

**Bureau of Land Management**  
**WIND RIVER/BIGHORN BASIN DISTRICT**  
**Worland Field Office**

**Greet Individual Allotment**  
**#00141**

**Standards for Healthy Rangelands**  
**and**  
**Guidelines for Livestock Grazing Management**  
for  
Public Lands Administered by the Bureau of Land Management in the  
State of Wyoming

FY2014/15



The BLM's multiple-use mission is to sustain the health and productivity of the public lands for the use and enjoyment of present and future generations. The Bureau accomplishes this by managing such activities as outdoor recreation, livestock grazing, mineral development, and energy production, and by conserving natural, historical, cultural, and other resources on public lands.

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## 1.0 INTRODUCTION

The Bureau of Land Management (BLM) grazing regulations at 43 CFR 4130.3-1(c) require that grazing permits issued by the BLM contain terms and conditions that ensure conformance with BLM regulations at 43 CFR 4180, which are the regulations under which the Standards for Healthy Rangelands and Guidelines for Livestock Grazing Management for Public Land Administered by the Bureau of Land Management in the State of Wyoming were developed. Recently, the Worland Field Office completed an assessment of the achievement of these standards on the Greet Individual Allotment No. 00141. The results of this assessment are presented in this report. This assessment will serve to inform the BLM's determination as to whether these standards are being met, and, if they are not met, whether existing grazing management practices contribute to their lack of attainment.

### 1.1 Standards

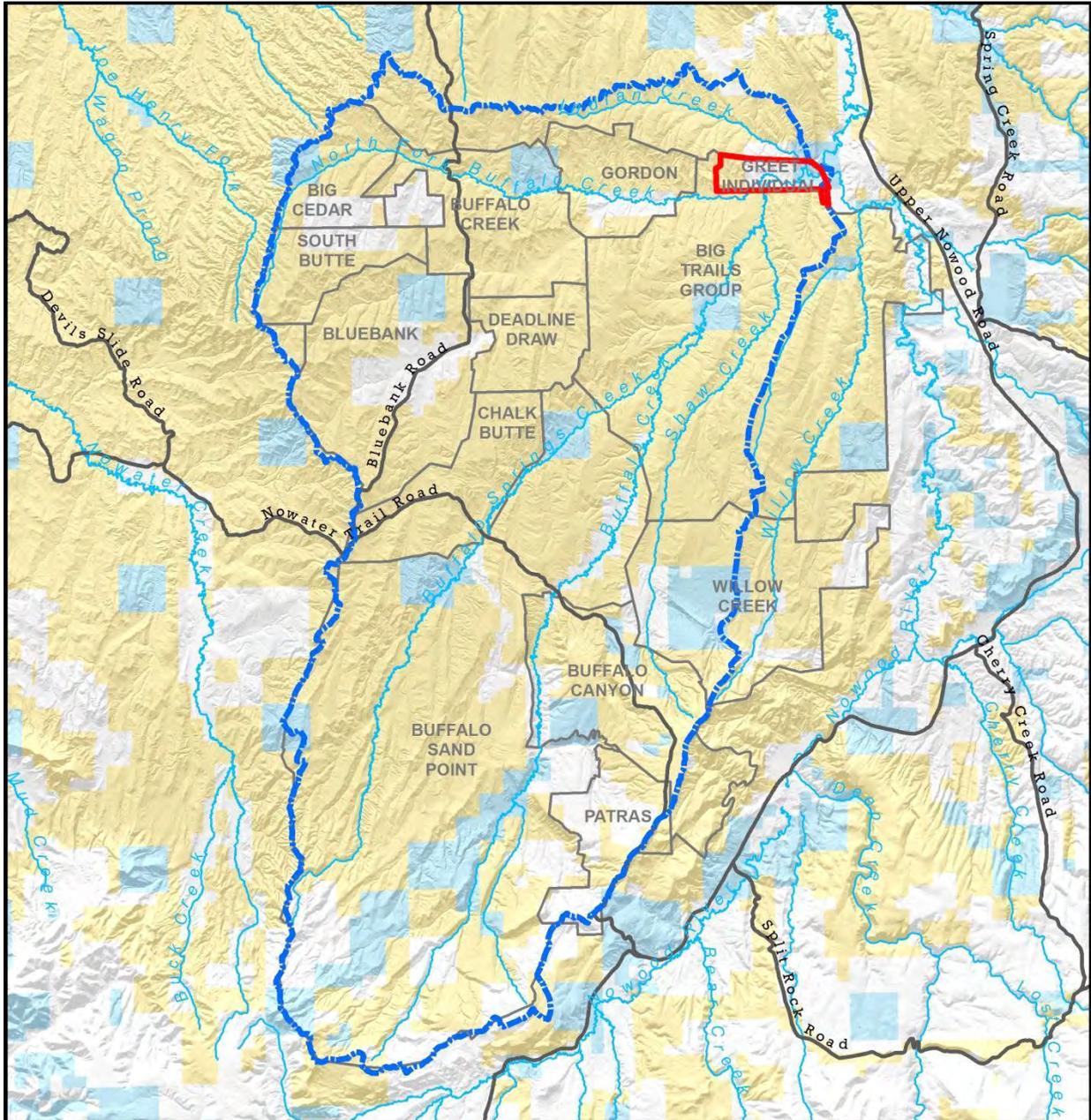
The approved standards for rangeland health are as follows:

- Standard #1: Within the potential of the ecological site (soil type, landform, climate, and geology), soils are stable and allow for water infiltration to provide for optimal plant growth and minimal surface runoff.
- Standard #2: Riparian and wetland vegetation has structural, age and species diversity characteristic of the state of channel succession and is resilient and capable of recovering from natural and human disturbance in order to provide forage and cover, capture sediment, dissipate energy, and provide ground water recharge.
- Standard #3: Upland vegetation on ecological site consists of plant communities appropriate to the site which are resilient, diverse, and able to recover from natural and human disturbance.
- Standard #4: Rangelands are capable of sustaining viable populations and a diversity of native plant and animal species appropriate to the habitat. Habitats that support or could support threatened species, endangered species, species of special concern, or sensitive species will be maintained or enhanced.
- Standard #5: Water quality meets State standards
- Standard #6: Air quality meets State standards

## 2.0 Affected Environment – Allotment Description, Resource Values, and Uses

### 2.1 Location and Land Ownership

The Greet Individual Allotment is located approximately 20 miles south of Ten Sleep, WY. The allotment encompasses approximately 272 acres of public land, 435 acres of private and 240 acres State lands. For management priorities, the allotment consists of 27% public AUMs and is classified in the “M” (maintain) category.



### 2.2 Climate/Air Quality

The allotment is within a transitional precipitation zone of 5-9 inch and 10-14 inch Big Horn Basin Precipitation Zone (Precip Zone). The average annual precipitation collected at the BLM Buffalo Creek rain gauge, located 7 miles south of the allotment, is approximately 9.30 inches and the average annual precipitation 7 miles at the BLM

Spring Creek gage is 13.3 inches. Approximately one-half of the annual precipitation falls during the critical growing season of April through June.

The following general climate description is provided by the US Department of Agriculture, Natural Resources Conservation Service (NRCS), Ecological Site Description, Loamy Range Site, 10-14E Big Horn Basin Precipitation Zone (Site ID R032XY322WY):

Annual precipitation ranges from 10-14 inches per year. The normal precipitation pattern shows the least amount of precipitation in December, January, and February, increasing to a peak during the latter part of May. Amounts decrease through June, July, and August and then increase some in September. Much of the moisture that falls in the latter part of the summer is lost by evaporation and much of the moisture that falls during the winter is lost by sublimation. Average snowfall exceeds 20 inches annually. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with more than normal precipitation.

Temperatures show a wide range between summer and winter and between daily maximums and minimums, due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may occur in winter and bring rapid rises in temperature. Extreme storms may occur during the winter, but most severely affect ranch operations during late winter and spring.

Winds are generally not strong as compared to the rest of the state. Daytime winds are generally stronger than nighttime and occasional strong storms may bring brief periods of high winds with gusts to more than 75 mph.

Growth of native cool-season plants begins about April 15 and continues to about July 15. Cool weather and moisture in September may produce some green up of cool season plants that will continue to late October.

The following information is from the “Thermopolis 2” climate station:

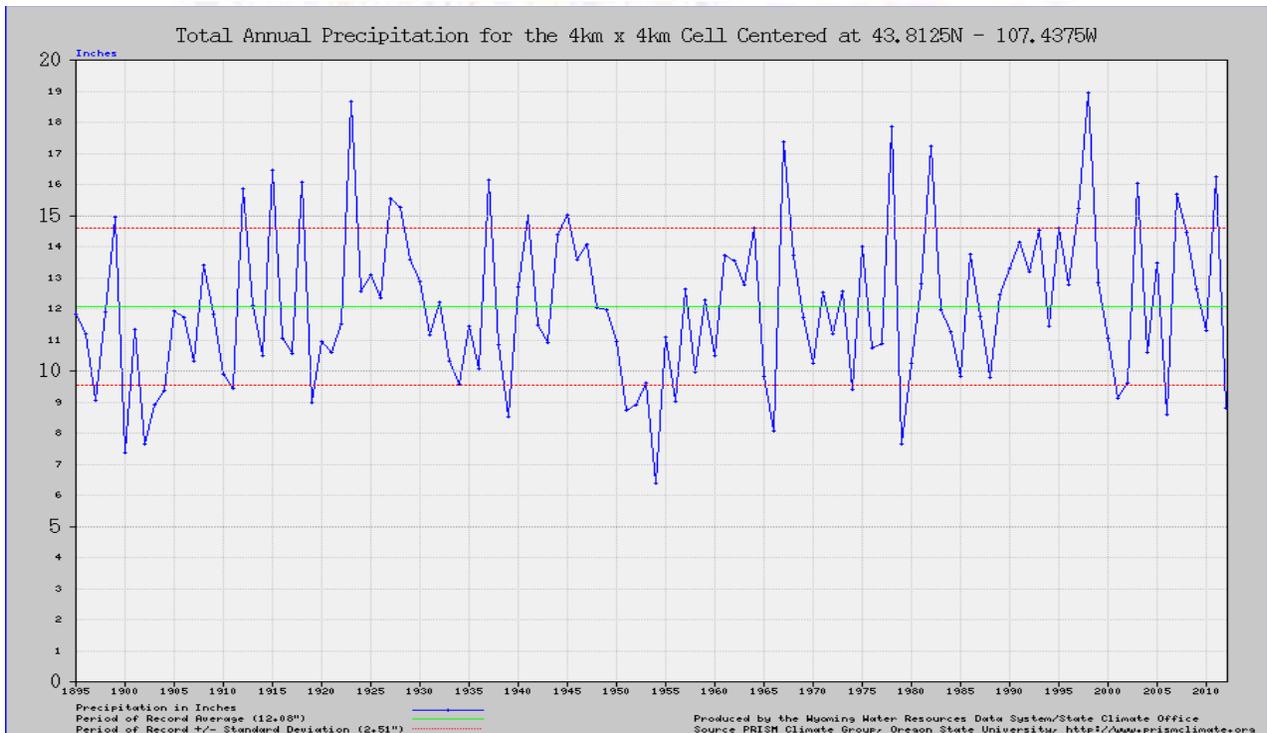
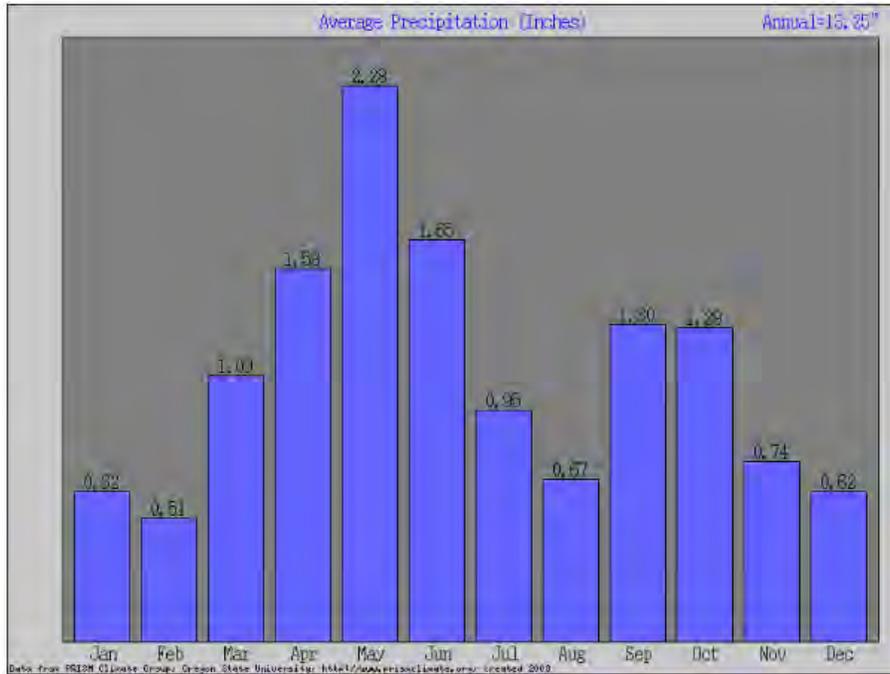
	<u>Minimum</u>	<u>Maximum</u>	<u>5 yrs. out of 10 between</u>
<b>Frost-free period (days):</b>	<b>74</b>	<b>149</b>	<b>May 23 – September 16</b>
<b>Freeze-free period (days):</b>	<b>112</b>	<b>180</b>	<b>May 8 – October 1</b>
<b>Annual Precipitation (inches):</b>	<b>7.6</b>	<b>21.9</b>	

Mean annual precipitation: 12.35 inches

Mean annual air temperature: 46.2 °F (30.1°F Avg. Min. to 62.3°F Avg. Max.)

For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at <http://www.wcc.nrcs.usda.gov/> website. Other climate station(s) representative of this precipitation zone include” Grass Creek 1E”, “Thermopolis”, Thermopolis 25NW”, “Buffalo Bill Dam” and “Black Mountain”.

An additional climate source is referenced to present overall climate data. According to the PRISM (Parameter-elevation Regressions on Independent Slopes Model), overall averages from monthly precipitation, mean annual precipitation, mean annual air temperature, have been sampled from 4 kilometer x 4 kilometer grid cell selected that is centered at 43.81565 N, -107.41226 W, that was approximated to be the average for the Greet Individual Allotment. The model produced 12.3 inches of annual precipitation from 1895-2012 and closely matches the NRCS data above. In total, 40 percent of the annual precipitation is during the months of April-June with May receiving 2.28 inches on average.



The maximum and minimum elevations for each allotment within the Buffalo Creek watershed were calculated along with the average slope given in percent rise for each 10 meter digital elevation grid. The Greet Individual allotment is positioned at the bottom of the watershed and contains the outlet of Buffalo Creek where it conflues with the Nowood River. The elevation range for the Buffalo Creek watershed is 7302 to 4640 feet above sea level at the confluence with the Nowood River at the bottom of Buffalo Creek.

Allotment	Max Elev (ft)	Min Elev (ft)	Average Elev (ft)
Big Cedar	5303	4926	5104
Big Trails	5326	4657	4915
Blue Bank	5411	4871	5095
Buffalo Canyon	6243	5013	5599
Buffalo Creek	5150	4781	4948
Buffalo Sand Point	7051	4848	5468
Chalk Butte	5303	4915	5102
Deadline Draw	5212	4838	4996
Gordon	5210	4720	4878
<b>Greed Individual</b>	<b>4909</b>	<b>4644</b>	<b>4743</b>
Patras	6252	5380	5844
South Butte	5470	4967	5238
Willow Creek	6018	4982	5279

### 2.3 Soils

The soils reflect the desert environment in which they formed. They are highly variable, reflecting differences in parent material (shale, sandstone and/or mixed alluvium), position on the landscape, slope and aspect. Soil depth ranges from 1 inch to over 60 inches with sandstone and soft shale bedrock common below the substratum. The soils typically have a light brown surface layer. Loamy and sandy surface textures dominate most of the landscape. The subsoil often reflects an increase in clay being expressed as an argillic horizon. Increases in sodium are also common being reflected as a natric horizon in the subsoil. Slopes range from 0 to 60 percent, but are generally less than 30 percent.

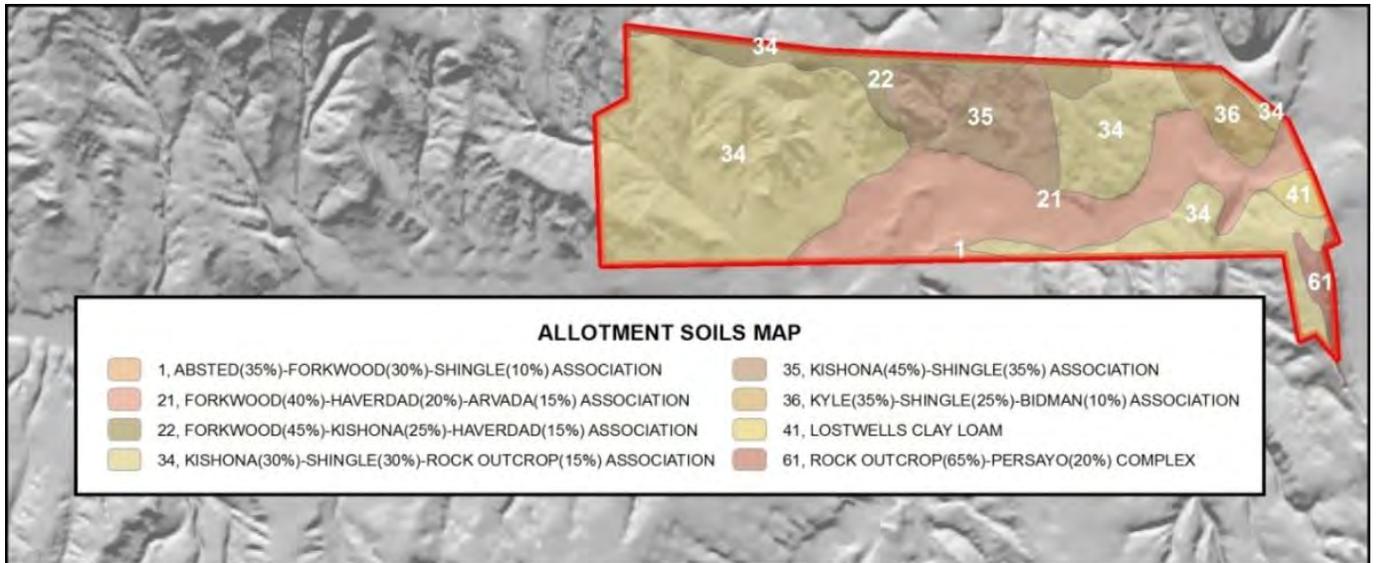
The Greet Individual Allotment is situated within the 10-14 inch Big Horn Basin (BH) Precip Zone as depicted by NRCS spatial data. Based on the soil survey data for Washakie County, the dominant soil units found in the allotment are listed below:

Soil Map Unit	Name	Acreage in Allotment	Characteristics	Ecological Site
1	Absted-Forkwood-Shingle Assn.	4	Absted soils are on fan remnants, alluvial fans, hillslopes and terraces, very fine sandy loam. Forkwood soils are on terraces, alluvial fans, fan remnants, hills, ridges and pediments. Shingle soils are very shallow or shallow to bedrock	Loamy 10-14 R032XY322WY Shallow Clayey 10-14" R032XY358WY
21	Forkwood-Haverdad-Arvada	219	Forkwood soils are on terraces, alluvial fans, fan remnants, hills, ridges and pediments. Haverdad series consists of very deep, well drained soils formed in stratified alluvium on flood plains and low terraces. Arvada soils are on alluvial fans, fan remnants, fan terraces and hillslopes. Slopes are 0 to 25%	Loamy 10-14" R032XY322WY Saline Lowland 10-14" R032XY338WY Saline Upland 10-14" R032XY344WY
22	Forkwood-Kishona-Haverdad	58	Forkwood soils are on terraces, alluvial fans, fan remnants, hills, ridges and pediments. Kishona soils are formed in alluvium on fan aprons, alluvial fans, fan remnants, hills, ridges terraces. Haverdad	Loamy 10-14" R032XY322WY, Lowland (LL) 10-14" R032XY328WY

			series consists of very deep, well drained soils formed in stratified alluvium on flood plains and low terraces.	
34	Kishona-Shingle-Rock Outcrop	510	Shingle series consists of well drained soils that are very shallow or shallow to bedrock. They formed in residuum and colluvium derived from interbedded shale and sandstone or in alluvium from mudstone. Shingle soils are on bedrock controlled hillslopes and ridges. Slopes are 0 to 80 %. Rock outcrop is exposures of shale and sandstone Kishona soils are formed in alluvium on fan aprons, alluvial fans, fan remnants, hills, ridges terraces. Kishona's lack argillic horizon.	Loamy 10-14" R032XY322WY Shallow Clayey 10-14" R032XY358WY Rock Outcrop
35	Kishona-Shingle	99		Saline Upland 10-14" R032XY344WY Shallow Clayey 10-14" R032XY358WY
36	Kyle-Shingle-Bidman Association	33	The Kyle soil is on back slopes of uplands, the shingle soil is on the tops of ridges and hills, and the Bidman is on fans.	Loamy 10-14" R032XY322WY, Shallow Loamy 10-14" R032XY362WY
41	Lostwells Clay Loam	11	Lostwells series consists of very deep, well drained soils that formed in alluvium. Lostwells soils are on alluvial terraces and floodplains and have slopes of 0 to 10 %	Loamy 10-14" R032XY322WY
61	Rock Outcrop-Persayo Complex 15-70% Slopes	14	Rock outcrop is exposures of shale and sandstone. Persayo is shallow and well drained. Runoff is rapid, and hazard of erosion is high.	Shallow Loamy 10-14" R032XY362WY, Very Shallow 10-14". R032XY376WY

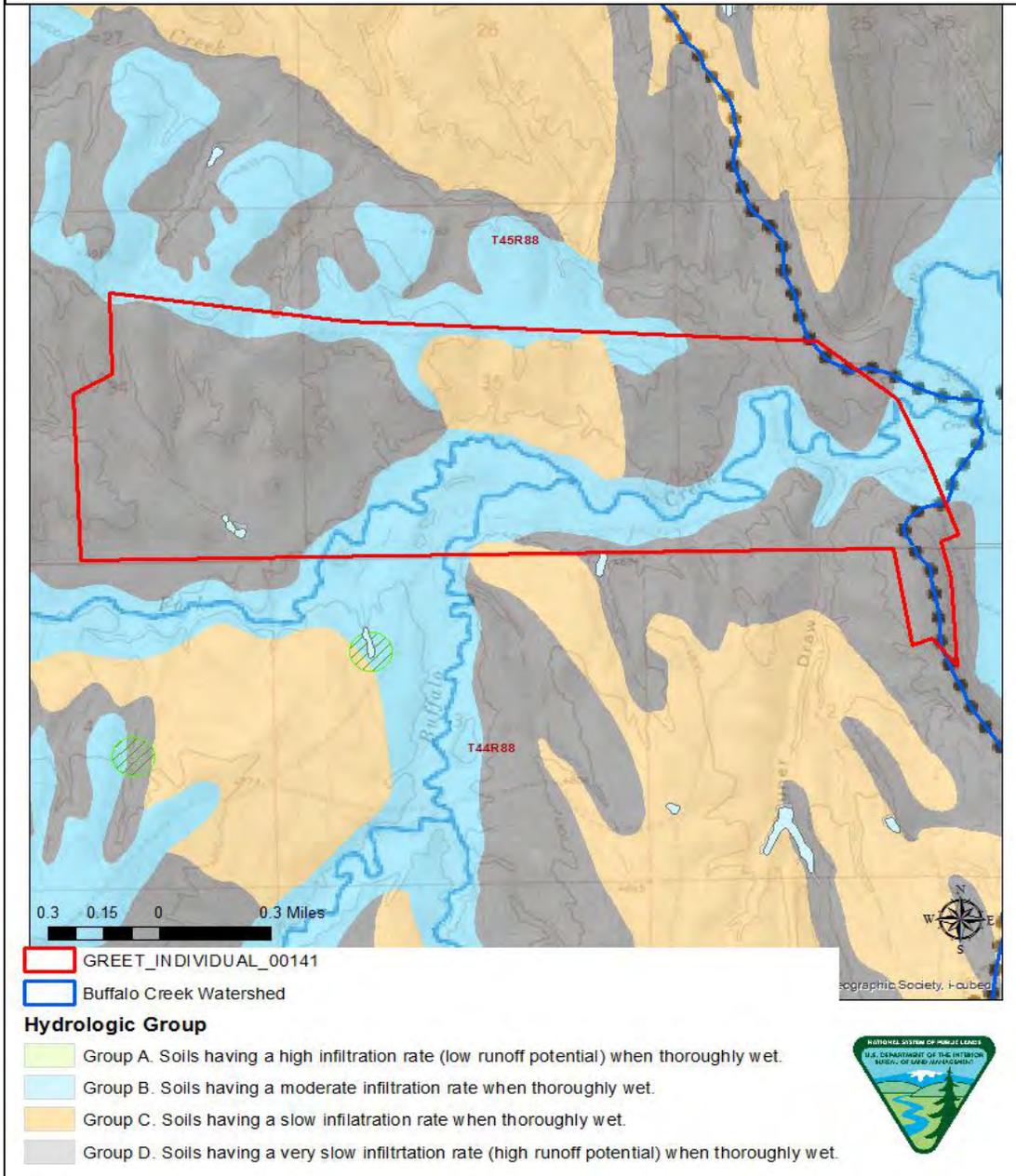
Three rangeland health assessments utilizing the methodology described in Interpreting Indicators of Rangeland Health, BLM Technical Reference 1734-6, were relied upon in the analysis of the Greet Individual Allotment. The assessments were conducted at monitoring sites selected for this analysis. The table below shows the soils and soil characteristic for each assessment site.

<b>Soil Features</b>	<b>SEC6 NESE</b>
<b>Soil Name</b>	Forkwood
<b>Parent Material Kind</b>	sandstones and shales
<b>Surface Texture</b>	silty clay
<b>Soil Stability Index</b>	3.6



The Soil Hydrologic Group map below displays the distribution of the dominant soil hydrologic group that is assigned to the watershed. Group B type soils are those where the dominant soil type in the soil map unit contains moderate/high infiltration rates, locally in the watershed these areas are located within the floodplain area of Buffalo Creek. The group C soils are from loamy range ecological sites in the watershed. The group D soils are very common in the shale outcrop sections of the watershed where shale and other rock outcrops are common and the depth to the bedrock is less than 50 centimeters. The Greet Individual allotment is dominantly group D soils with some group B soils along the Buffalo Creek drainage.

## Greet Individual #00141 Dominant Soil Hydrologic Groups

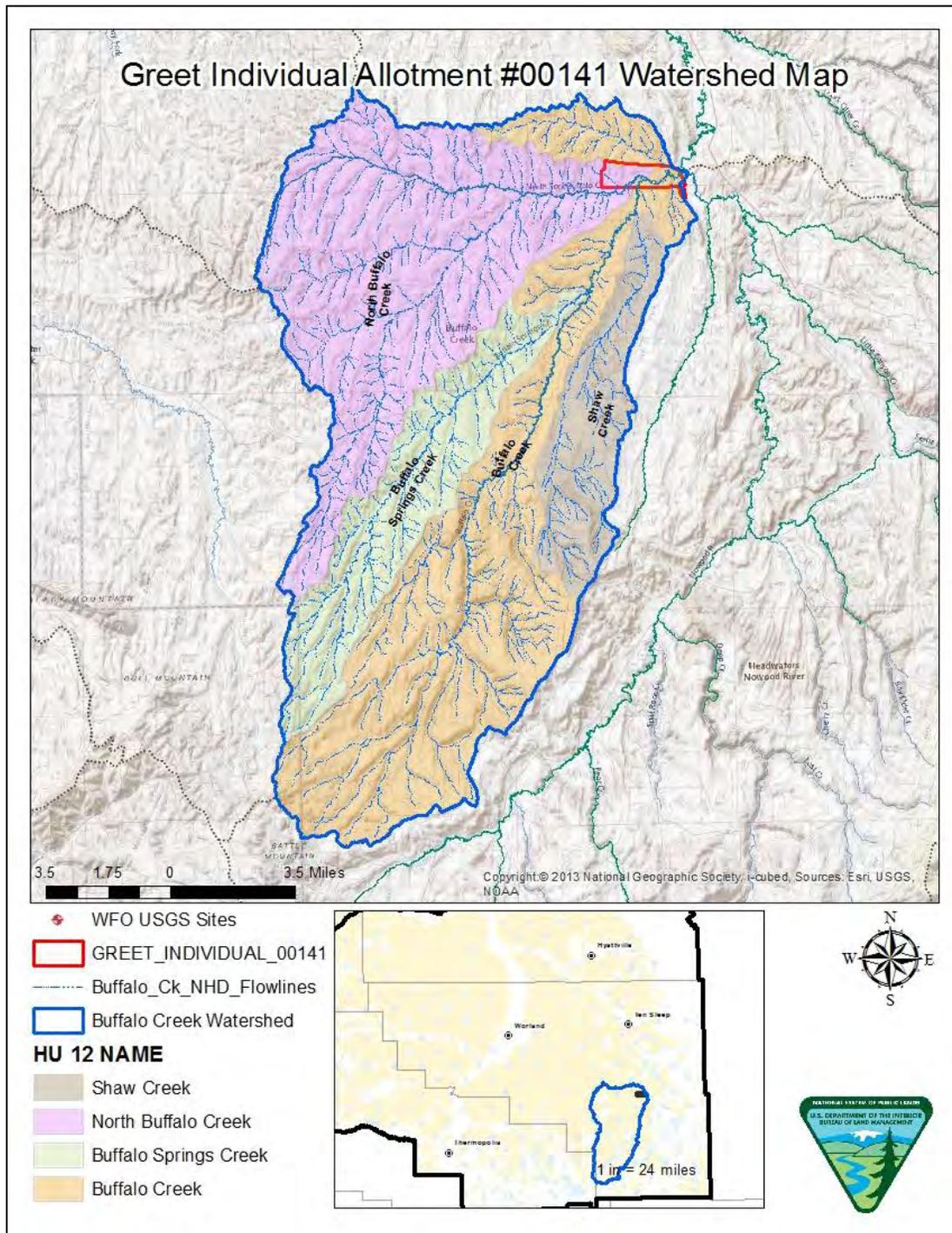


## 2.4 Hydrology / Riparian

### 2.4.1 Surface Water/Watershed

The Greet Individual allotment is located mostly within the Buffalo Creek USGS (level #5) watershed. The allotment contains the lower reaches of the Buffalo Creek and North Buffalo Creek sub-watersheds (level #6). The allotment consists of % 1.0 and 1.4% of the total area of the Buffalo and North Buffalo Creek sub-watersheds. The eastern portion of the allotment drains into the Nowood River and consists of a minor portion of the sub-watershed (<0.001 %).

Sub-Watershed Name (HU12)	HUC 12	Acres	(mi)	Allot Acres	Allot mi <sup>2</sup>	% of Acres of Sub-watershed in the allotment
Buffalo Creek	100800080201	43,766	68.38	439	0.7	1.0
North Buffalo Creek	100800080204	34,549	53.98	489	0.8	1.4
Nowood River-Willow Creek	100800080105	37,944	59.29	18	0.0	0.001
<b>Total:</b>		<b>116,259</b>	<b>181.65</b>	<b>946</b>	<b>1.5</b>	



The total length of ephemeral/intermittent channels for the allotment is 11.3 kilometers that are Buffalo Creek and North Buffalo Creek and their tributaries. Rainfall patterns in arid and semi-arid regions influence when stream flow is most likely (EPA, 2008).

**Rosgen Channel Types (Rosgen,1996)**

The main channel material or d50 for the Buffalo Creek is a classified as sand material size. These channel types generate naturally high bed-load and sediment transport rates and flow only in response to precipitation events between 2-5 percent of the total days in the average year (Hedman, 1983). Rosgen F5 type channels are described as entrenched, meandering channels which are deeply incised in valleys of relatively low relief such as the Buffalo Creek sub-watershed (Anderson,2009).They contain highly weathered rock and erodible materials, and high lateral extension rates and bar deposition following infrequent storm events. Other less entrenched reaches of the Buffalo Creek and tributaries such as the Nowood River are classified as Rosgen C5 channels, when healthy, where there is still periodic flooding and access to the floodplain from high flow events. The average main channel slope is the low< 1 percent).

**Drainage Pattern-** The dominant land forming topographic process is from alluvial forces of erosion. The drainage pattern is a dendritic drainage pattern that reflects horizontal sedimentary bedrock over which it was formed. The drainage density or amount of drainages per square mile is high, and very high steep rock outcrops of the allotment.

Allotment	Main Channel	Avg. Main Channel Slope	Rosgen Channel Types
Greet Individual	Buffalo Creek	0.80	F5
Greet Individual	North Fork Buffalo Creek	0.50	F5

The following hydrograph was taken as part of the Nowood River Level I watershed study, where potential reservoir storage sites were analyzed and the inflows into the proposed sites were estimated based on runoff from the watershed. This hydrograph represents watersheds located west of the Nowood River at elevations ranging from 5000-6500 feet (Anderson,2009 p.3.38).

The gage is located approximately 2,900 feet upstream of the confluence of Buffalo Creek and the Nowood River. The site is located on lands owned by the State of Wyoming and accessed through the Greet Ranch. The Buffalo Creek watershed upstream of the gage is approximately 174.6 square miles. The gage was installed on March 12, 2009 and removed on November 11, 2009. Snowmelt runoff had not completely occurred when the gage was installed. Figure 3.44 displays the hydrograph measured at this site. Note the rise in the hydrograph beginning in October. This apparent increase in stream flow is the result of bank sloughing resulting in a shift in the gage rating curve resulting in a false reporting of higher flows.

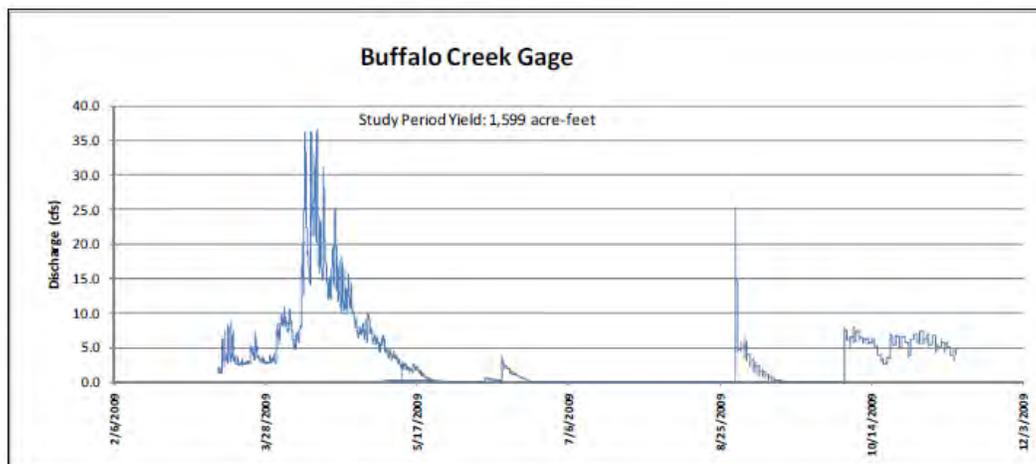
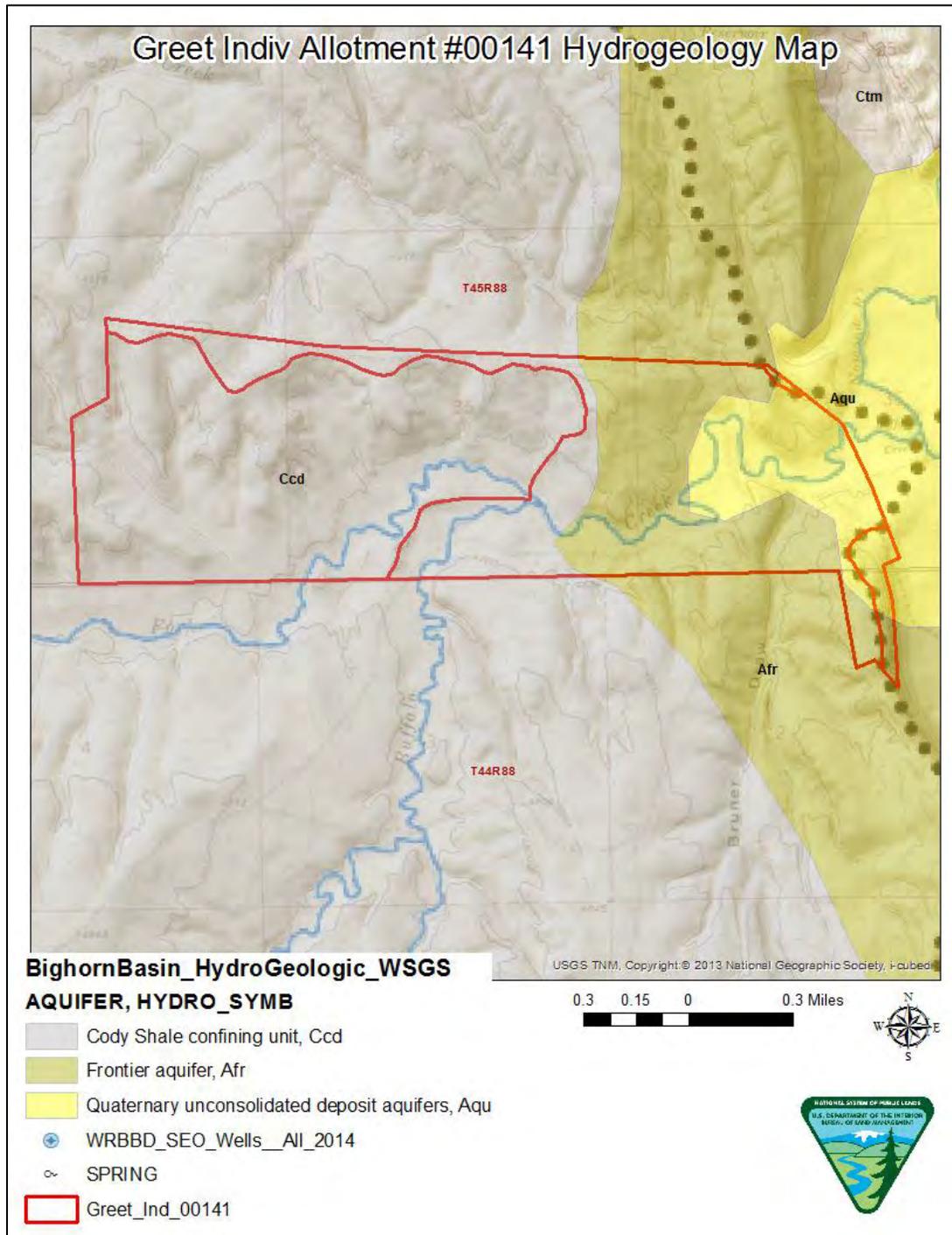


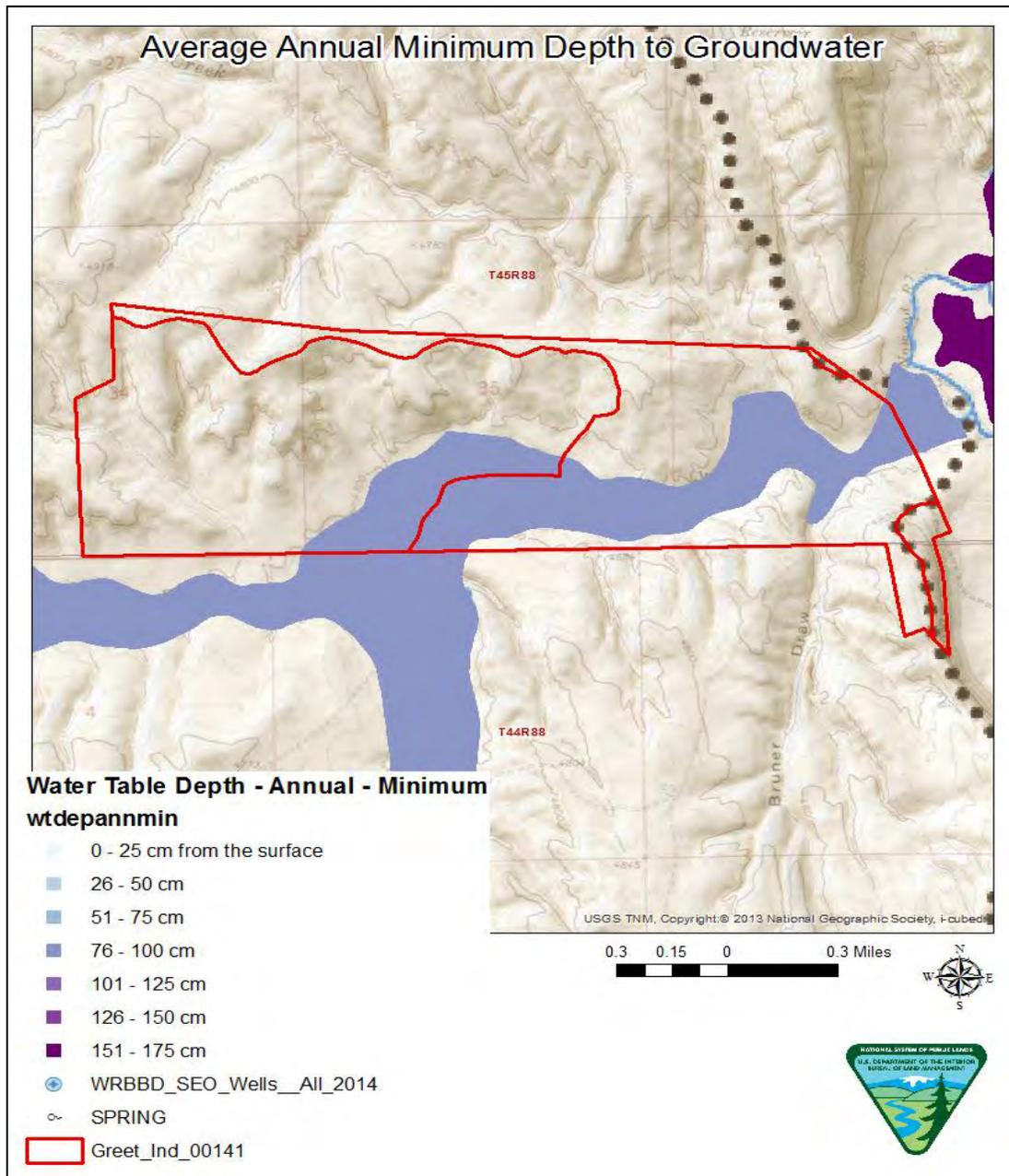
Figure 3.44 Buffalo Creek Hydrograph: March 14 through November 11, 2009

### 2.4.2 Groundwater

The area is located in a semi-erosive area with high amounts of runoff and very low permeability due to very fine grained geologic outcrops of primarily Cretaceous aged outcrop of the Cody Shale Formation. The Cretaceous Frontier Formation is dominant sandstone that forms sandstone ridges in the allotment. The minor portions of the allotment are mapped as a Quaternary aquifer near the drainages of North Buffalo and Buffalo Creek.



The average annual minimum depth to groundwater is found along the floodplain areas of the main drainages and is mapped at a depth of 75-100 centimeters annually and greater than 125 centimeters for the Patras allotment. There are no water wells in the allotment.



Ground-water recharge in arid and semi-arid regions has generally been viewed as the sum of several different distinct pathways including mountain-block recharge, mountain-front recharge, spatially distributed recharge, and ephemeral stream channel recharge. Recent research has expanded this view to include the mediating role of vegetation (i.e. water use by vegetation), and the greater role of ephemeral stream channel recharge in basin floors (EPA, 2008 p.22). The ground-water recharge for this watershed is likely in the form of ephemeral stream channel recharge.

### 2.4.3 Water Quality (Surface)

The main drainages of Buffalo Creek are classified by the Wyoming Department of Environmental Quality (DEQ) as class 3B type streams. The associated beneficial uses for class 3B streams are found in the table below. This is the default rating given by the DEQ and this stream flows on average three to four weeks annually and is considered ephemeral. DEQ defines “these streams support other aquatic life, recreation, wildlife, agriculture, industry, and provide scenic value throughout portions of the year”.

Wyoming DEQ Surface Water Use Class and TMDL Summary

Surface Water Classes	WY DEQ Use Designations										
	Drinking Water	Game Fish	Non-Game Fish	Fish Consumption	Other Aquatic Life	Recreation	Wildlife	Agriculture	Industry	Scenic Value	
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	

### 2.4.4 Riparian

Buffalo Creek and North Buffalo Creek are the main drainages of the allotment that contain riparian habitat. These segments are located on state and private land and not further evaluated in this document. There are no other riparian areas or wetlands on public land in this allotment.

## 2.5 Upland Vegetation

The uplands and drainages throughout the allotment are made up of a variety of shallow and saline range sites. The main sites include: Rock Outcrop, Shallow Loamy, and Loamy sites making up the majority of the allotment acres.

Plant composition within the allotment observed on the transect and generally throughout the allotment included: Needle&Thread (*Hesperostipa comata*), Bluebunch wheatgrass (*Pseudoroegneria spicata*), prairie Junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa secunda*), Western wheatgrass (*Pascopyrum smithii*), Cheatgrass (*Bromus Tectorum*), Plains pricklypear (*Opuntia polyacantha*), Scarlet globemallow (*Sphaeralcea coccinea*), sego lily (*Calochortus nuttallii*), Textile onion (*Allium textile*), Hood’s Plox (*Phlox hoodii*), Wyoming Big sagebrush (*Artemisia tridentata ssp. wyomingensis*), and greasewood (*Sarcobatus vermiculatus*) This list is not all inclusive; however the vegetation noted are those that are quite evident and readily found. Cheatgrass (*Bromus tectorum*), field brome (*Bromus arvensis*) and numerous annual forbs were found to be the most common and dominate plants in the allotment. No known threatened or endangered plant species have been documented in the allotment.

## 2.6 Invasive Species

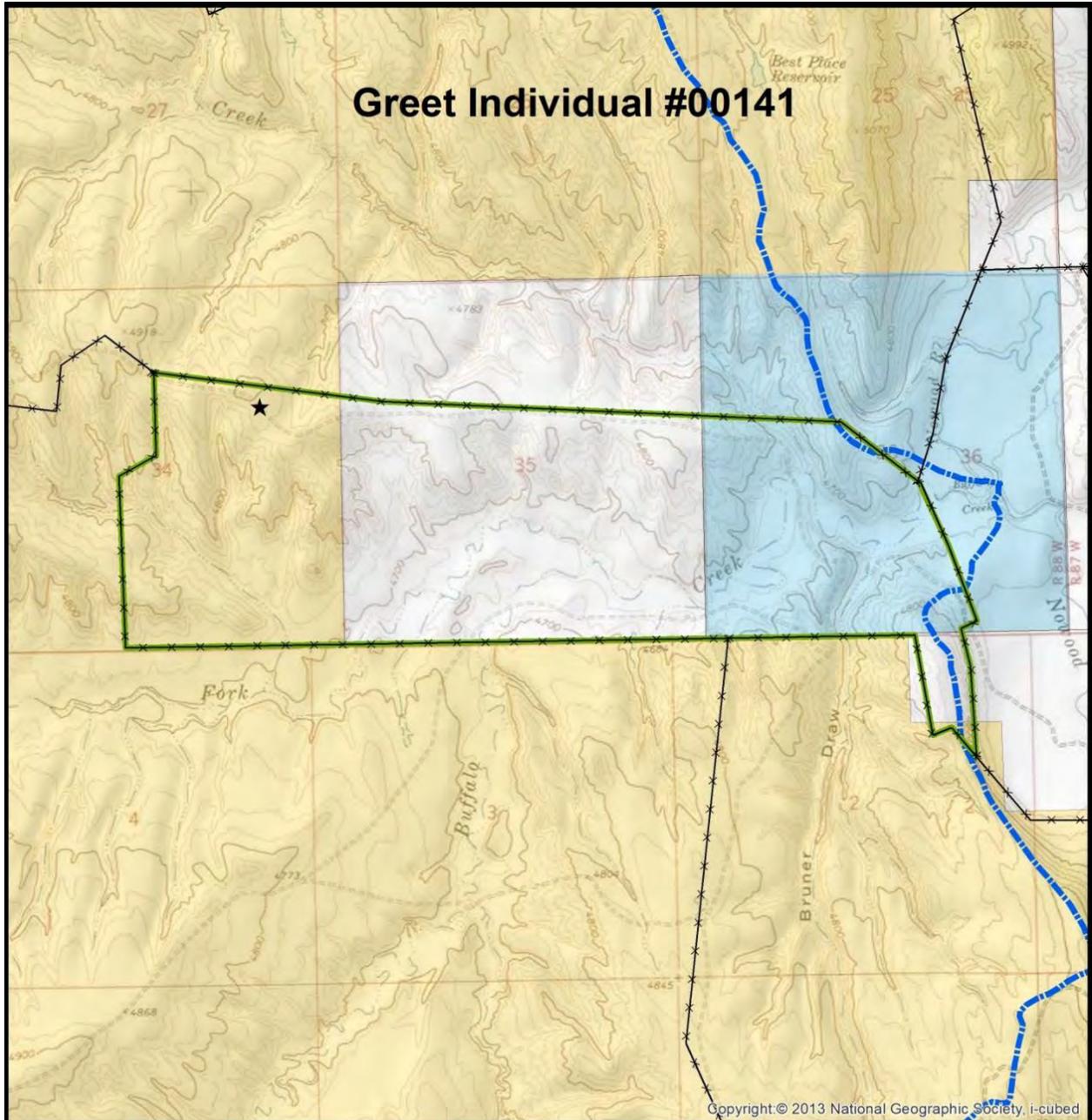
Noxious weed species inventoried within the allotment include saltcedar (*Tamarix chinensis*) around reservoirs holding water and Canada thistle (*Cirsium arvense*) within drainages with active springs. Cheatgrass (*Bromus tectorum*) has become established and is the dominant species in most of the allotment.

## 2.7 Livestock Grazing Management

The Greet Individual Allotment is permitted for cattle grazing in the summer. A total of 52 animal unit months (AUMs) of livestock grazing use are permitted as follows:

122 Cattle      06/10-07/15      29% Public Land      52 AUMs

A search through the billing records shows that the allotment was billed in full 8 out of 10 years. Two of the past 10 years were not billed and assumed to be either conservation nonuse or for operational reasons. Since the allotment was billed in full and because of its small size, it is unknown what the actual use was. The 10 year average comes to 42.5 AUMs or 80% of permitted use.



<ul style="list-style-type: none"> <li>★ Assessment Point</li> <li> Buffalo Creek Watershed</li> <li> Allotment Boundary</li> <li> Fence Line</li> <li>★ Assessment Point</li> <li> Bureau of Land Management</li> <li> Private</li> <li> State</li> </ul>	<p><b>MAP AREA</b></p>	 
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**WORLAND FIELD OFFICE**

## **2.8 Wildlife**

Wildlife habitat on the Greet Individual allotment is suitable for a wide range of big game, non-game, and sensitive wildlife species. The allotment is characterized primarily by gently sloped sagebrush plains with deeper draws sloping into the Buffalo Creek drainage. The vegetation is characterized by a mix of Wyoming Big sagebrush, perennial grasses, and cheatgrass, with components of salt tolerant brush species and bluebunch wheatgrass. Mule deer and antelope use the allotment year round with higher concentrations of mule deer utilizing it during late fall and winter. Elk may also be found there during winter months. The entire allotment is designated as crucial big game winter habitat for mule deer, elk, and antelope. The allotment also provides habitat for a wide range of wildlife species such as small mammals and predators, numerous grassland passerines, sage grouse, prairie dogs, and raptors.

## **2.9 Threatened, Endangered, Candidate, or Sensitive Species**

No known threatened or endangered species have been identified on the allotment, however Greater Sage-grouse, a BLM sensitive species, can be found there at various seasons of the year. The entire allotment is within designated sage grouse core breeding area. Various additional sagebrush obligate avian species such as the Sage sparrow, Brewer's sparrow, and Sage Thrasher may also utilize habitat within the allotment. No White-tail prairie dog colonies have been identified within the allotment.

## **3.0 Summary of Monitoring Data / Assessments**

In the summer of 2014, one monitoring site was selected in the allotment as part of the Rangeland Health Assessment process. Ecological site, soil type, vegetative community, topography, location of water sources, and livestock grazing history are some of the factors that were considered in the selection of these monitoring sites. The allotment map in section 2.7, illustrates the monitoring site locations. Photographs of each assessment site are located in section 3.4.

### **3.1 Monitoring Data**

Rangeland Health Assessments were conducted at the monitoring sites by an interdisciplinary team using the 17 Indicators of Rangeland Health as described in BLM Technical Reference 1734-6. Field observations were compared to the Reference Sheets appropriate for that range site to determine departures from normal. Individual ratings for the *Rangeland Health Indicators* are displayed for each monitoring site below.

<b>Rangeland Health Indicators</b>	
<b>Indicator</b>	<b>Departure from Reference Sheet</b>
	<b>Greet Individual SEC34 SENE</b>
1. Rills	N-S
2. Water-flow patterns	N-S
3. Pedestals and/or terracettes	S-M
4. Bare ground	M
5. Gullies	N-S
6. Wind-scoured, blowouts, &/or deposition areas	N-S
7. Litter movement	N-S
8. Soil surface resistance to erosion	M
9. Soil surface loss or degradation	M
10. Plant community composition & distribution relative to infiltration	S-M
11. Compaction layer	N-S
12. Functional / structural groups	M-E
13. Plant mortality / decadence	N-S
14. Litter amount	S-M
15. Annual production	N-S
16. Invasive plants	M-E
17. Reproductive capability of perennial plants	M
<b>Indicator Summary</b>	<b>SEC34 SENE</b>
<b>Soil / Site Stability</b> ( <i>Indicators 1-9, 11</i> )	<b>S-M</b>
<b>Hydrologic Function</b> ( <i>Indicators 1-5, 8-11, 14</i> )	<b>S-M</b>
<b>Biotic Integrity</b> ( <i>Indicators 8-9, 11-17</i> )	<b>M</b>
N-S None to Slight    S-M Slight to Moderate    M Moderate M-E Moderate to Extreme    E-T Extreme to Total	

### 3.2 Soils and Site Stability

Data collected for the Rangeland Health Assessments were used to evaluate soil and site stability on the allotment. Standard 1 for Healthy Rangelands was evaluated based on the attribute ratings for *Soil and Site Stability* using rangeland health indicators 1 through 9 and 11.

#### Greet Individual Allotment SEC34 SENE Assessment Site

The overall Soil and Site Stability rating for this sight was averaged to have a Slight to Moderate departure from the reference state for a Loamy 10-14" site. The indicator evaluation matrix field notes are summarized as followed: Active rill formations were not observed on the site. Water-flow patterns were uncommon and short, less than 2 inches, and stable. Few active pedestals present with some evidence of past pedestals found around bunch grasses and Sagebrush. Amount and size of bare ground areas were moderately higher than expected with unconnected patches 5-6 feet in diameter. Gullies were not present on any of the upland sites. No wind scoured, blowouts or depositional areas present. Litter movement matched what was expected for the site with small and large classes staying in place. Soil surface resistance to erosion (SSI) on this site was 3.6; and soil surface appeared to have been moderately reduced throughout the site with 2 inches 'A' horizon. No evidence of compaction layers.

### 3.3 Hydrology

#### 3.3.1 Surface Water

According to the hydrograph that was presented in 2.3.1 for Buffalo Creek, the majority of the flow in the channels is during late March and April with little to no flow in the channel from May through September. The upland drainages in the Greet Individual allotment are on a dip slope with moderate amounts of infiltration and minimal runoff. The amount of runoff from the allotment is correlated with the soil and hydrologic indicators using the *Rangeland Health Indicators as presented above in section 3.1*. The overall soil and hydrologic function indicators

were rated with a slight to moderate departure from the reference conditions as described above. This suggests that the timing and amount of runoff from upland areas is within healthy rangeland parameters and near what is expected for the ecological site. The erosional observations for the hydrology are linked with the soil indicators as described above in section 3.2. The bank conditions of the larger channels are a Rosgen F type characteristics indicate poor entrenched channel conditions. There is one reservoir named Ritchie Reservoir that is located in the SESE of Section 34 of Township 45N Range 88W, this reservoir sporadically holds 6.5 acre feet of water at full capacity but is currently dry and has a reduced capacity.

### **Human Influence**

The historic construction of the reservoirs in the allotment has changed the flow pattern of the drainages. When functioning, the reservoirs trap and store sediment that otherwise would be delivered downstream. When the reservoirs become in disrepair the release the previously stored sediment and often create head cuts or changes in the channel geometry that can cause excessive erosion. The reservoirs in this allotment were of small size and have a minimal impact to the surface water runoff of Buffalo Creek. Other anthropogenic disturbances that alter runoff conditions such as roads are minimal in this allotment. There are no other surface water issues such as water diversions present in this allotment.

#### **3.3.2 Ground Water**

There are no wells or springs in the allotment. Any potential groundwater recharge would occur in where the Frontier Aquifer is present and form infiltration along drainages. Currently there is no demand for additional groundwater in the allotment.

#### **3.3.3 Water Quality**

Due to the flow regime of the channel, there has been no specific data gathered for this allotment. The following are taken from the Nowood Level I study.

“The Bureau of Land Management (BLM) in Wyoming is partnering in the implementation of several section 319 watershed plans statewide as part of their Watershed and Water Quality Improvement efforts. Given the distribution of private, state and federal (primarily BLM) lands within the Nowood watershed, this type of partnering may be applicable to future BMP projects that might best be implemented across land ownerships (Anderson,2009 p. 7.4).

#### **Wyoming DEQ:**

It is anticipated that as the Wyoming Department of Environmental Quality (WDEQ) continues the inventory of waters of the State and the identification of Impaired and/or Threatened water bodies, BLM will be partnering with the WDEQ to improve water quality in water bodies on Public Lands. In the course of developing watershed plans or TMDL's for these watersheds, BLM will be routinely involved in watershed health assessments, planning, project implementation and Best Management Practice (BMP) monitoring.

Anthropogenic uses and activities on the landscape can have significant impacts – both adverse and beneficial– on water quality and the health of a watershed. Human-related disturbances are numerous and include livestock grazing, land clearing, mining, timber harvesting, ground- water withdrawal, stream flow diversion, channelization, urbanization, agriculture, roads and road construction, off-road vehicle use, camping, hiking, and vegetation conversion. Biological stressors include habitat loss, alteration, effluent discharge, and degradation from decline in water quality, and changes in channel and flow characteristics (EPA, 2008 p.65). These types of indicators are taken into consideration for standard 5 evaluations.

#### **3.3.4 Riparian**

There are no riparian areas on public land in the allotment and therefore standard 2 is not applicable for this allotment.

### **3.4 Upland Vegetation**

Data from the line intercept cover transects, the 17 Indicators of Rangeland Health, and other field observations were used to evaluate the vegetative community on the allotment. Standard 3 for Healthy Rangelands was evaluated based on the attribute ratings for Biotic Integrity using rangeland health indicators 8 through 9, and 11 through 17.

The vegetative community, ground cover, and soil surface attributes for the assessment sites was noted, measured and compared to the ecological site description (ESD) and corresponding reference sheet for a Loamy 10-14 inch precipitation zone (R032XY322WY) ecological site dated 5/23/2008).

The Historic Climax Plant Community for a Loamy ecological site is a Bluebunch Wheatgrass/Rhizomatous Wheatgrass plant community. This community would be dominated by cool season grasses (75%) followed by a nearly even balance of forbs (10%) and woody species (15%). With moderate continuous season long grazing or extended droughts a transition from HCPC to a Perennial Grass/Big sagebrush state may occur. This state is dominated by cool season grasses but short warm season grasses and various forbs are present and shrubs would be a conspicuous part of the site. The state has a hydrologic, soil, and biotic community that is stable and intact. From this state, with frequent and severe grazing, lack of fire, extended droughts or severe grazing in conjunction with wildfire or brush control the vegetative state can be converted to a Blue grama sod community, a Big Sagebrush/bare ground community or a salt tolerant shrub/ bare ground community and from there to a salt tolerant shrub/rhizomatous wheatgrass state.

States beyond the Perennial grass/Big sagebrush community are likely to have a biotic, soil, and hydrologic function that is at risk or not functioning. Herbaceous production will decline, the undesirable species increase as the desirable species decrease, and the ability to move towards HCPC is diminished without mechanical treatments, reseeding efforts, soil remediation efforts, and intense grazing management.

A summary of the cover data collected is shown in the table below:

<b>Vegetation Monitoring Data</b>						
<b>Monitoring Site</b>	<b>Ecological Site 10-14"p.z.</b>	<b>Basal Veg. Cover</b>	<b>Interspace Litter</b>	<b>Bare Ground</b>	<b>Sagebrush Presence</b>	<b>Brte presence ((hits/transect pts)*100)</b>
SEC34_SENE	Loamy	13%	2%	11%	14%	54

Cheatgrass presence is derived from total "hits" on cheatgrass, canopy or basal, throughout the transect. It is a representation of the amount times the plant was encountered along a transect in relation to the amount of points observed on the transect.

#### SEC 34 SENE

All of the indicators evaluated were averaged to have a "Moderate" departure from the reference state for a Loamy 10-14" site. The dominant functional / structural groups at this monitoring site was 54% cheatgrass, *Bromus Tectorum*, followed by shrubs, followed by mid stature grasses, mainly Sandberg bluegrass *Poa secunda*, then followed by sagebrush and perennial cool-season bunchgrasses. All plants exhibited good annual production however reproductive capability of bunchgrasses was moderately reduced do to incapacity to establish within cheatgrass dominated areas. Cheatgrass and field brome were not evenly distributed throughout the allotment but occurred in large monoculture patches.



The site monitored on this allotment does not fit clearly into any of the plant community types described in the Ecological Site Description. The vegetative components described in the *Perennial Grass/Big Sagebrush Plant Community* are present on these sites, although not in the desired abundance. While the desirable perennial grasses if found on these sites exhibited good vigor and seed production, it appears that they are struggling to successfully compete with cheatgrass. Since vegetative trend studies have not been conducted on the allotment, it is not known whether the amount of cheatgrass is increasing, decreasing, or remaining stable. Any increase in the amount of cheatgrass on these sites would likely correspond to a decrease in the frequency of desirable perennial grasses. This would likely have the effect of pushing these sites into an ecological state similar to the *Big Sagebrush/Bare Ground Plant Community* type, with cheatgrass replacing the bare ground component. Due primarily to the decreased perennial grass component, and the high occurrence of cheatgrass in the allotment, the *Biotic Integrity* at each site monitored in the allotment was rated as a “Moderate” departure.

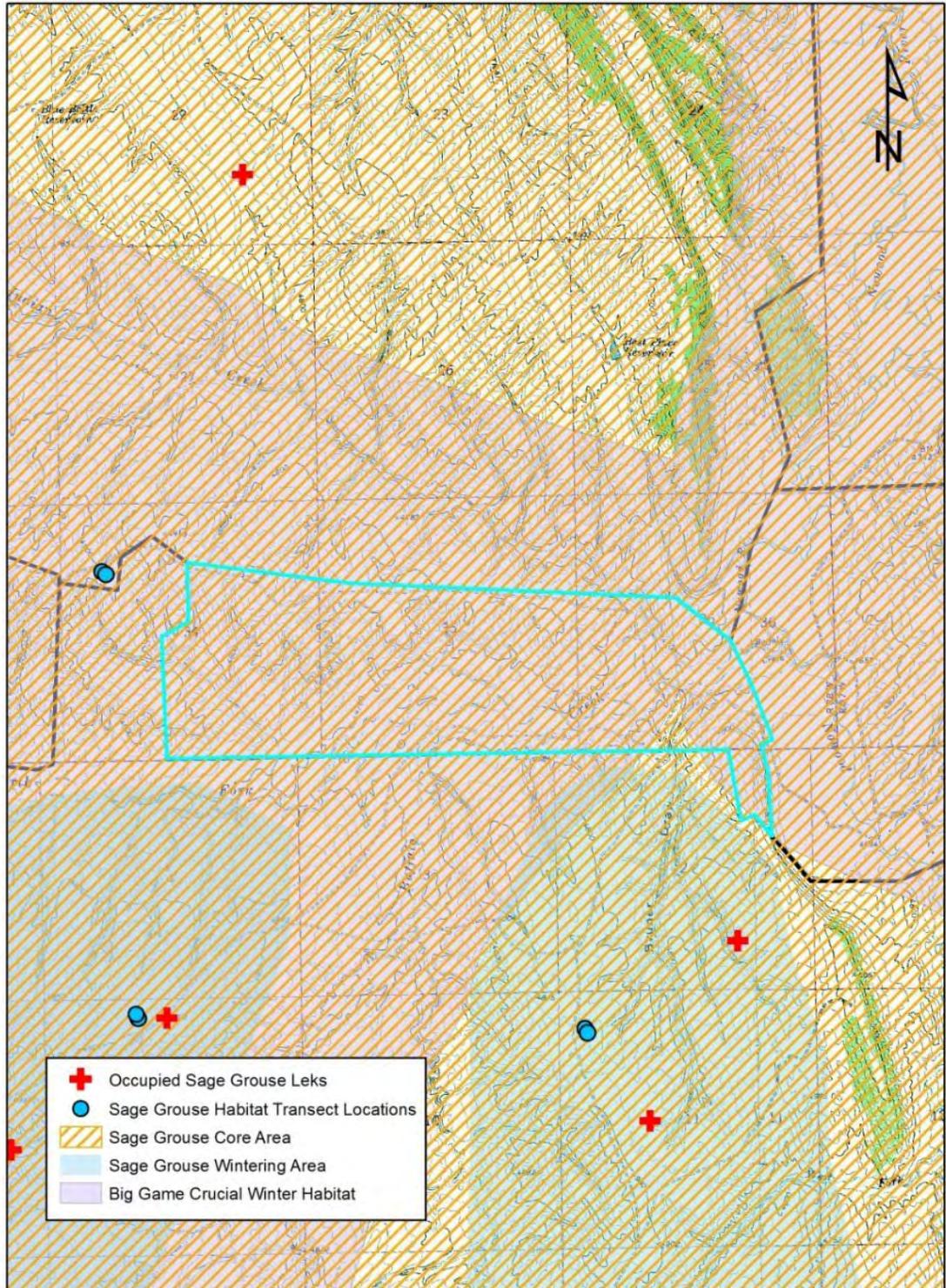
#### **Additional Observations**

Every ecological site on the allotment was not intensively monitored. The site selected for monitoring was determined to be representative of the overall condition of the upland sites within the allotment. Field observations indicate that the majority the allotment was best represented by the selected monitoring/assessment site.

### **3.5 Wildlife Habitat**

Wildlife habitat on the Greet Individual allotment is characterized by a Wyoming big sagebrush/perennial grass plant community. The area consists of benches and smaller drainages that make up the lower Buffalo Creek drainage flowing east into Nowood Creek. Pronghorn antelope can be found there throughout the year. Mule deer and elk are also found on the allotment with higher concentrations during the winter months. A single habitat assessment transect representative of the sage-grouse habitat on the allotment was conducted during the growing season of 2014 to determine and record the canopy cover, brush height, and vegetation components of the wildlife habitat on the allotment. Live sagebrush canopy cover was determined to be 14 percent at the transect point, and sagebrush height averaged 9 inches. Belt transect surveys determined the mature sagebrush component to average 58 percent, indicating sagebrush growth appropriate for sagebrush/perennial grass habitat in this precipitation zone. These measures indicate viable habitat to sustain the numerous sagebrush obligate and native wildlife species that can be expected to be found at this site.

# Greet Individual Allotment Wildlife Habitat Map



<b>Sage-grouse Habitat Transect #1</b>					
Date: 5/19/14_		Observers: <u>Ken Stinson, Jim Andersen</u>			
Allotment Name: Greet Ind.					
Location: LAT/LONG N 43'49.533 W 107'25.561					
<b>Line Intercept Canopy Cover</b>					
<b>Species</b>		<b>% Cover</b>			
Live Big Sagebrush		14			
Dead Big Sagebrush					
Other SPP: (Fringed)					
Other SPP: (Rabbit Brush)					
<b>Shrub Species</b>		<b>Average Height in inches</b>			
Live Big Sagebrush		9			
Other SPP: (Gardner Saltbush)					
Other SPP: (Bud Sage)					
<b>Belt Transect</b>					
<b>Species</b>	<b>%Young</b>	<b>%Mature</b>	<b>%Decadent</b>	<b>%Dead</b>	
Big Sagebrush	0	58	17	25	
<b>Daubenmire Cover Class &amp; Vegetation Height Data</b>					
Summary of Vegetation Height	New Herbaceous Mean Ht: 7.5"		Residual Herbaceous Mean Ht:0.66 "		
Summary of Cover Class (%)	New Perennial Grasses: 16.0%	New Annual Grass: 2.5%	Perennial Forb: 4.6%	Residual Herbaceous: 0.9%	Other: 52.5%
<b>Browse Utilization</b>					
ARTR					
Other Species: 40/50 %			High		
Other Species: Winter Fat 70%			High		



## 4.0 Conclusions

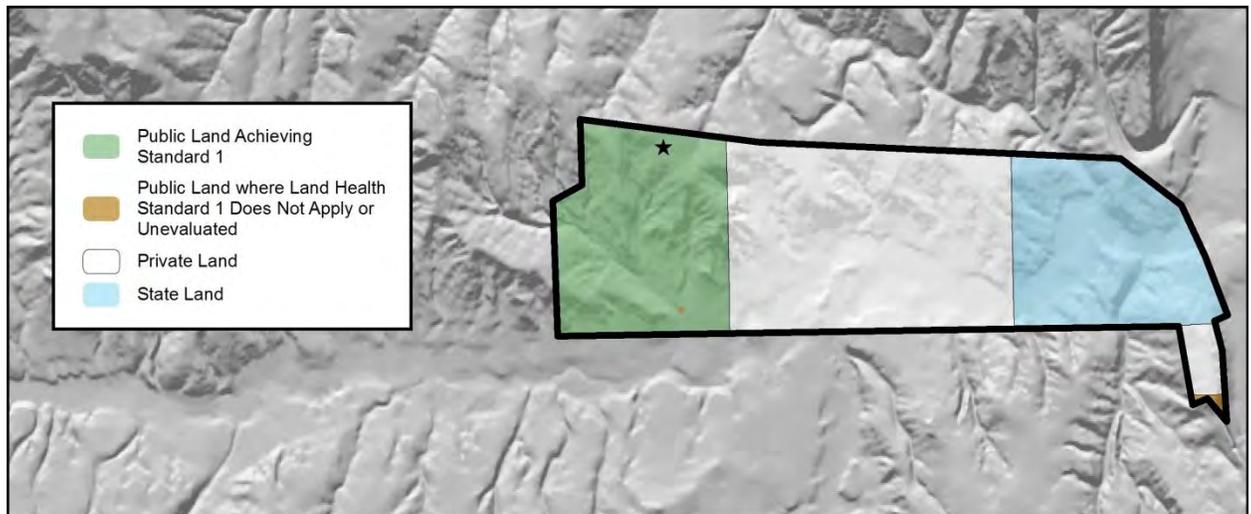
This section draws conclusions and makes determinations regarding:

- A. Progress towards or attainment of the standards for rangeland health, and
- B. Whether livestock management is in conformance with the guidelines, and
- C. Whether existing grazing management or levels of grazing use are significant factors in failing to achieve the standards or conform to the guidelines.

### 4.1 Standard 1

*Within the potential of the ecological site (soil type, landform, climate, and geology), soils are stable and allow for water infiltration to provide for optimal plant growth and minimal surface runoff.*

Land Health Reporting Categories	Acres
Public Land <b>Achieving</b> Standard 1	268.5
Public Land <b>Not Achieving</b> Standard 1	0
Public Land where Land Health Standard 1 <b>Does Not Apply</b> or Unevaluated	3.3
Total Public Land Acres	271.4



Rationale: The attribute ratings for *Soil and Site Stability* and *Hydrologic Function* were rated as “None to Slight” at both assessment locations. Throughout the allotment, the soils are stable. Erosion indicators (rills and water flow patterns) are minimal, only being present in association with areas of rock outcrops. Gullies have not developed in the allotment. The soil structure combined with a surface layers that are rich in organic matter and root masses protect the soil from rain drop impact and the erosive forces of overland flow. The vegetative communities supported by the soils are capable of minimizing runoff and allow for maximum infiltration. There is no indication of historic soil loss.

Acres where Land Health Standards DOES NOT APPLY or UNEVALUATED are areas where soil and vegetation cover was not quantifiable or nonexistent. Examples include: Slopes exceeding 60%, rock outcrops, Badland type soils, historic growth Juniper/Mountain Mahogany sites, or reservoir bottoms with or without water.

#### 4.2 Standard 2

*Riparian and wetland vegetation has structural, age and species diversity characteristic of the state of channel succession and is resilient and capable of recovering from natural and human disturbance in order to provide forage and cover, capture sediment, dissipate energy, and provide ground water recharge. **Not Applicable***

Rationale: There are no naturally occurring riparian areas or wetlands within the allotment on public land that have been documented, verified, and monitored. The riparian areas in the vicinity of Buffalo Creek are on private and state land.

#### 4.3 Standard 3

*Upland vegetation on ecological site consists of plant communities appropriate to the site which are resilient, diverse, and able to recover from natural and human disturbance.*

Based on the assessment of the data collected as well as observations throughout the allotment, the following table summarizes the number of acres that were determined to meet Standard and Guidelines, the number of acres that were determined to not meet Standard and Guidelines, and the number of acres that no determination was made. This table is also visually represented by the map below.

Land Health Reporting Categories	Acres
Public Land <b>Achieving</b> Standard 3	129.3
Public Land <b>Not Achieving</b> Standard 3 Casual Factor: Historic Grazing	138.8
Public Land where Land Health Standard 3 <b>Does Not Apply</b> or Unevaluated	3.3
Total Public Land Acres	271.4



#### **RATIONALE- MET:**

As it pertains to the acres that ARE MEETING the Standard, these sites are in a dynamic equilibrium with the Historic Climax Plant Community. This means that at this time these sites have appropriate pathways available to them to respond to proper grazing strategies, favorable environmental conditions, and environmental disturbances. These sites have a vegetative community that is stable, intact, resistant to change and provides for soil and watershed stability. These areas are represented by the slopes that transition from undisturbed upland sites to the ephemeral drainageways.

**RATIONALE- NOT MET:** Overall Biotic Integrity was rated as a “Moderate” departure from the Reference Sheet, specifically the functional structural groups and invasive species indicators were rated at Moderate to Extreme. These acres have had a significant change or shift from the potential of the site and do not have an appropriate plant community capable of recovering or returning to a functional community without mechanical treatments, seedings, intensive grazing management, etc. The causal factor to not meeting the standard is attributed to historical grazing practices given that the allotment is currently permitted at 52 AUMs, which provides for a stocking rate of .05 AUMs per acre annually. The NRCS Ecological Site Guides utilized throughout this document indicate that a continuous season long stocking rate appropriate for the defined range sites is .30 AUMs per acre on loamy range sites in the Perennial Grass/Big Sagebrush state. The current stocking rate appears to be in line with that prescribed by the NRCS and there is no evidence to indicate that the current permitted livestock grazing on the allotment is contributing to further degradation of these acres.

As such, historical grazing use as described above in combination with the aggressive and opportunistic nature of cheatgrass is determined to be the causal factor for acres not meeting the standard. While some Rangeland Health Standards are not met because of the high frequency of Cheatgrass, the guidelines for livestock grazing are still within compliance. With the persistence of Cheatgrass and the lack of a successful control agent at this time, is not reasonable or cost-effective to restore, maintain, or improve plant communities. Success is not known to have occurred, and is rated to be low and highly variable for the rate of control of most species. It is a consensus that the site in theory could be brought to a community that looks similar to an at-risk community within the reference state, but that it is not possible to reach the reference community condition once annuals have established on a site as a niche.

Acres where Land Health Standards DOES NOT APPLY or UNEVALUATED are areas where soil and vegetation cover was not quantifiable or nonexistent. Examples include: Slopes exceeding 60%, rock outcrops, Badland type soils, historic growth Juniper/Mountain Mahogany sites, or reservoir bottoms with or without water.

#### 4.4 Standard 4

*Rangelands are capable of sustaining viable populations and a diversity of native plant and animal species appropriate to the habitat. Habitats that support or could support threatened species, endangered species, species of special concern, or sensitive species will be maintained or enhanced. MET/NOT MET*

##### *Greet Individual Allotment*

Land Health Reporting Categories	Acres
Public Land <b>Achieving</b> Standard 4	129
Public Land <b>Not Achieving</b> Standard 4	139
Public Land where Land Health Standard 4 <b>Does Not Apply</b> or unevaluated	3
Total Public Land Acres	271

Rationale: Wildlife habitat within the allotment, where big sagebrush, perennial grass vegetation characteristics are intact, is capable of sustaining viable populations of animal species appropriate to undisturbed habitat. These areas, which consist of approximately 129 acres, can sustain all wildlife species that would be expected to be found there. Within this allotment are also approximately 139 acres that are not meeting vegetation standards due to current or historic conditions such as disturbance or invasive plants, resulting in localized diminished capability of sustaining wildlife populations appropriate to the overall site vegetation and precipitation characteristics.

#### **4.5 Standard 5**

*Water quality meets State standards. UNKNOWN*

**Rationale:**

There is no information specific to this allotment or the management of this allotment available to indicate that the standard is being or not being met. Buffalo Creek in this watershed is not described in the WYDEQ 2012 report.

The use classifications defined (WYDEQ, 2001) for the drainages in the allotment are considered to be Class 3B waters.

“Class 3B waters are tributary waters, including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life, including invertebrates, amphibians, or other flora and fauna that inhabit waters of the State at some stage of their life cycles.”

Anthropogenic uses and activities on the landscape can have significant impacts – both adverse and beneficial– on water quality and the health of a watershed. Human-related disturbances are numerous and include livestock grazing, land clearing, mining, timber harvesting, ground- water withdrawal, stream flow diversion, channelization, urbanization, agriculture, roads and road construction, off-road vehicle use, camping, hiking, and vegetation conversion. Biological stressors include habitat loss, alteration, effluent discharge, and degradation from decline in water quality, and changes in channel and flow characteristics (EPA, 2008 p.65).The allotment was reviewed for these types of impacts and none were identified as a causal factor for this standard.

There is no information currently available to indicate that this Standard is or is not being met. It can be concluded however that the soils and runoff conditions are appropriate for the allotment and lower amounts of sediment would be delivered from runoff in the allotment. Other management impacts that would have a potential to impair water quality such as excessive roads, mining, wildfire are not present in this allotment.

Review of casual factors that are currently available for this allotment indicate that this standard is being met. However, per BLM state office policy, compliance with Wyoming State Water Quality Standards is unknown because no official determination has been made by the Wyoming DEQ.

#### **4.6 Standard 6**

*Air quality meets State standards. UNKNOWN*

**Rationale:**

No information is currently available to indicate that this Standard is or is not being met. An air quality monitoring station was recently established in the Bighorn Basin, but no monitoring data is available at this time. Until specific data becomes available, the determination for this Standard is UNKNOWN, per direction from the BLM Wyoming State Office.

#### **4.7 Guidelines for Livestock Grazing Management: *COMPLIANT***

*Guidelines provide for, and guide the development and implementation of, reasonable, responsible, and cost-effective management practices at the grazing allotment and watershed level. These management practices will either maintain existing desirable conditions or move rangelands toward statewide standards within reasonable timeframes. Appropriate guidelines will ensure that the resultant management practices reflect the potential for the watershed, consider other uses and natural influences, and balance resource goals with social, cultural/historic, and economic opportunities to sustain viable local communities.*

##### **Rationale:**

While some Rangeland Health Standards are not met because of the high frequency of Cheatgrass, the guidelines for livestock grazing are still within compliance. Current grazing management practices on the Greet Individual Allotment are following the guidelines by sustaining a conservative stocking rate of .05 AUMs per acre annually. The NRCS Ecological Site Guides utilized throughout this document indicate that a continuous season long stocking rate appropriate for the defined range sites is .30 AUMs per acre on loamy range sites in the Perennial Grass/Big Sagebrush state. Even though growing season use is permitted annually, the stocking rate alone ensures that adequate amounts of vegetative ground cover, including standing plant material and litter, remain after authorized use to support infiltration, maintain soil moisture storage, stabilize soils, allow the release of sufficient water to maintain system function, and to maintain subsurface soil conditions that support permeability rates and other processes appropriate to the site.

## 5.0 Resource Specialist Signatures

X 

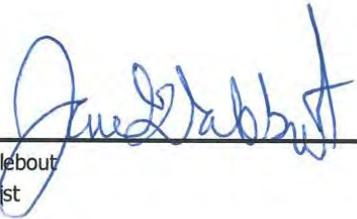
Michael Peck  
Rangeland Management Specialist

X 

John Elliott  
Supervisory Rangeland Management Specialist

X 

Ted Igleheart  
Wildlife Biologist

X 

Jared Dalebout  
Hydrologist

X 

Michael J. Phillips  
Assistant Field Manager - Resources

## 6.0 DETERMINATION

Based on the information provided in this assessment, *I have determined that all of the standards ARE NOT being met but that livestock grazing IS in conformance with the guidelines.*

**X** 

Rebecca Good  
Worland Field Office Manager

DATE:           MAY 22 2015

## 7.0 REFERENCES

72. Friedman, Jonathan M.; Scott, Michael L.; Auble, Gregor T. 1997. Water management and cottonwood forest dynamics along prairie streams. In: Knopf, Fritz L.; Samson, Fred B., eds. Ecology and conservation of Great Plains vertebrates. Ecological Studies, Vol. 125. New York: Springer-Verlag: 49-71. [28993]
179. Scott, Michael L.; Auble, Gregor T.; Friedman, Jonathan M. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications. 7(2): 677-690. [28708]
- Binkley, D., Brown, T. 1993. Management Impacts on Water Quality of Forests and Rangelands. USDA Forest BLM 1998. Riparian Area Management. A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas. Technical Reference 1737-15.
- Christopher P. Kirol, Jeffrey L. Beck, Jonathan B. Dinkins, and Michael R. Conover, 2012. Microhabitat Selection for Nesting and Brood-Rearing by the Greater Sage-Grouse in Xeric Big Sagebrush. The Condor 114(1):75–891
- Coates, P.S., Lockyer, Z.B., Farinha, M.A., Sweeney, J.M., Johnson, V.M., Meshriy, M.G., Espinosa, S.P., Delehanty, D.J., and Casazza, M.L., 2011, Preliminary analysis of Greater Sage-grouse reproduction in the Virginia Mountains of northwestern Nevada: U.S. Geological Survey Open-File Report 2011-1182, 32 p.
- Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000a. Guidelines for management of sage grouse populations and habitats. Wildlife Society Bulletin 28:967-985.
- EPA,2008. The Ecological and Hydrological Significance of Ephemeral and Intermittent Streams in the Arid and Semi-arid American Southwest. U.S. Environmental Protection Agency and USDA/ARS Southwest Watershed Research Center, EPA/600/R-08/134, ARS/233046, 116 pp. [http://www.epa.gov/esd/land-sci/pdf/EPHEMERAL\\_STREAMS\\_REPORT\\_Final\\_508-Kepner.pdf](http://www.epa.gov/esd/land-sci/pdf/EPHEMERAL_STREAMS_REPORT_Final_508-Kepner.pdf)
- Hamerlinck, J.D. and C.S. Arneson, editors. 1998. Wyoming Ground Water Vulnerability Assessment Handbook. Spatial Data and Visualization Center Publication Report SDVC 98-01. University of Wyoming. Laramie, Wyoming. Volume 1.
- Hedman, E.R. Osterkamp, W.R. 1982. Streamflow Characteristics Related to Channel Geometry of Streams in Western United States. U.S Geological Survey Water Supply Paper 2193, pp12-13.
- Rosgen, D.L. 1996. A classification of natural rivers. Catena, Vol. 22, pp 169-199.
- WYDEQ, 2001. **Wyoming Surface Water Classification List June 2001**. Wyoming Department Environmental Quality. p A.15.
- WYDEQ,2012. **Wyoming Water Quality Assessment and Impaired Waters List 2012 Integrated 305(B) and 303 (d) Report** Wyoming Department of Environmental Quality. p 28.  
**Wyoming DEQ 2012 305b Report**