (2.34-3.29)	3.18 (2.59-3.90)	3.77 (2.94-4.85)	4.27 (3.20-5.75)
2-day	1.01 (0.931-1.10)	1.26 (1.16-1.37)	1.58 (1.44-1.72)	1.86 (1.68-2.05)	2.28 (2.01-2.57)	2.64 (2.27-3.04)	3.04 (2.53-3.62)	3.49 (2.81-4.31)	4.17 (3.19-5.47)	4.76 (3.49-6.57)
3-day	1.08 (0.998-1.18)	1.35 (1.24-1.47)	1.70 (1.55-1.86)	2.01 (1.81-2.21)	2.46 (2.17-2.77)	2.85 (2.45-3.28)	3.28 (2.74-3.90)	3.76 (3.03-4.64)	4.48 (3.44-5.85)	5.11 (3.77-7.01)
4-day	1.16 (1.06-1.26)	1.45 (1.33-1.58)	1.82 (1.66-2.00)	2.15 (1.94-2.37)	2.64 (2.33-2.98)	3.06 (2.63-3.52)	3.52 (2.94-4.18)	4.03 (3.26-4.97)	4.80 (3.70-6.23)	5.46 (4.04-7.44)
7-day	1.31 (1.21-1.43)	1.64 (1.51-1.78)	2.06 (1.88-2.26)	2.43 (2.19-2.67)	2.97 (2.62-3.34)	3.42 (2.95-3.93)	3.93 (3.29-4.66)	4.48 (3.64-5.51)	5.32 (4.12-6.89)	6.03 (4.49-8.22)
10-day	1.46 (1.34-1.58)	1.82 (1.68-1.98)	2.30 (2.10-2.51)	2.70 (2.45-2.97)	3.28 (2.92-3.67)	3.76 (3.28-4.28)	4.29 (3.64-5.00)	4.85 (4.01-5.83)	5.73 (4.54-7.25)	6.47 (4.94-8.57)
20-day	1.85 (1.70-2.02)	2.31 (2.12-2.52)	2.90 (2.65-3.17)	3.38 (3.05-3.72)	4.06 (3.60-4.54)	4.60 (4.00-5.23)	5.17 (4.40-6.03)	5.78 (4.78-6.92)	6.64 (5.30-8.25)	7.33 (5.69-9.41)
30-day	2.22 (2.04-2.41)	2.77 (2.54-3.01)	3.45 (3.15-3.75)	4.00 (3.63-4.38)	4.76 (4.25-5.30)	5.37 (4.71-6.07)	6.00 (5.14-6.92)	6.66 (5.57-7.89)	7.58 (6.12-9.30)	8.31 (6.53-10.5)
45-day	2.66 (2.45-2.89)	3.33 (3.06-3.62)	4.15 (3.79-4.50)	4.80 (4.37-5.24)	5.70 (5.09-6.33)	6.40 (5.63-7.22)	7.13 (6.14-8.18)	7.89 (6.64-9.27)	8.93 (7.28-10.9)	9.76 (7.75-12.3)
60-day	3.14 (2.89-3.42)	3.93 (3.60-4.27)	4.85 (4.44-5.28)	5.58 (5.06-6.10)	6.55 (5.86-7.22)	7.28 (6.44-8.15)	8.03 (6.98-9.14)	8.80 (7.50-10.2)	9.81 (8.16-11.8)	10.6 (8.60-13.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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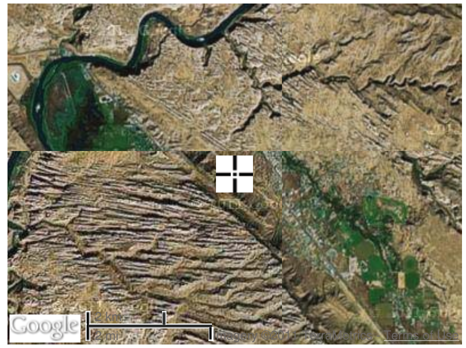
PF graphical



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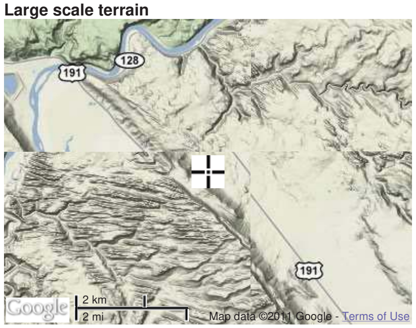
Large scale terrain



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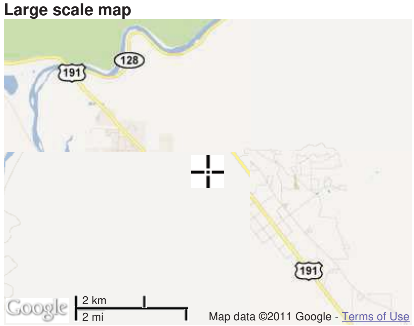
Large scale map



Large scale aerial