PEABODY WESTERN

Peabody Western Coal Company

January 15, 2020

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining
Reclamation and Enforcement
1999 Broadway, Suite 3320
Denver, CO 80202-3050

RE: Phase II Bond Release Application / Peabody Western Coal Company / Kayenta Mine Permit AZ-0001F / J16, J19, and J21 Permanent Program Areas

Dear Mr. Spangler:

Peabody Western Coal Company (PWCC) submits to the Office of Surface Mining Reclamation and Enforcement (OSMRE) the enclosed application materials in accordance with 30 CFR 800.40 for phase II release of bond on approximately 2,650 acres of mined and reclaimed lands in the permanent program area of J16, J19, and J21 at Kayenta Mine. The J16, J19, and J21 reclaimed lands described within this Bond Release Application are subject to the Permanent Program Performance Standards at 30 CFR 816 and the requirements of the OSMRE issued Kayenta Mine Permit AZ-0001F permit application package approved October 3, 2017.

Enclosed, please find one electronic thumb drive of the Bond Release Application. PWCC understands that OSMRE will complete a preliminary application review and will provide PWCC a response that will include details of information required so that OSMRE can deem the application complete. Once OSMRE has deemed the application complete, PWCC will submit a complete official application with signed documents to OSMRE along with any additional hard copies and electronic thumb drives OSMRE directs PWCC to provide.

Please direct any questions and correspondence to me at 928.677.5130 or by email at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

PUBLIC NOTICE

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for bond release on a portion of the lands in the J16, J19, and J21 Coal Resource Areas (CRAs) within the Kayenta Mine Permit AZ-0001F. PWCC is seeking a release of Phase II bond liability for a portion of the J16, J19, and J21 areas currently under bond with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Federal Insurance Company, Liberty Mutual Insurance Company, and Travelers Casualty and Surety Company of America. PWCC is seeking a reduction in bond of $4,506,760 under the Phase II application. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release application consists of information currently contained in the AZ-0001F permit application package (PAP) approved October 3, 2017. The PAP outlines PWCC's reclamation operations on Permanent Program Lands. The total areas in J16, J19, and J21 requested for Phase II release is 2,650 acres. Reclamation was completed between 1984 and 2019. Reclamation activities included backfilling and grading, replacement of soil or plant growth media, and revegetation. Other reclamation activities included mitigation of unsuitable material and drainage control construction. The Kayenta Mine permit for the release areas is under Navajo Tribal Coal Lease 14-20-0603-9910 and Hopi Tribal Coal Lease 14-20-0450-5743 and operates pursuant to Code of Federal Regulations (CFR), Title 30; Subchapter E, Part 750; Subchapter G, Parts 773 and 774; and Subchapter K, Parts 810 and 816. This notice is hereby given that:

1. The name and business address of the applicant is:

    Peabody Western Coal Company
    Kayenta Mine
    P.O. Box 650
    Kayenta, AZ 86033

2. The mine permit area is located approximately 18 miles south southwest of Kayenta, Arizona. The permit area for the Phase II bond release areas is located in USGS 7.5 minute quadrangle maps "Yucca Hill" and "Cliff Rose Hill" within the following lands of Navajo County, Arizona that are described relative to the Gila and Salt River Base Meridian as:

    A total of 459 acres of land located within the J16 CRA. The computer-generated centroid location is Latitude 36° 29' 8.33" N and Longitude 110° 18' 7.01" W. A total of 1,101 acres of land located within the J19 CRA. The computer-generated centroid location is Latitude 36° 27' 29.27" N and Longitude

110° 18’ 26.88” W. A total of 1090 acres of land located within the J21 CRA. The computer-generated centroid location is Latitude 36° 25’ 45.17” N and Longitude 110° 16’ 42.61” W.

3. Locations of where copies of the application and permit are available for public review and/or inspection are:

The Navajo Nation Minerals Department
Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Forest Lake Chapter House
Navajo Route 41
20 miles north of Pinon
Pinon, AZ 86510

Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
One Federal Center, Building 41
Lakewood, CO 80225-0065

Hopi Tribe
Office of Mining and Minerals
Resources, Highway 264
1 Miles East of Kykotsmovi
Kykotsmovi, AZ 86039

Peabody Western Coal Company
Kayenta Mine
Mesa Central Warehouse Office
8 miles Hwy 160 and Route 41 Junction
Kayenta, Arizona 86033

OSM Website: https://www.wrcc.osmre.gov/initiatives.shtm

4. The names and addresses of the OSM-WRCC representative where written comments, objections, requests for a public hearing, or requests for an informal conference may be submitted on or before 5:00 p.m., (To Be Determined), thirty (30) days after the last publication date are:

Ms. Amy McGregor
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
One Federal Center, Building 41
Lakewood, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

5. Interested persons may obtain more information concerning the bond release by contacting Marie Shepherd, Senior Manager Environmental for PWCC at 928.677.5130.

6. The application has been filed with OSMRE and will be acted upon pursuant to the Permanent Regulatory Program (30 CFR Parts 750 and 774) approved by the Secretary of the Interior under Title V of the Surface mining Control and Reclamation Act of 1977.

Peabody Western Coal Company

October 20, 2020

Bureau of Indian Affairs
Navajo Area Office
Ms. Sharon A. Pinto, Area Director
P.O. Box 1060
301 West Hill Street
Gallup, New Mexico 87305-1060

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Ms. Pinto:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

The application and permit are available for public review and/or inspection at:

The Navajo Nation Minerals Department Office of Surface Mining Window Rock Boulevard Window Rock, AZ 86515	Forest Lake Chapter House Navajo Route 41 14 miles north of Pinon Pinon, AZ 86510

Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
Denver, CO 80225-0065

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

October 20, 2020

Bureau of Land Management
Arizona State Office
Mr. Stewart Boyd
Native American Minerals Lead
One North Central Ave., Suite 800
Phoenix, Arizona 85004

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Boyd:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

Peabody Western Coal Company

October 20, 2020

The Hopi Tribe
Office of Mining and Minerals
Attn: Norman Honie Jr.
P.O. Box 123
Kykotsmovi, AZ 86039

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Honie Jr:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Pinon, AZ 86510

Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
Denver, CO 80225-0065

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

Peabody Western Coal Company

October 20, 2020

Kayenta Chapter
Mr. Stanley Clitso, President
P.O. Box 1088
Kayenta, Arizona 86033

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Clitso:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
Denver, CO 80225-0065

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

October 20, 2020

Navajo Tribal Utility Authority
Mr. Walter W. Haase, P.E., General Manager
P.O. Box 170
Fort Defiance, Arizona 86504-0170

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Haase:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Window Rock Boulevard
Window Rock, AZ 86515

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Navajo Route 41
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Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
Denver, CO 80225-0065

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

Peabody Western Coal Company

October 20, 2020

Shonto Chapter
Ms. Elizabeth Whitethorne-Benally
P. O. Box 7800
Shonto, AZ 86054

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Ms. Whitethorne-Benally:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

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Window Rock Boulevard
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Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
Denver, CO 80225-0065

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

October 20, 2020

Chilchinbeto Chapter
Mr. Thomas Bradley, President
P.O. Box 1681
Kayenta, Arizona 86033

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Bradley:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

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Office of Surface Mining
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Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

October 20, 2020

Forest Lake Chapter
Ms. Fern Benally, President
P.O. Box 441
Pinon, Arizona 86510

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Ms. Benally:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

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Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

October 20, 2020

Navajo Nation
Minerals Department
Mr. Akhtar Zaman
P.O. Box 1910
Window Rock, AZ 86515

RE: Notice of Application for Phase II Bond Release; J16, J19, and J21 Coal Resource Areas; Kayenta Mine

Dear Mr. Zaman:

Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement (OSMRE) for Phase II bond release on portions of the J16, J19, and J21 Coal Resource Areas. The release areas are in the southeastern portion of the PWCC lease area. PWCC is seeking release from Phase II bond liability for those surety bonds currently held with Zurich American Insurance Company, Continental Casualty Company, National Fire Insurance Company of Hartford, Liberty Mutual Insurance Company, Federal Insurance Company, and Travelers Casualty and Surety Company of America. The total combined bond for Kayenta Mine is $178,569,992.

The Phase II bond release areas are located within the Kayenta Mine Permanent Program permit area (AZ-0001F PAP) in the southeastern portion of the PWCC lease area. PWCC is seeking a reduction of the total J16, J19, and J21 bond amount of $4,506,760 at this time by gaining regulatory approval for release of lands described in the application from Phase II bond liability. The total area sought for release includes 2,650 acres of disturbed land. Approval of Phase II will allow for Phase III bond release to proceed on this area once all requirements for this phase are met. Phase III is the final bond release step and once approved will allow for the planned return of these lands to the Navajo Nation in the future. Until that time, PWCC will continue to control and manage reclaimed lands in the release areas described.

Reclamation of the Phase II release areas which includes; backfilling and grading, drainage control, mitigation of unsuitable material, and topsoil replacement was completed between 1984 and 2019. Revegetation activities were initiated in 1996 and were conducted in accordance with the Surface Mining Control and Reclamation Act (SMCRA) and the requirements of the OSMRE Permit AZ-0001F PAP. Reclamation activities are documented in annual reports submitted previously to OSMRE.

The application and permit are available for public review and/or inspection at:

The Navajo Nation Minerals Department
Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Forest Lake Chapter House
Navajo Route 41
14 miles north of Pinon
Pinon, AZ 86510

Office of Surface Mining
Reclamation and Enforcement
Western Region Office
P. O. Box 25065
Denver, CO 80225-0065

If you have questions, comments, or wish to request a hearing or informal conference regarding this bond release application, please contact:

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
P. O. Box 25065
Denver, CO 80225-0065
WR Permitting Information Line, 1-866-847-7362

Please direct your questions about this application to me at 928.677.5130 or email them to me at mshepherd2@peabodyenergy.com.

Respectfully,

Marie Shepherd
Senior Manager Environmental
Kayenta Mine

C: Jeremy Spangler (OSMRE-WRO)

SECTION 1

J16, J19, and J21 Phase II Bond Release Supporting Documentation

Introduction

Peabody Western Coal Company (PWCC) is requesting Phase II bond release on portions of lands within the J16, J19, and J21 areas of the Kayenta Mine. The bond release application included in this submittal contains required documentation and information to support Phase II bond release for 2,650 acres of mined and reclaimed lands in the permanent program areas within the J16, J19, and J21 Coal Resource Areas (CRAs) as shown on Map 1.1. None of the proposed permanent ponds or a request for permanent roads are included in this release application. These features will be further evaluated in relation to the final land use and customary use areas over the entire release application areas. Information such as the public notice, affidavit of publication, and copies of notification letters to the Tribes, government agencies, and utilities are included in Section 1 of the application. Information for the Phase II technical portions of the application are contained in Section 2 (Soil and Suitable Material Data), Section 3 (Historical Revegetation), and Section 4 (Suspended Solids Outside of the Permit Area) of this document.

Permit and Bond Release Summary Information

The J16, J19, and J21 Coal Resource Areas are located within PWCC's Kayenta Mine. The Kayenta Mine operates under Permit AZ-0001F issued by the Office of Surface Mining Reclamation and Enforcement (OSMRE) to PWCC Kayenta Mine on October 3, 2017. Permit AZ-0001F authorized continuation of ongoing Kayenta Mine surface coal mining and reclamation activities in CRAs N9, J19, and J21, as well as to perform reclamation activities in CRAs previously mined (i.e. N11) for the 5-year period July 2015 through July 2020.

The mine permit area is located approximately 18 miles south southwest of Kayenta, Arizona (USGS 7.5 minute quadrangle maps "Yucca Hill" and "Cliff Rose Hill"). The permit area for the J16, J19, and J21 Phase II bond release is located within the following lands of Navajo County, Arizona that are described relative to the Gila and Salt River Base Meridian as:

> A total of 459 acres of land located within the J16 CRA. The computer-generated centroid location is Latitude 36^{o} 29' 8.33" N and Longitude 110^{o} 18' 7.01" W. A total of 1,101 acres of land located within the J19 CRA.

The computer-generated centroid location is Latitude 36° 27' 29.27" N and Longitude 110° 18' 26.88" W. A total of 1090 acres of land located within the J21 CRA. The computer-generated centroid location is Latitude 36° 25' 45.17" N and Longitude 110° 16' 42.61" W.

The type of bond and the amount of bond filed for Kayenta Mine Permit AZ-0001F are described in Table 1.1. The portion requested for release in the J16, J19, and J21 CRAs includes $4,506,760 for Phase II. Justification for these release dollars are explained in the following section.

Table 1.1 Bond Information for Kayenta Mine.

Bond Surety	Bond Number	Bond Amount
Continental Casualty Company & National Fire Insurance Company of Hartford	9264222	$28,304,188
Continental Casualty Company of Chicago & National Fire Insurance Company of Hartford	9264224	$15,417,651
Federal Insurance Company	82154865	$10,797,629
Liberty Mutual Insurance Company	60S003887	$29,012,760
Travelers Casualty and Surety Company of America	105243347	$23,847,246
Travelers Casualty and Surety Company of America	105191031	$28,000,000
Zurich American Insurance Company	8940860	$43,190,518
Total		**$178,569,992**

Phase II Bond Reduction Cost

PWCC is seeking a reduction in the surface stabilization and topsoil replacement bond for Phase II in the amount of $4,506,760. Surface stabilization has been accomplished for 459 acres in J16, 1,101 acres in J19, and 1,090 acres in J21 as documented in Section 2 of this application. Previously approved Phase II releases in J19 and J21 were approved in 2012 (736 acres - $686,445 in J19; 2471 acres - $686,000 in J21). Topsoil replacement has been accomplished for 459 acres in J16 as documented in Section 2 of this application. The previous Phase I bond release in J16 for 459 acres (approved July 11, 2017) did not include any cost for topsoil replacement. This combined bond reduction amount was determined using direct and indirect unit costs calculated for 2,650 acres as documented in Permit AZ-0001F, Chapter 24, Table 24-1-4. Reclamation cost estimates as of July 2017 were used. The direct costs for revegetation are listed in Table 1.2.

Table 1.2. Bond Reduction of Direct Cost Associated with Topsoil Replacement in J16 and Surface Stabilization in J16, J19, and J21.	
Project Category	**Bond Reduction Amount**
General Grading @ 50% (459 acres/533* acres) for J16	$540,432
Surface Ripping @ 50% (459 acres/533* acres) for J16	$74,407
Topsoil Replacement (459 acres/533* acres) for J16	$1,383,255
General Grading @ 50% for 1,101 acres in J19**	$902,212
General Ripping @ 50% for 1,101 acres in J19**	$124,657
General Grading @ 50% for 1,090 acres in J21***	$349,752
General Grading @ 50% for 1,090 acres in J21***	$48,314
Total Direct Cost for Topsoil Replacement in J16 and Surface Stabilization in J16, J19, and J21	**$3,423,029**
*Total disturbed acres in J16 CRA per 2018 Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines as submitted to OSMRE on June 28, 2019.	
**Available amount based upon previous Phase II release (736 acres-$686,445) for J19 CRA.	
***Available amount based upon previous Phase II release (2471 acres-$686,000) and Phase III release (1,384 acres-$168,380) for J21 CRA.	

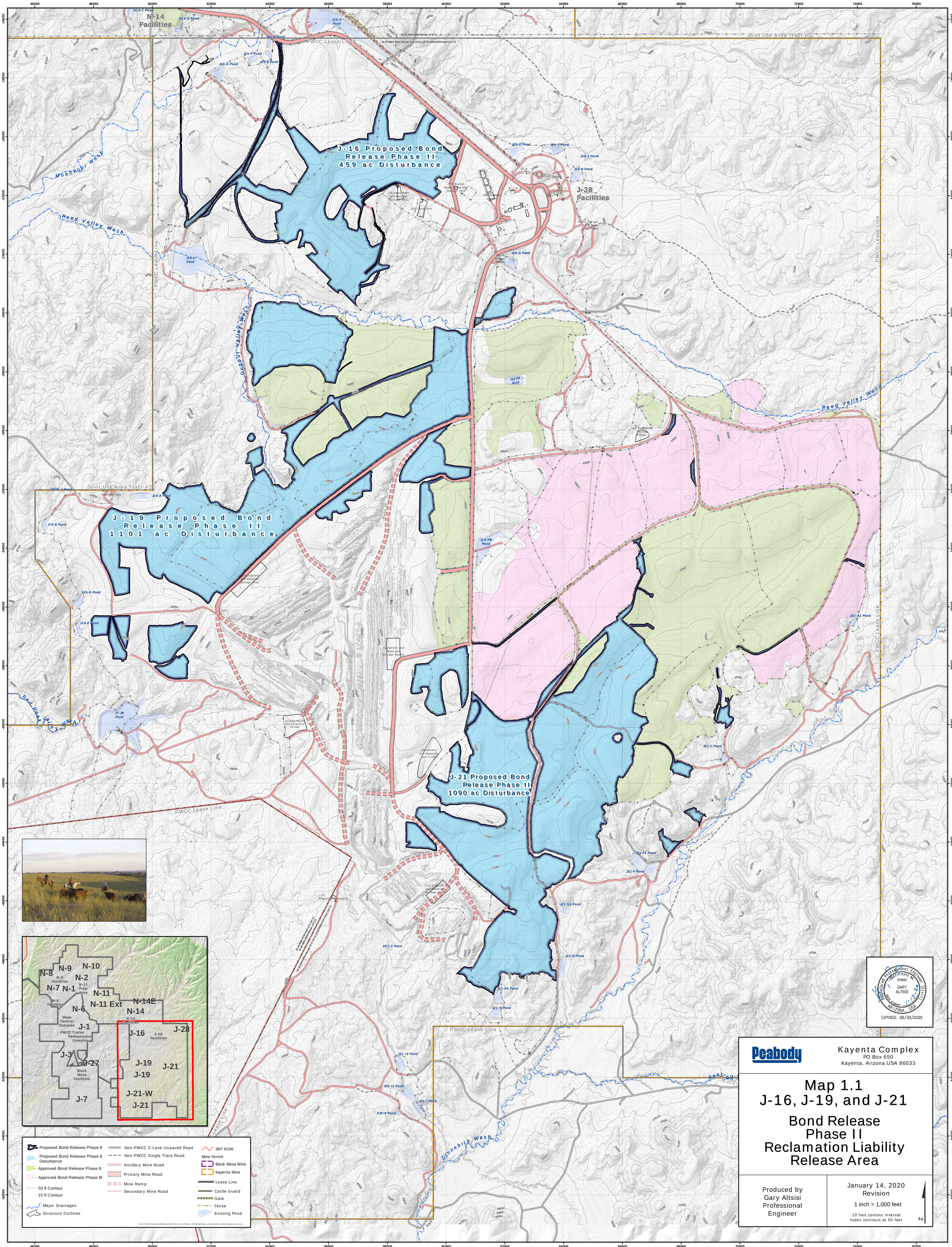
Table 1.3 shows the indirect costs obtained from Permit AZ-0001F, Chapter 24, Table 24-1-4 that are associated with the Phase II direct cost as determined during June 2010 and adjusted for inflation through July 2017.

Table 1.3. Bond Reduction on Indirect Costs Associated with Topsoil Replacement in J16 and Surface Stabilization in J16, J19, and J21.	
Project Category	**Bond Reduction Amount**
Mobilization/demobilization (1.5%)	$51,345
Contingencies (2.0%)	$68,461
Engineering redesign fee (2.0%)	$68,461
Contractor profit and overhead (15.0%)	$513,454
Reclamation management fee (2.0%)	$68,461
Inflation (5.16%; July 2017 - January 2020)	$176,628
AZ transaction privilege tax (4.0%)	$136,921
Total Indirect Cost	**$1,083,731**

The total direct, indirect, tax, and July 2017 to January 2020 inflation costs for Phase II bond categories is $4,506,760.

Permanent Facilities

There are no requests included in this application for any facilities to be retained as permanent features. None of the sediment ponds (including those proposed as permanent), roads, or Kayenta Mine support facilities located within the J16, J19, and J21 Coal Resource Areas are included in this application.


J-16 Proposed Bond Release Phase II 459 ac Disturbance
J-19 Proposed Bond Release Phase II 1101 ac Disturbance
J-21 Proposed Bond Release Phase II 1090 ac Disturbance
N-14 Facilities
J-28 Facilities
Moenkopi Wash
Reed Valley Wash
Dinnebito Wash
PWCC Lease Line
Joint Use Area Tract #2
N-8
N-9
N-10
N-2
N-7
N-1
N-11
N-6
N-11 Ext
N-14E
N-14
J-1
J-16
J-28
J-3
J-27
J-19
J-21
J-21-W
J-7
Black Mesa Facilities
Proposed Bond Release Phase II
Proposed Bond Release Phase II Disturbance
Approved Bond Release Phase II
Approved Bond Release Phase III
50 ft Contour
10 ft Contour
Major Drainages
Structure Outlines
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road
SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Lease Line
Cattle Guard
Gate
Fence
Existing Pond
File: F:\GIS\Projects\BondRelease\RLRA J16 J19 J21 Phase II 2019\Maps\Map 1.1 Reclamation Liability Release Area.mxd
Registered Professional Engineer (Civil)
Certificate No. 37842
GARY ALTSISI
Date signed: 1-13-20
ARIZONA, USA
EXPIRES: 09/30/2020
Peabody
Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033
Map 1.1
J-16, J-19, and J-21
Bond Release
Phase II
Reclamation Liability
Release Area
Produced by
Gary Altsisi
Professional
Engineer
January 14, 2020
Revision
1 inch = 1,000 feet
10 foot contour interval
Index contours at 50 feet
N

ATTACHMENT 2.1

CERTIFICATION

PEABODY WESTERN COAL COMPANY
KAYENTA MINE, J16, J19, J21 COAL RESOURCE AREAS, PHASE II BOND RELEASE APPLICATION
NAVAJO COUNTY, ARIZONA

I HEREBY CERTIFY that, to the best of my knowledge and belief, all applicable reclamation activities described in the attached Phase II Bond Release Application, dated January 15, 2020 have been accomplished in accordance with the reclamation requirements of the Act, the regulatory program, and the approved reclamation plan contained in the AZ-0001F Permit. The bond release parcel is free from enforcement actions.

Peabody Western Coal Company - Kayenta Mine

By: ______________________

Randy Lehn
Director Operations Support - Kayenta Mine

STATE OF ARIZONA

COCONINO COUNTY

Signed or attested before me this 14th day of January 2020, by Randy Lehn, Director Operations Support of Kayenta Mine owned by Peabody Western Coal Company, a Delaware Corporation, on behalf of said Kayenta Mine.

LORETTA JONES
Notary Public - Arizona
Navajo County
Commission # 548873
My Comm. Expires Aug 14, 2022

____
Notary Public

My commission expires:

August 14 2022

SECTION 2

Phase II Bond Release Supporting Information

Soil and Suitable Material Data

Introduction

This Phase II bond release application for the J16, J19, and J21 Coal Resource Areas (CRAs) is requesting release for topsoil replacement in the J16 CRA since it was not included with the Phase I bond release application that was approved by OSMRE on July 11, 2017. Information is provided on topsoil and suitable material thickness sampling to document an adequate thickness of topsoil and mitigation material has been replaced in the J16 CRA.

Soil and Suitable Material Thickness – J16

Topsoil and suitable material replacement on permanent program lands within the J16 CRA occurred from 1984 thru 2013. Topsoil and suitable material replacement status for the release area shown on Map 2.1 was previously reported to the regulatory authority on the Reclamation Status Map 2 (as of December 31, 2013) shown on the Southeast Sheet contained in the 2013 Reclamation Status and Monitoring Report, Black Mesa and Kayenta Mines (submitted May 2014). Soil was redistributed on final graded slopes from stockpiles or replaced directly from soil removal areas prior to ripping and contour discing. Pursuant to Chapter 22 of Permit AZ-0001F, the thickness of soil replaced shall exceed the minimum average of 1 foot.

One (1) red rocked cultural planting and steep slope site, totaling 0.86 acres as shown on Map 2.1, received suitable residual soils and weathered overburden derived from scoria. Nine (9) rocked downdrain sites, totaling 4.20 acres as shown on Map 2.1, received suitable durable rock.

Final soil depth surveys of the J16 permanent program reclaimed areas were completed from 2006 through 2011 as shown on Map 2.1. Personnel from Buchanan Consultants, Ltd. (BCL), Office of Surface Mining Reclamation and Enforcement Albuquerque Area Office (OSM), and Peabody Western Coal Company (PWCC) observed sites in the J16 permanent program reclaimed areas in order to verify suitable material and soil replacement thickness. A stratified grid sampling scheme using a random number generator program was used for the 2006 BCL-PWCC survey to locate 21 sites prior to going into the field. A sampling density of about 1 site per 25 acres was used being like the density used and approved previously at Kayenta Mine for the N1/N2, N7/N8, N14, J19, and J21 soil and suitable material thickness evaluations. A Tremble GeoXT survey grade GPS unit was used to navigate to each of the sites. During 2007, OSMRE inspectors located 75 sites systematically in the field to verify a mean thickness of 12 inches or more of soil and suitable material had been replaced in J16. Forty-two (42) additional sites were placed in the J16 area and observed by

OSMRE, BCL, and PWCC from 2007 thru 2011 to verify soil and suitable material thickness requirements for the Soil Thickness Spoil Quality Evaluation and Recommended Mitigation Plan for the J16 Project (PWCC, 2011 and OSMRE, 2012). Sites were systematically placed near areas requiring thicker replacement of mitigation materials. At most of the sites, a 3 ½-inch bucket auger was used to verify the soil thickness by excavating to the contact with spoil. Soil thickness at 28 of the 42 OSMRE–BCL–PWCC sites sampled from 2007 to 2011 in J16, were measured from the sidewall of an excavated backhoe pit. Field texture, when recorded, was determined in accordance with Natural Resource Conservation Service (NRCS) nomenclature using a wet texture test. The results of the soil and suitable material thickness verification surveys are shown in Tables 2.1 thru 2.4 and Map 2.1 shows all sampled sites with corresponding thickness values.

One hundred thirty-eight (138) samples were collected over the 459 acres of disturbed lands within the release area. However, only the randomly placed soil and suitable material sites were selected to determine representative thickness since all other sites were placed systematically for different purposes as mentioned previously. Soil and suitable material thickness among the 21 random profiles placed over the J16 release area ranged from 12 to at least 28 inches, with a mean of greater than 21 inches (Table 2.1). Note, this mean thickness value does not include any thickness attributed to suitable plant growth material (spoil), suitable residual soils, and weathered overburden derived from scoria.

The mean soil and suitable material thickness of greater than 21 inches exceeds the minimum 1-foot average topsoil thickness requirements presented in the approved reclamation plan in Chapter 22 of Permit AZ-0001F. This mean thickness of 1.8 feet also equals the average combined topsoil and mitigation material thickness of 1.8 feet as required by the spoil suitability mitigation requirements discussed in the Phase I bond release application approved by OSMRE on July 11, 2017. In conclusion, PWCC has satisfied soil and suitable material thickness replacement requirements in conformance with the applicable regulatory requirements and as stipulated by the approved reclamation plan for the J16 Phase I release area shown on Map 2.1.

References Cited

Office of Surface Mining Reclamation and Enforcement (OSMRE). February 29, 2012. Acceptance of J16 Mitigation Plan, Western region Office, Denver, Colorado. Letter and Technical Evaluation sent to: Peabody Western Coal Company, Kayenta, Arizona.

Peabody Western Coal Company (PWCC). July 13, 2011. J16 Soil Thickness – Spoil Quality Evaluation and Recommended Mitigation Plan. Kayenta Mine, Kayenta, Arizona. Report Prepared for: The Office of Surface Mining Reclamation and Enforcement, Western Region Office, Denver, Colorado.

Table 2.1. Soil and Suitable Material Thickness Verification Sites Sampled by Buchanan (BCL) and PWCC at J16 During July 19-21, 2006 (See Map 2.1 for Site Locations).

Site ID	Easting (Feet) [1]	Northing (Feet) [1]	Soil Thickness (Inches) [2]	Field Texture [3]
22	55478	-23357	26+	sl
23	53338	-21649	14	l
24	54598	-19497	22	l
25	56607	-20228	12	l
26	55564	-21271	12	l
27	55564	-22314	23	sl
28	54521	-23357	21	sl
29	55564	-23357	25+	l
30	56607	-23357	23	cl
31	56607	-24400	27	sl
32	57650	-24400	23	l
33	56607	-21271	26+	cl
34	57650	-21271	14	l
35	57650	-20228	19	l
36	58693	-20228	28	l
37	58693	-21271	23+	sl
38	59736	-21271	16	l
39	59736	-20228	25	cl
40	54521	-22314	20	sl
41	57650	-19185	20	l
42	56607	-22314	16	l
MEAN			**21+**	

[1]PWCC coordinate system. [2]+ indicates soil thickness exceeds measured value. [3]sl-sandy loam, l-loam, cl-clay loam.

Table 2.2. Soil and Suitable Material Thickness Verification Sites Sampled by the Office of Surface Mining Reclamation and Enforcement, Albuquerque Area Office (OSMAAO) at J16 During 2007 (See Map 2.1 for Site Locations).			
Mine Area	Soil Thickness (Inches)	Easting (Feet) [1]	Northing (Feet) [1]
J16	17	59852	-20906
J16	23	59622	-20955
J16	31	58403	-21072
J16	12	58397	-21515
J16	38	59630	-21316
J16	28	59493	-21205
J16	28	59079	-21135
J16	12	59121	-20904
J16	28	59637	-21627
J16	12	59153	-21345
J16	15	59131	-21677
J16	26	58392	-20887
J16	26	58710	-20873
J16	20	58717	-21251
J16	10	58686	-21556
J16	26	58750	-21084
J16	31	59741	-21078
J16	6	58400	-21230
J16	13	57753	-20943
J16	14	58392	-21377
J16	14	58367	-21388
J16	12	59145	-21344
J16	12	59917	-21267
J16	16	57999	-21547
J16	14	57975	-21664
J16	7	57855	-21316
J16	18	56531	-23620
J16	9	57643	-21693
J16	10	57568	-21372
J16	9	57442	-21111
J16	20	57156	-21128
J16	10	57233	-21343

J16	8	57269	-21548
J16	11	57277	-21854
J16	14	56817	-21178
J16	16	56869	-21518
J16	20	56943	-21833
J16	12	58092	-20932
J16	10	56694	-22106
J16	12	57017	-22087
J16	9	57380	-22606
J16	12	57195	-22442
J16	9	55833	-22932
J16	10	57259	-23726
J16	12	57268	-22905
J16	8	57059	-23176
J16	22	56244	-23403
J16	13	58244	-21190
J16	12	56245	-23084
J16	8	57095	-23441
J16	18	56514	-24829
J16	12	56838	-23654
J16	15	57403	-24347
J16	10	57389	-24021
J16	19	56524	-24708
J16	7	56793	-23900
J16	14	57155	-23850
J16	18	55983	-25040
J16	20	56661	-24036
J16	10	57081	-24161
J16	22	56523	-24176
J16	15	57098	-23554
J16	10	55989	-23150
J16	15	56720	-24435
J16	22	57140	-24441
J16	15	56852	-24171
J16	21	56716	-24937
J16	19	56324	-23786

J16	13	56593	-23396
J16	21	56226	-24815
J16	18	56185	-24087
J16	21	56285	-24580
J16	11	55988	-22841
J16	12	56856	-23330
J16	13	56766	-24722
Mean	**16**		

(1) PWCC coordinate system.

Table 2.3. Soil and Suitable Material Thickness Verification Sites Sampled by OSMAAO, BCL, and PWCC at J16 During 2007-2011 (See Map 2.1 for Site Locations).			
Site ID	Soil Thickness (Inches) [1]	Easting (Feet) [2]	Northing (Feet) [2]
19RG4.5	36	57908	-19708
19RG10.5	18	58693	-20472
19RG14	12	58557	-20742
19RG19.5	32	57925	-21133
19RG20	13	57897	-20742
19RG20.51	36	57898	-20623
19RG20.52	7	57944	-20776
20RG8	16	57567	-20412
20RG11.5	15	56210	-20496
20RG19	20	56907	-20742
20RG19.5	15	56902	-20901
20RG19.51	17	57005	-20740
20RG21.5	0[3]	56928	-21291
20RG22	12+	57567	-20742
20RG23.5	12	57232	-21140
20RG25.5	28	57646	-21117
20RG25.51	44	57659	-20991
20RG25.52	18	57471	-20984
20RG27	12+	57237	-20742
20RG28	16	57237	-20412
21RG16.5	14	55019	-21626
21RG16.51	19	55125	-21474
21RG16.52	28	55157	-21638
21RG18.5	20	56543	-21666
21RG23	16	55917	-21732
23RG7.5	18	54016	-22149
23RG25.5	20	55952	-22623
23RG25.51	18	55971	-22782
23RG25.52	27	55807	-22682
26RG37.5	6	57189	-23955
26RG43.5	36	56927	-23784
26RG44.5	12	56779	-23480

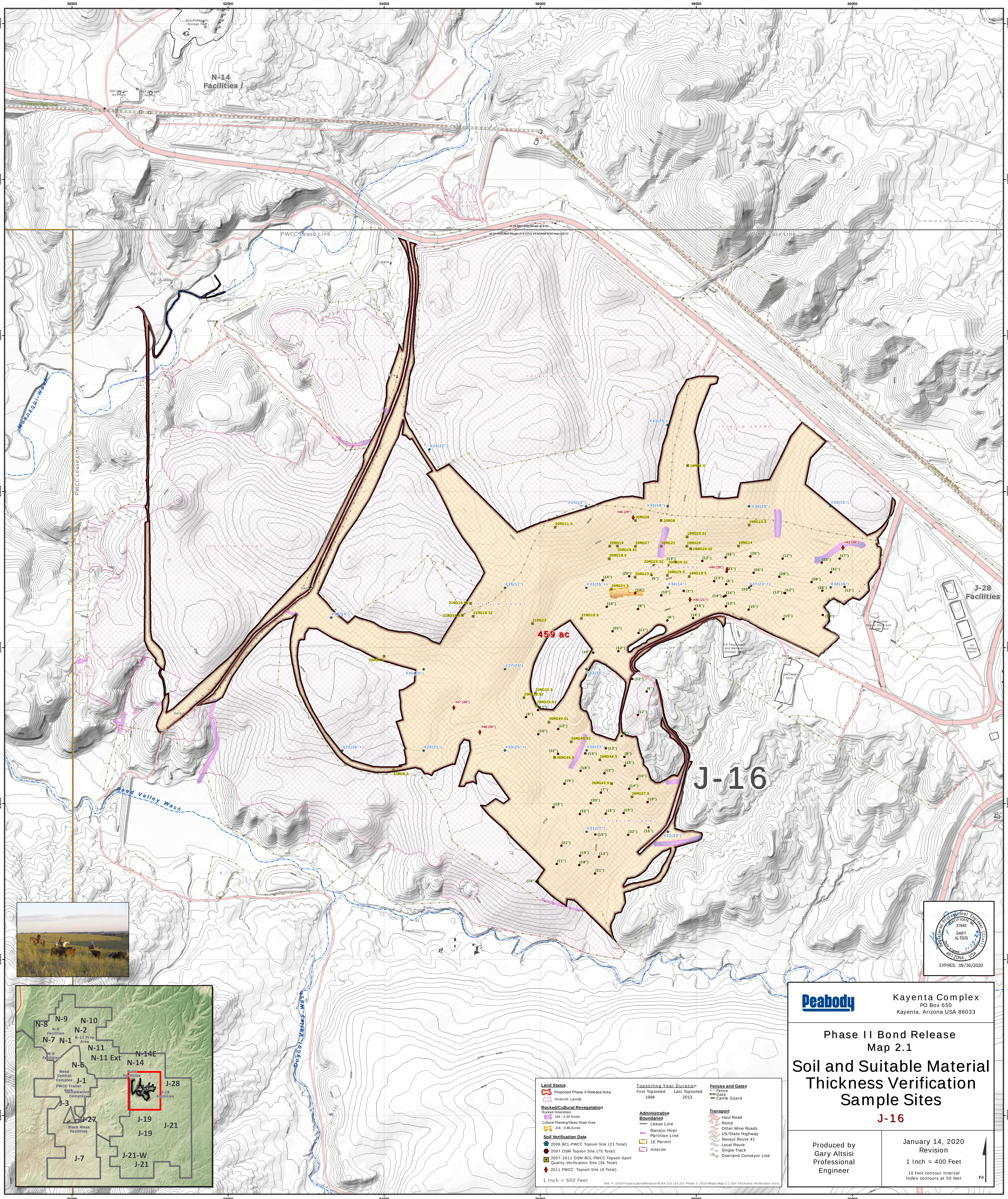
26RG45.5	36	56198	-23446
26RG49.51	21	56125	-22995
26RG49.52	15	56410	-23247
27RG6.5	10	54134	-23607
Mean	**19+**		

(1) + indicates soil thickness exceeds measured value. (2) PWCC coordinate system.
(3) This value not included in the mean calculation as this is a cultural site.

Table 2.4. Soil and Suitable Material Thickness Verification Sites Sampled by PWCC at J16 During 2011 (See Map 2.1 for Site Locations).

Site ID	Soil Thickness (Inches)	Easting (Feet) [1]	Northing (Feet) [1]
43	39	59896	-20764
44	39	58409	-21040
45	21	57934	-21425
46	29	57209	-20373
47	28	54908	-22807
48	26	55242	-23124
Mean	**30**		

[1] PWCC coordinate system.


N-14
Facilities
PWCC Lease Line
Moenkopi Wash
Reed Valley Wash
Dogout Valley Wash
Interim Lands
459 ac
J-16
J-28
Facilities
Registered Professional Engineer (Civil)
Certificate No. 37842
GARY
ALTSISI
Date signed: 1-13-20
ARIZONA, USA
EXPIRES: 09/30/2020
Land Status
Proposed Phase II Release Area
Interim Lands
Rocked/Cultural Revegetation
Rocked Downdrain
J16 - 4.20 Acres
Cultural Planting/Steep Slope Area
J16 - 0.86 Acres
Soil Verification Data
2006 BCL-PWCC Topsoil Site (21 Total)
2007 OSM Topsoil Site (75 Total)
2007-2011 OSM-BCL-PWCC Topsoil-Spoil Quality Verification Site (36 Total)
2011 PWCC Topsoil Site (6 Total)
1 Inch = 500 Feet
Topsoiling Year Duration
First Topsoiled
1994
Last Topsoiled
2013
Administrative Boundaries
Lease Line
Navajo-Hopi Partition Line
1E Permit
Interim
Fences and Gates
Fence
Gate
Cattle Guard
Transport
Haul Road
Ramp
Other Mine Roads
US/State Highway
Navajo Route 41
Local Route
Single Track
Overland Conveyor Line
File: F:\GIS\Projects\BondRelease\RLRA J16 J19 J21 Phase II 2019\Maps\Map 2.1 Soil Thickness Verification.mxd
Peabody
Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033
Phase II Bond Release
Map 2.1
Soil and Suitable Material Thickness Verification Sample Sites
J-16
Produced by
Gary Altsisi
Professional
Engineer
January 14, 2020
Revision
1 Inch = 400 Feet
10 foot contour interval
Index contours at 50 feet
N
N-8
N-9
N-10
N-2
N-7
N-1
N-11
N-11 Ext
N-14E
N-14
N-6
J-1
J-28
J-3
J-27
J-19
J-21
J-7
J-21-W
Black Mesa Facilities

SECTION 3

Phase II Bond Release Supporting Information

INTRODUCTION

The Phase II Bond Release information contained in this section includes historical revegetation information and results and analysis of vegetation sampling in support of the application. The Phase 1 bond release for the Reclaimed Liability Release Areas (RLRA) included in this application in the J16, J19, and J21 Coal Resource Area Permanent Program lands were approved in 2017 and 2018.

HISTORICAL REVEGETATION

Revegetation activities for J16, J19, and J21 RLRAs included in this application were conducted during the years 1996 through 2017. Details of revegetation procedures and applied seed mixes for initial seeding and reseeding have been previously reported to the regulatory authority in annual monitoring reports. This information and supporting maps are contained in the Minesoil Reconstruction and Revegetation Activities – Report, Black Mesa and Kayenta Mines for the years 1996 through 1999 as well as in Tab 2 of the Reclamation Status and Monitoring Report, Black Mesa and Kayenta Mines for the years 2000 through 2017. Revegetation procedures are summarized as follows. Upon completion of soil replacement, sites were deep ripped and then contour furrow disked to aid in surface stabilization and prepare the seedbed. The sites were then seeded during the next available seeding season using the approved permanent seed mix and appropriate seeding practices. Following seeding the sites were mulched with native grass hay at two tons per acre and then crimped to anchor the mulch. Map 3.1 shows the permanent program revegetation areas by year of seeding included in this Phase II application.

PHASE II VEGETATION SAMPLING

The sampling methods and results presented in the application address the requirements for Phase II bond release. Sampling methods are consistent with approved vegetation baseline and monitoring study methods for the Kayenta Mine as outlined in the AZ-0001F PAP, Chapter 9, Attachment 2. These methods have been used for all sampling at Kayenta Mine.

The Guideline to Bond Release Procedures for Permanent Programs Lands, Indian Programs Branch, Western Region Office of Surface Mining Reclamation and Enforcement (2017) states that the operator must demonstrate for Phase II bond release that "the reclaimed plant community is successfully established in accordance with 30 CFR 816.111 and the approved PAP." 30 CFR 816.111 states that the vegetative cover must be:

1. Diverse, effective, and permanent;
2. Comprised of species native to the area, or of introduced species where desirable and necessary to achieve the approved postmining land use and approved by the regulatory authority;
3. At least equal in extent of cover to the natural vegetation of the area; and
4. Capable of stabilizing the soil surface from erosion.

This section includes the discussion of the first three requirements. Section 4 of this application includes the discussion of sediment loss and erosion.

Phase II bond release requires statistically valid methods and random sampling of reclaimed and reference areas and comparison of the sampling results for these two areas. For purposes of permanent program vegetative cover evaluations, the J7, N7/8, and N14 sagebrush reference areas (SBRAs) determine the cover success standard. A minimum of 20 samples were collected in the RLRAs and 15 samples in the SBRAs. Sample adequacy was calculated from first-hit foliar vegetation cover sample values using the following formula:

$$N_{min} = \frac{t^2 * s^2}{d^2 * \bar{x}^2}$$

where:
N_{min} = minimum number of samples required
t = one-tailed t-value with n-1 degrees of freedom
s^2 = sample variance (n-1 degrees of freedom)
d = 0.1 (level of precision or desired detectable reduction)
$\bar{x}$ = sample mean

The vegetation sampling locations are shown on Maps 3.2 (RLRAs) and (SBRAs). The vegetation data included in this application were collected in fall 2016, spring and fall 2017, and spring and fall 2019 in the RLRAs and SBRAs as shown in Table 3.1. No SBRA data were collected in spring 2017 to compare to the J16 RLRA data, so these data were compared to the fall SBRA data collected four months later. Data collected along four previously established permanent transects within the J19 and J21 RLRAs were also included with these datasets to achieve sample adequacy.

Table 3.1: Sample Size and Dates for the J16, J19, and J21 RLRAs and J7, N7/8, and N14 SBRAs

Site ID	Fall 2016	Spring 2017	Fall 2017	Spring 2019	Fall 2019
		Phase II RLRAs			
J16 RLRA		20[1]		20	20
J19 RLRA	20			24[2]	20
J21 RLRA	20			24[2]	
		Sagebrush Reference Areas			
J7 SBRA	15		15	15	15
N7/8 SBRA	15		15	15	15
N14 SBRA	15		15	15	15

[1] Compared to fall 2017 SBRA data.
[2] Includes data from four permanent transects within the RLRA.

VEGETATION DATA SUMMARY

Data summaries for the vegetation monitoring studies supporting this liability release application are presented in this section and summarized in Table 3.2. Total first hit live foliar vegetation data were used for this evaluation. Ground cover data were used for sediment loss and erosion evaluations discussed in Section 4 of this application. Raw data for all datasets is presented in Appendices 3.1 (RLRAs) and 3.2 (SBRAs). The data in each of these appendices is organized by area and year.

Sample Adequacy

A summary of sample adequacy calculations for total vegetation cover in the J16, J19, and J21 RLRAs as well as the J7, N7/8, and N14 SBRAs is presented in Table 3.3. Adequate samples were obtained in all sample areas during each sampling period within the years sampled except for J19 RLRA in spring 2019 when the allowable ground cover was used for field calculations rather than foliar cover.

Table 3.2: Summary Statistics for the J16, J19, and J21 RLRAs and J7, N7/8, and N14 SBRAs

Site ID	Sample Period	Foliar Vegetation Cover	Ground Cover*	Grass Cover	Shrub/ Subshrub Cover	Total Species Present
Phase II RLRAs						
J16 RLRA	Spring 2017	34.0	46.9	27.6	6.1	25
	Spring 2019	16.4	28.7	15.3	2.9	33
	Fall 2019	24.5	45.8	18.2	5.4	20
J19 RLRA	Fall 2016	41.3	65.5	22.4	6.7	32
	Spring 2019	25.8	44.9	11.0	4.3	46
	Fall 2019	26.1	45.1	16.6	5.9	24
J21 RLRA	Fall 2016	41.4	68.9	29.6	5.7	43
	Spring 2019	28.0	55.3	16.3	5.7	40
Sagebrush Reference Areas						
J7 SBRA	Fall 2016	36.5	59.3	20.1	15.9	20
	Fall 2017	35.0	60.1	18.9	12.6	20
	Spring 2019	40.3	55.5	16.8	19.5	38
	Fall 2019	31.0	59.3	12.3	15.8	37
N7/8 SBRA	Fall 2016	32.2	69.9	10.3	18.3	33
	Fall 2017	31.7	60.4	10.3	19.1	26
	Spring 2019	25.4	77.1	3.7	10.5	50
	Fall 2019	23.3	75.7	3.5	10.9	48
N14 SBRA	Fall 2016	42.6	60.2	20.7	19.1	9
	Fall 2017	41.5	56.9	20.5	18.5	13
	Spring 2019	27.1	56.5	7.4	16.2	22
	Fall 2019	43.0	66.4	18.4	21.8	18

* Ground cover includes vegetation, standing dead, litter, and rock cover.

Table 3.3: Sample Adequacy Calculations for the J16, J19, and J21 RLRAs and J7, N7/8, and N14 SBRAs

Site ID	Sample Period	Mean	Standard Deviation	t-statistic	Sample Size	Minimum Sample Size
Phase II RLRAs						
J16 RLRA	Spring 2017	33.95	9.01	1.328	20	13
	Spring 2019	16.35	4.04	1.328	20	11
	Fall 2019	24.50	3.95	1.328	20	5
J19 RLRA	Fall 2016	41.3	6.4	1.328	20	5
	Spring 2019*	25.8	10.1	1.319	24	27
	Fall 2019	26.05	4.30	1.328	20	5
J21 RLRA	Fall 2016	41.40	7.96	1.328	20	7
	Spring 2019	27.96	9.19	1.319	24	19
Sagebrush Reference Areas						
J7 SBRA	Fall 2016	36.47	5.76	1.345	15	5
	Fall 2017	35.0	5.4	1.345	15	5
	Spring 2019	40.27	10.37	1.345	15	12
	Fall 2019	31.00	7.09	1.345	15	10
N7/8 SBRA	Fall 2016	32.20	7.15	1.345	15	9
	Fall 2017	31.7	7.2	1.345	15	10
	Spring 2019	25.40	7.20	1.345	15	15
	Fall 2019	23.33	5.16	1.345	15	9
N14 SBRA	Fall 2016	42.60	8.54	1.345	15	8
	Fall 2017	41.5	3.4	1.345	15	2
	Spring 2019	27.07	4.99	1.345	15	7
	Fall 2019	43.00	5.29	1.345	15	3

* Sample adequacy was calculated in the field using Phase III allowable ground cover rather than foliar cover.

SBRA Cover

Total live vegetation foliar cover ranged from 23.3 percent in the N7/8 SBRA in fall 2019 to 43.0 percent in the N14 SBRA in fall 2019 (Table 3.2). Average foliar cover for all three SBRAs was lowest in spring 2019 at 30.9 percent and highest at 37.1 percent in fall 2016. Total ground cover (including live vegetation, standing dead, litter, and rock cover) ranged from a low of 55.5 percent in spring 2019 in the J7 SBRA to a high of 77.1 percent in the N7/8 SBRA in spring 2019. Average ground cover for all three SBRAs was lowest in fall 2017 at 59.1 percent and highest at 67.1 percent in fall 2019.

Litter cover was the greatest component of the ground cover after live vegetation but was highly variable in the three SBRAs. Litter cover ranged from 11.5 percent in the J7 SBRA in spring 2019 to 25.7 percent in the N14 SBRA in spring 2019 (Appendix 3.2). Litter cover averaged 17.9 percent over the 12 SBRA sampling events.

Rock cover was consistently greatest in the N7/8 SBRA ranging from 11.5 percent in fall 2017 to 24.1 percent in fall 2019. The other SBRAs had little or no rock. Values for rock cover averaged less than 0.1 percent in the N14 SBRA and 1.6 percent in the J7 SBRA.

The shrub/subshrub component comprised the largest component of the vegetation cover in eight of the 12 sampling events and the second most component in the other four. Shrubs/subshrubs comprised an average of 49 percent of the vegetation cover across all datasets. The most common shrub species in all three SBRAs was big sagebrush (*Artemisia tridentata*) with a significant contribution from fourwing saltbush (*Atriplex canescens*) and Greene's rabbitbrush (*Chrysothamnus greenei*) in the J7 and N7/8 SBRAs. Native perennial grasses were the largest component in the four sampling events not dominated by shrubs and were the second most common in another six sampling events. Native perennial grasses comprised 38 percent of the vegetation cover on average. Blue grama (*Bouteloua gracilis*) was the most commonly encountered grass species in all three SBRAs.

RLRA Cover

J16 RLRA Cover

Total foliar cover was 34.0 percent in spring 2017, 16.4 percent in spring 2019, and 24.5 percent in fall 2019 (Table 3.2 and Appendix 3.1). Total ground cover was 46.9 percent in spring 2017, 28.7 percent in spring 2019, and 45.8 percent in fall 2019. Litter cover was the greatest component of the ground cover after live vegetation and ranged from a low of 10.7 percent in spring 2019 to a high of 18.3 percent in fall 2019. Rock cover ranged from 1.5 to 2.6 percent.

The grass component comprised most of the total vegetation cover in all three years. Total grass cover was 27.6 percent in spring 2017, 12.4 percent in spring 2019, and 18.2 percent in fall 2019 (Table 3.2) and comprised between 74 and 81 percent of the total vegetation cover each year. The dominant species was Russian wildrye (*Elymus junceus*) contributing between 39 and 43 percent of the total vegetation cover each year. Native warm season perennial grasses, primarily blue grama and sand dropseed (*Sporobolus cryptandrus*) also contributed substantially. Shrubs and subshrubs, primarily fourwing saltbush and forage kochia (*Kochia prostrata*) were the other important species contributing between 18 and 22 percent of the total vegetation cover each year.

J19 RLRA Cover

Total foliar cover was 41.3 percent in fall 2016, 25.8 percent in spring 2019, and 26.1 percent in fall 2019 (Table 3.2 and Appendix 3.1). Total ground cover was 65.5 percent in fall 2016, 44.9 percent in spring 2019, and 45.1 percent in fall 2019. Litter cover was the greatest component of the ground cover after live vegetation and ranged from a high of 20.9 percent in fall 2016 to a low of 16.1 percent in fall 2019. Rock cover ranged from 1.8 to 3.0 percent.

The grass component comprised most of the total vegetation cover in all three years. Total grass cover was 22.4 percent in fall 2016, 11.0 percent in spring 2019, and 16.6 percent in fall 2019 (Table 3.2) and comprised between 43 and 64 percent of the total vegetation cover each year. The dominant species was Russian wildrye contributing between 24 and 35 percent of the total vegetation cover each year. Native warm season perennial grasses, primarily blue grama, alkali sacaton (*Sporobolus airoides*), and sand dropseed also contributed substantially. Shrubs and subshrubs, primarily fourwing saltbush were the other important species contributing between 16 and 23 percent of the total vegetation cover each year.

J21 RLRA Cover

Total foliar cover was 41.4 percent in fall 2016 and 28.0 percent in spring 2019 (Table 3.2 and Appendix 3.1). Total ground cover was 68.9 percent in fall 2016 and 55.3 percent in spring 2019. Litter cover was consistent with 22.2 percent in fall 2016 and 23.6 percent in spring 2019. Rock cover was 1.2 percent in fall 2016 and 2.9 percent in spring 2019.

The grass component comprised most of the total vegetation cover in both years. Total grass cover was 29.6 percent in fall 2016 and 16.3 percent in spring 2019 (Table 3.2) and comprised 71 percent and 58 percent of the total vegetation cover, respectively. The dominant species, Russian wildrye, contributed 29 percent and 39 percent of the total vegetation cover in fall 2016 and spring 2019, respectively. Native warm season perennial grasses, primarily blue grama and alkali sacaton also contributed substantially. Shrubs and subshrubs, primarily fourwing saltbush were the other important species contributing 14 and 20 percent of the total vegetation cover each year, respectively.

Species Diversity

Species diversity is measured by recording all species occurring within one meter on either side of each vegetation cover transect. The total number of species observed along all RLRA transects was lowest in the fall 2019 sampling of the J16 RLRA with only 20 species and highest in the J19 RLRA in spring 2019 with 46 species observed. The J16 RLRA was the least diverse with an average of 26 species across the three sampling events. The J19 RLRA averaged 34 species across the three sampling events and the J21 RLRA was the most diverse with an average of 41.5 species across the two sampling events. In the SBRAs the lowest species diversity was found in the N14 SBRA which ranged from 9 to 22 species across the four sampling events and averaged 15.5 species. The highest diversity was in the N7/8 SBRA with 39.3 species across the four sampling events and the J7 SBRA averaged 28.8 species.

RLRA REVEGETATION SUCCESS CHARACTERIZATION

The data collected in the J16, J19, and J21 RLRAs demonstrates that they have developed vegetation cover that meets the requirements for Phase II bond release. An effective, diverse, and permanent vegetative cover has been established that is consistent with the post-mining land use. The vegetation cover on the RLRAs is comparable to that observed on the SBRAs and it is anticipated that these RLRAs are on their way to achieving the goals of final bond release when they reach that stage of maturity.

Vegetation Cover

Total vegetation cover in the J19 and J21 RLRAs was equal to or greater than that observed in the reference areas in fall 2016 (Figures 3.1 and 3.2, respectively) and the spring 2017 J16 RLRA data was comparable to the fall 2017 SBRA data (Figure 3.3). However, vegetation cover in all three RLRAs decreased from these first sampling events to the spring 2019 sampling event. This was primarily due to extreme drought conditions during 2018 with October-September at only 60 percent of the historic average (Figure 3.4). While spring 2019 was wetter than average (January – June precipitation was 288 percent of average) leading to an overall above average precipitation year in 2018-2019, the July – September precipitation was only 47 percent of average (Figure 3.5). This dry summer did not allow the vegetation to rebound to the pre-drought conditions. The spring 2019 cover in J16 and J19 RLRAs was also impacted by trespass grazing in some pastures. Due to the drought conditions in 2018, PWCC did not allow local residents to graze reclaimed areas in the winter of 2018-2019; however, some fences were cut and grazed anyway without PWCC's knowledge.

Even with these impacts to the vegetation cover, both the spring and fall 2019 J19 RLRA vegetation cover and the fall 2019 J16 RLRA vegetation cover was greater than that observed at the same time in the N7/8 SBRA and were close to one of the other SBRAs (Figure 3.1). Additionally, the spring 2019 J21 RLRA vegetation cover was greater than both the N7/8 and N14 SBRAs (Figure 3.2).

The SBRAs are much less impacted by climatic variability than the RLRAs for two reasons both related to their status as climax vegetation communities compared to the early seral vegetation communities in the RLRAs. The SBRAs are dominated by slow-growing woody species (subshrubs, shrubs, and trees) with a secondary component of native perennial grasses. Both vegetation groups have had the time to develop root reserves to help them withstand drought years. Woody species are included in the reclamation, but the Phase II RLRAs have not had sufficient time for them to mature. Among the five 2019 RLRA datasets, woody species ranged from 16 to 23 percent of the vegetation cover and averaged only 18 percent. Conversely, woody species averaged 56 percent (ranging from 48 to 68 percent) of the vegetation cover in the six 2019 SBRA datasets. Further, because the primary post-mining land use is livestock grazing, the RLRAs have been purposely seeded with a larger component of perennial grasses.

Figure 3.1: Total Foliar Vegetation Cover (Mean + Standard Error) in the J19 RLRA and SBRAs

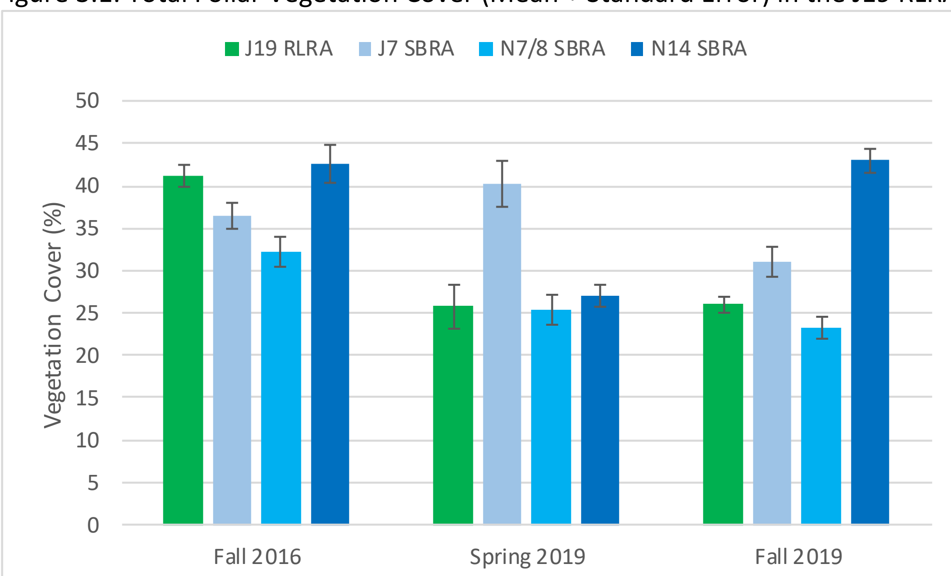


Figure 3.2: Total Foliar Vegetation Cover (Mean + Standard Error) in the J21 RLRA and SBRAs

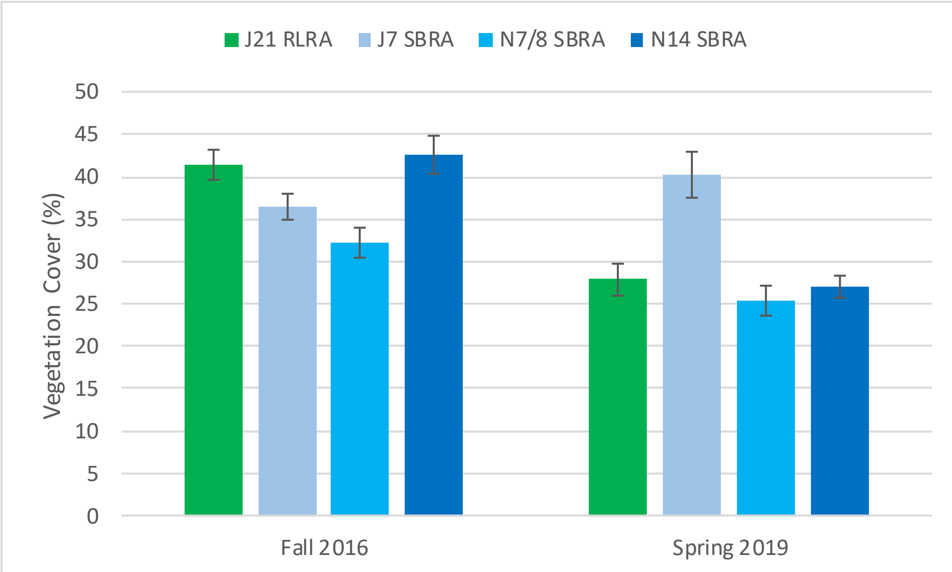
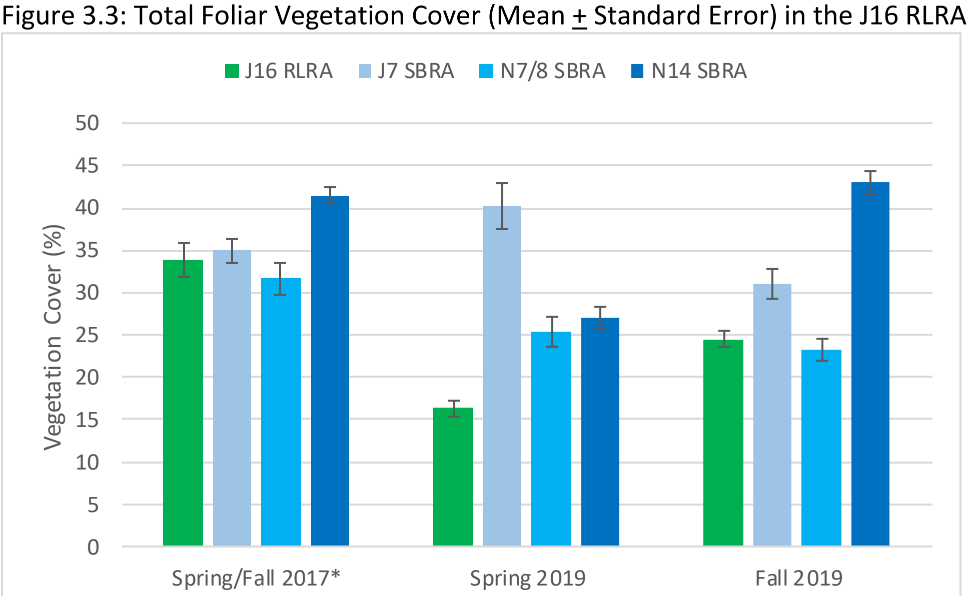
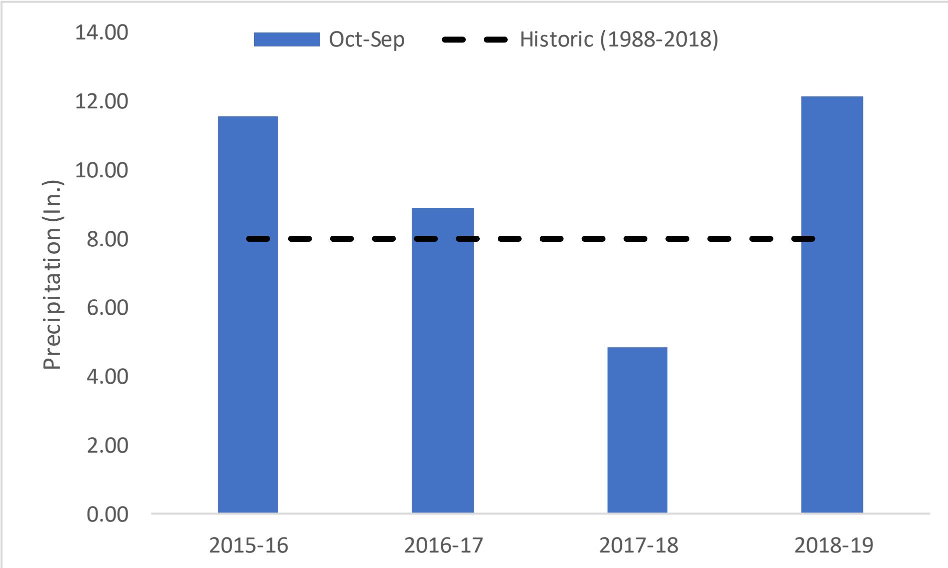


Figure 3.3: Total Foliar Vegetation Cover (Mean $\pm$ Standard Error) in the J16 RLRA and SBRAs



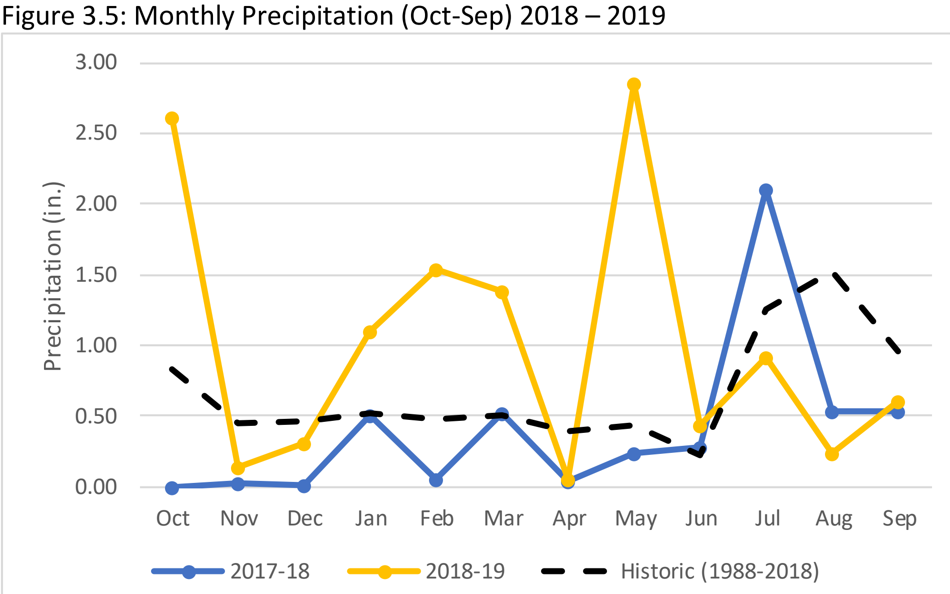
* J16 RLRA data were collected in spring 2017 while SBRA data were collected in fall 2017.

Figure 3.4: Annual Precipitation (Oct-Sep) 2016 – 2019



* Precipitation data averaged from the three closest weather stations (6R, MET12, and 200).

Figure 3.5: Monthly Precipitation (Oct-Sep) 2018 – 2019

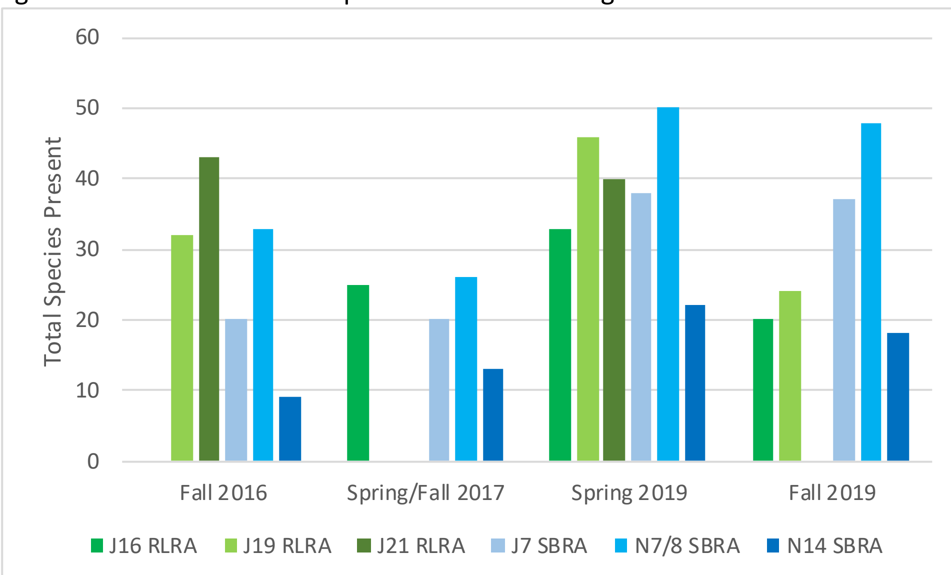


* Precipitation data averaged from the three closest weather stations (6R, MET12, and 200).

Species Diversity

The total species diversity in the RLRAs was greater than the N14 SBRA in every sampling event and greater than the J7 SBRA in half of the sampling events (Figure 3.6). As with the vegetation cover data, the species composition of the RLRAs included more grasses and the SBRAs included more woody species. Given that these RLRAs are only at the Phase II stage of bond release, there is ample evidence to suggest that the RLRAs will meet Phase III standards in the future.

Figure 3.6: Total Number of Species Observed Along Transects



Utility for Post-Mining Land Use

Most of the vegetation cover observed in the J16, J19, and J21 RLRAs reflects approved seed mixes (82 percent on average of the relative cover). Seed mixes were formulated to provide good forage production and nutrient levels and palatability for all classes of livestock and a variety of wildlife. While no production data were collected as a part of Phase II sampling, an average of 72 percent of the relative vegetation cover was species known to have high palatability for livestock, with another 16 percent of the cover made up of species with medium forage palatability.

Russian wildrye was a primary species throughout all three RLRAs contributing an average of 34 percent of the relative cover. This species has a very long season of use and high digestibility through much of the year. It retains good nutrient qualities as standing hay in the winter. Russian wildrye also exhibits good regrowth and recovery after grazing and when spring moisture and summer rains are likely. These qualities make this grass a valuable species throughout the year and compliment the other reclamation species in the PWCC grazing management program.

Appendix 3.1

RLRA Raw Data

<u>J16 RLRA</u>
Spring 2017
Spring 2019
Fall 2019

<u>J19 RLRA</u>
Fall 2016
Spring 2019
Fall 2019

<u>J21 RLRA</u>
Fall 2016
Spring 2019

J16 RLRA - Spring 2017

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																							
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Kochia scoparia	0.15	10.00	0.44	0.15	0.42											P																3													
Sisymbrium altissimum	0.05	10.00	0.15	0.05	0.14											P																1													
Tragopogon dubius	0.00	5.00	0.00	0.00	0.00																																							P	
TOTAL INTRO. ANN. & BIEN. FORBS	0.20	15.00	0.59	0.20	0.56											P																4												P	
INTRODUCED ANNUAL GRASSES																																													
Bromus tectorum	0.05	10.00	0.15	0.05	0.14																											1												P	
TOTAL INTRODUCED ANNUAL GRASSES	0.05	10.00	0.15	0.05	0.14																											1												P	
NATIVE PERENNIAL FORBS																																													
Asclepias verticillata	0.00	5.00	0.00	0.00	0.00													P																											
Astragalus calycosus var. scaposus	0.00	10.00	0.00	0.00	0.00			P												P																									
Leucelene ericoides	0.00	10.00	0.00	0.00	0.00			P																																		P			
Penstemon palmeri	0.00	5.00	0.00	0.00	0.00															P																									
Sphaeralcea coccinea	0.00	40.00	0.00	0.00	0.00	P						P								P										P		P		P		P		P							
Sphaeralcea grossulariaefolia	0.00	5.00	0.00	0.00	0.00															P																									
Tow nsendia exscapa	0.00	5.00	0.00	0.00	0.00			P																																					
TOTAL NATIVE PERENNIAL FORBS	0.00	55.00	0.00	0.00	0.00	P		P				P						P		P										P		P		P		P		P				P			
INTRODUCED PERENNIAL FORBS																																													
Onobrychis viciifolia	0.00	5.00	0.00	0.00	0.00																																	P							
TOTAL INTRO. PERENNIAL FORBS	0.00	5.00	0.00	0.00	0.00																																	P							
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron smithii	1.45	60.00	4.27	1.50	4.17	P		3		1		1								6		1								11		1		1						P		1		3	1
Hilaria jamesii	4.90	100.00	14.43	4.95	13.75	2		5		17		4		4		9		10		P		3		2		4		P		5		2		1		3		2	1	1		9		15	
Oryzopsis hymenoides	0.10	25.00	0.29	0.20	0.56	P	1							1						P						1	1					P													
Sitanion hystrix	0.00	5.00	0.00	0.00	0.00																											P													
TOTAL NATIVE PERENNIAL GRASSES (c)	6.45	100.00	19.00	6.65	18.47	2	1	8		18		5		5		9		10		6		4		2		5	1	P		16		3		2		3		2	1	1		10		18	1
NATIVE PERENNIAL GRASSES (w arm)																																													
Bouteloua curtipendula	0.00	5.00	0.00	0.00	0.00															P																									
Bouteloua gracilis	2.90	80.00	8.54	3.10	8.61	16	2	5		4		P		1				P		9	2			P		P				1		3		2		5		P				4		8	
Sporobolus airoides	3.75	35.00	11.05	3.75	10.42			6				1						5												5				18								39		1	
TOTAL NATIVE PERENNIAL GRASSES (w)	6.65	80.00	19.59	6.85	19.03	16	2	11		4		1		1				5		9	2			P		P				6		3		20		5		P				43		9	
INTRODUCED PERENNIAL GRASSES (cool)																																													
Elymus junceus	14.50	95.00	42.71	16.10	44.72	8	4	1		9		12		21	1	12		2		5	4	14	3	20	8	26	3	36	2	11	2	22		14	2	15	1	17	2	30				15	
TOTAL INTRO. PERENNIAL GRASSES (c)	14.50	95.00	42.71	16.10	44.72	8	4	1		9		12		21	1	12		2		5	4	14	3	20	8	26	3	36	2	11	2	22		14	2	15	1	17	2	30				15	
NATIVE SUBSHRUBS																																													
Ceratoides lanata	0.00	10.00	0.00	0.00	0.00							P																																P	
Gutierrezia sarothrae	0.10	25.00	0.29	0.10	0.28	P		2				P																										P						P	
TOTAL NATIVE SUBSHRUBS	0.10	25.00	0.29	0.10	0.28	P		2				P																										P						P	
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	1.90	40.00	5.60	1.95	5.42			P		15		P				P		21	1			2																		P				P	
TOTAL INTRO. SUBSHRUBS FORBS	1.90	40.00	5.60	1.95	5.42			P		15		P				P		21	1			2																		P				P	

J16 RLRA - Spring 2017 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
NATIVE SHRUBS					
Atriplex canescens	3.90	90.00	11.49	3.90	10.83
Chrysothamnus nauseosus	0.20	10.00	0.59	0.20	0.56
TOTAL NATIVE SHRUBS	4.10	90.00	12.08	4.10	11.39
Standing dead	0.25	15.00		0.25	
Litter	11.20	100.00		11.20	
Bare ground	53.16	100.00		53.16	
Rock	1.45	55.00		1.45	
TOTALS	100.01		100.00	102.06	100.00
TOTAL VEGETATION COVER	33.95	s=(9.01)		36.00	s=(9.41)
GROUND COVER (Veg+Litter+St.Dead+Rock)	46.85	s=(10.54)		48.90	s=(10.26)
SPECIES DENSITY (# of species/100 sq.m.)	7.00	s=(2.62)			

Percent Foliar Cover

PLANT SPECIES	1		2		3		4		5		6		7		8		9		10	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE SHRUBS																				
Atriplex canescens	9				P		P		3		1		P		4		9		17	
Chrysothamnus nauseosus	1														3					
TOTAL NATIVE SHRUBS	10				P		P		3		1		P		7		9		17	
Standing dead															1					
Litter	6		25		4		28		8		11		2		4		8		8	
Bare ground	58		45		49		50		60		67		60		67		61		52	
Rock			8		1		4		2						1		2		1	
TOTALS	100	7	100	0	100	0	100	0	100	1	100	0	100	1	100	6	100	3	100	8
TOTAL VEGETATION COVER	36	7	22	0	46	0	18	0	30	1	22	0	38	1	27	6	29	3	39	8
GROUND COVER (Veg+Litter+St.Dead+Rock)	42	7	55	0	51	0	50	0	40	1	33	0	40	1	33	6	39	3	48	8
SPECIES DENSITY (# of species/100 sq.m.)	9		10		6		10		5		6		7		12		5		4	

PLANT SPECIES	11		12		13		14		15		16		17		18		19		20	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE SHRUBS																				
Atriplex canescens	5		5		3		7		4		2		7		1				1	
Chrysothamnus nauseosus																				
TOTAL NATIVE SHRUBS	5		5		3		7		4		2		7		1				1	
Standing dead			1																3	
Litter	15		8		8		11		3		12		17		7		9		30	
Bare ground	49		50		56		46		56		63		53		61		38		22	
Rock							3		1				4						2	
TOTALS	100	4	100	2	100	2	100	0	100	2	100	1	100	3	100	0	100	0	100	1
TOTAL VEGETATION COVER	36	4	41	2	36	2	40	0	40	2	25	1	26	3	32	0	53	0	43	1
GROUND COVER (Veg+Litter+St.Dead+Rock)	51	4	50	2	44	2	54	0	44	2	37	1	47	3	39	0	62	0	78	1
SPECIES DENSITY (# of species/100 sq.m.)	5		3		7		11		7		5		7		5		5		11	

J16 RLRA - Spring 2019

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																									
Cleome serrulata	0.00	10.00	0.00	0.00	0.00			P																P	
Descurainia pinnata	0.25	50.00	1.53	0.25	1.53	1				P	P	1				P		1	P	2			P		P
Descurainia richardsonii	0.00	15.00	0.00	0.00	0.00			P					P												P
Gilia pumila	0.00	5.00	0.00	0.00	0.00							P													
Helianthus petiolaris	0.00	5.00	0.00	0.00	0.00			P																	
Lappula redowskii	0.25	70.00	1.53	0.25	1.53	P		1		P	P	P	P	P		P		P	P	1			1	2	P
TOTAL NATIVE ANN. & BIEN. FORBS	0.50	70.00	3.06	0.50	3.06	1		1		P	P	1	P	P		P		1	P	3			1	2	P
INTRODUCED ANNUAL & BIENNIAL FORBS																									
Chenopodium album	0.00	40.00	0.00	0.00	0.00		P			P		P					P			P			P	P	P
Kochia scoparia	0.05	35.00	0.31	0.05	0.31	P	P			1			P		P					P					P
Melilotus officinalis	0.00	10.00	0.00	0.00	0.00												P						P		
Ranunculus testiculatus	0.00	15.00	0.00	0.00	0.00									P				P						P	
Salsola iberica	0.00	30.00	0.00	0.00	0.00	P		P					P			P							P	P	
Sisymbrium altissimum	0.00	45.00	0.00	0.00	0.00	P				P			P	P			P	P		P				P	P
Sisymbrium irio	0.35	45.00	2.14	0.35	2.14			P		2		1	1			P					1		1	P	1
TOTAL INTRO. ANN. & BIEN. FORBS	0.40	80.00	2.45	0.40	2.45	P	P	P		3		1	1	P	P	P	P	P		P	1		1	P	1
INTRODUCED ANNUAL GRASSES																									
Bromus tectorum	0.05	30.00	0.31	0.05	0.31		P		1		P									P	P		P		
TOTAL INTRODUCED ANNUAL GRASSES	0.05	30.00	0.31	0.05	0.31		P		1		P									P	P		P		
NATIVE PERENNIAL FORBS																									
Erigeron concinnus	0.00	5.00	0.00	0.00	0.00			P																	
Penstemon eatonii	0.00	10.00	0.00	0.00	0.00			P																	P
Physaria acutifolia	0.00	20.00	0.00	0.00	0.00			P		P						P								P	
Sphaeralcea coccinea	0.15	30.00	0.92	0.15	0.92			P		1				1				P	P						1
TOTAL NATIVE PERENNIAL FORBS	0.15	40.00	0.92	0.15	0.92			P		1				1		P		P	P					P	1
NATIVE PERENNIAL GRASSES (cool)																									
Agropyron smithii	0.10	65.00	0.61	0.10	0.61	1	P	P		P	P			P	P			P	P	P		P	P		1
Agropyron spicatum	0.10	25.00	0.61	0.10	0.61										1	P			1				P		P
Hilaria jamesii	1.80	65.00	11.01	1.80	11.01	1	P	1	4		1	3		7	1		2		5		2		1		8
Oryzopsis hymenoides	0.00	5.00	0.00	0.00	0.00					P															
Poa sp.	0.00	15.00	0.00	0.00	0.00							P						P			P				
TOTAL NATIVE PERENNIAL GRASSES (c)	2.00	90.00	12.23	2.00	12.23	2	P	1	4	P	1	3		7	2	P	2	P	6	P	2	P	1		9
NATIVE PERENNIAL GRASSES (warm)																									
Bouteloua gracilis	1.05	90.00	6.42	1.05	6.42	2	2		1	2	2	3	P	2	P	P	P	P	1	2	4	P	P		P
Sporobolus airoides	0.00	5.00	0.00	0.00	0.00											P									
Sporobolus cryptandrus	2.70	55.00	16.51	2.70	16.51		2	P	10			14			P	P	14	2		1	11	P			
TOTAL NATIVE PERENNIAL GRASSES (w)	3.75	95.00	22.94	3.75	22.94	2	4	P	11	2	2	17	P	2	P	P	14	2	1	3	15	P	P		P
INTRODUCED PERENNIAL GRASSES (cool)																									
Elymus junceus	6.60	100.00	40.37	6.60	40.37	6	12	4	P	5	12	P	15	3	9	6	1	10	6	8	P	16	10	3	6
TOTAL INTRO. PERENNIAL GRASSES (c)	6.60	100.00	40.37	6.60	40.37	6	12	4	P	5	12	P	15	3	9	6	1	10	6	8	P	16	10	3	6

J16 RLRA - Spring 2019 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																			
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE SUBSHRUBS																									
Ceratoides lanata	0.00	20.00	0.00	0.00	0.00								P	P						P					P
Gutierrezia sarothrae	0.00	5.00	0.00	0.00	0.00									P											
TOTAL NATIVE SUBSHRUBS	0.00	20.00	0.00	0.00	0.00								P	P						P					P
INTRODUCED SUBSHRUBS																									
Kochia prostrata	0.50	50.00	3.06	0.50	3.06	1		1		P		P	P	P			P		P				2	6	
TOTAL INTRO. SUBSHRUBS FORBS	0.50	50.00	3.06	0.50	3.06	1		1		P		P	P	P			P		P				2	6	
NATIVE SHRUBS																									
Artemisia tridentata	0.05	5.00	0.31	0.05	0.31									1											
Atriplex canescens	2.25	100.00	13.76	2.25	13.76	P	8	P	1	5	6	P	1	3	4	5	P	P	3	P	1	P	3	1	4
Atriplex confertifolia	0.10	15.00	0.61	0.10	0.61	1				P									1						
Atriplex obovata	0.00	5.00	0.00	0.00	0.00																	P			
TOTAL NATIVE SHRUBS	2.40	100.00	14.68	2.40	14.68	1	8	P	1	5	6	P	1	4	4	5	P	P	4	P	1	P	3	1	4
SUCCULENTS																									
Opuntia polyacantha	0.00	5.00	0.00	0.00	0.00															P					
TOTAL SUCCULENTS	0.00	5.00	0.00	0.00	0.00															P					
Standing dead	0.05	5.00		0.05																		1			
Litter	10.70	100.00		10.70		6	14	10	22	8	9	22	4	3	3	16	21	13	3	4	26	10	9	6	5
Bare ground	71.35	100.00		71.35		81	62	73	56	72	70	56	79	80	77	73	60	71	80	82	55	71	73	82	74
Rock	1.55	35.00		1.55				10	5	4					5		2	3				2			
TOTALS	100.00		100.00	100.00	100.00	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
TOTAL VEGETATION COVER	16.35	s=(4.04)		16.35	s=(4.04)	13 0	24 0	7 0	17 0	16 0	21 0	22 0	17 0	17 0	15 0	11 0	17 0	13 0	17 0	14 0	19 0	16 0	18 0	12 0	21 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	28.65	s=(8.98)		28.65	s=(8.98)	19 0	38 0	27 0	44 0	28 0	30 0	44 0	21 0	20 0	23 0	27 0	40 0	29 0	20 0	18 0	45 0	29 0	27 0	18 0	26 0
SPECIES DENSITY (# of species/100 sq.m.)	11.00	s=(2.99)				12	9	16	6	15	8	12	11	13	8	11	9	11	11	13	8	6	14	11	16

J16 RLRA - Fall 2019

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																			
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																									
Conyza canadensis	0.00	5.00	0.00	0.00	0.00																	P			
Descurainia pinnata	0.50	20.00	2.04	0.50	2.04				2	8							P					P			
Lappula redowskii	0.00	15.00	0.00	0.00	0.00					P	P										P				
Machaeranthera canescens	0.00	15.00	0.00	0.00	0.00										P					P					P
TOTAL NATIVE ANN. & BIEN. FORBS	0.50	45.00	2.04	0.50	2.04				2	8	P				P		P			P	P	P			P
INTRODUCED ANNUAL & BIENNIAL FORBS																									
Chenopodium album	0.10	45.00	0.41	0.10	0.41		P	P		P				2		P			P		P	P		P	
Kochia scoparia	0.05	25.00	0.20	0.05	0.20					P				P		1						P		P	
Lactuca serriola	0.00	5.00	0.00	0.00	0.00																			P	
Melilotus officinalis	0.00	5.00	0.00	0.00	0.00										P										
Salsola iberica	0.05	10.00	0.20	0.05	0.20											1	P								
Sisymbrium altissimum	0.00	40.00	0.00	0.00	0.00			P		P	P		P	P			P							P	P
Tragopogon dubius	0.00	20.00	0.00	0.00	0.00							P			P		P			P					
TOTAL INTRO. ANN. & BIEN. FORBS	0.20	80.00	0.82	0.20	0.81		P	P		P	P	P	P	2	P	2	P		P	P	P	P		P	P
INTRODUCED ANNUAL GRASSES																									
Bromus tectorum	0.30	45.00	1.22	0.30	1.22	P	P		5	P					P				1			P		P	P
TOTAL INTRODUCED ANNUAL GRASSES	0.30	45.00	1.22	0.30	1.22	P	P		5	P					P				1			P		P	P
NATIVE PERENNIAL FORBS																									
Astragalus calycosus var. scaposus	0.00	5.00	0.00	0.00	0.00															P					
Penstemon palmeri	0.00	10.00	0.00	0.00	0.00								P			P									
Ratibida columnaris	0.00	5.00	0.00	0.00	0.00																	P			
Sphaeralcea coccinea	0.00	10.00	0.00	0.00	0.00															P					P
TOTAL NATIVE PERENNIAL FORBS	0.00	25.00	0.00	0.00	0.00								P			P				P		P			P
NATIVE PERENNIAL GRASSES (cool)																									
Agropyron smithii	0.90	35.00	3.67	0.90	3.67						2				7			4	P	4			1		P
Agropyron spicatum	0.00	5.00	0.00	0.00	0.00															P					
Hilaria jamesii	1.75	65.00	7.14	1.75	7.13	1	12			P		1	P	1		1		3	P	P		4	9	3	
Oryzopsis hymenoides	0.00	40.00	0.00	0.00	0.00						P				P	P		P	P	P	P				P
TOTAL NATIVE PERENNIAL GRASSES (c)	2.65	85.00	10.82	2.65	10.79	1	12			P	2	1	P	1	7	1		7	P	4	P	4	10	3	P
NATIVE PERENNIAL GRASSES (warm)																									
Bouteloua curtipendula	0.25	5.00	1.02	0.25	1.02										5										
Bouteloua gracilis	1.40	85.00	5.71	1.40	5.70	5	3	2	2	P	P	P	P	P	1			2	1	2	4	1		2	3
Sporobolus cryptandrus	4.35	80.00	17.76	4.35	17.72	22	14	7	6	1	1		P		3	1		P	6		6	9	8	3	P
TOTAL NATIVE PERENNIAL GRASSES (w)	6.00	95.00	24.49	6.00	24.44	27	17	9	8	1	1	P	P	P	9	1		2	7	2	10	10	8	5	3
INTRODUCED PERENNIAL GRASSES (cool)																									
Elymus junceus	9.50	90.00	38.78	9.55	38.90			8 1	3	8	15	15	15	17	4	15	22	12	9	10	3	5	P	11	18
TOTAL INTRO. PERENNIAL GRASSES (c)	9.50	90.00	38.78	9.55	38.90			8 1	3	8	15	15	15	17	4	15	22	12	9	10	3	5	P	11	18
NATIVE SUBSHRUBS																									
Ceratoides lanata	0.05	10.00	0.20	0.05	0.20					1		P													
Gutierrezia sarothrae	0.00	10.00	0.00	0.00	0.00													P		P					
TOTAL NATIVE SUBSHRUBS	0.05	20.00	0.20	0.05	0.20					1		P						P		P					

J16 RLRA - Fall 2019 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																			
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	3.00	50.00	12.24	3.00	12.22					10		10				P		9		8										1		5				13		3						1	
TOTAL INTRO. SUBSHRUBS FORBS	3.00	50.00	12.24	3.00	12.22					10		10				P		9		8										1		5				13		3						1	
NATIVE SHRUBS																																													
Artemisia tridentata	0.00	5.00	0.00	0.00	0.00													P																											
Atriplex canescens	2.30	95.00	9.39	2.30	9.37	3		2		P		2		4		2				1		1		3		8		4		P		4		2		2		1		P		2		5	
Chrysothamnus nauseosus	0.00	10.00	0.00	0.00	0.00											P								P																					
TOTAL NATIVE SHRUBS	2.30	100.00	9.39	2.30	9.37	3		2		P		2		4		2		P		1		1		3		8		4		P		4		2		2		1		P		2		5	
Standing dead	0.40	25.00		0.40						1				1												4						1								1					
Litter	18.30	100.00		18.30		14		20		18		24		27		12		15		18		20		16		17		20		20		20		24		14		22		13		15		17	
Bare ground	54.25	100.00		54.25		55		46		54		46		47		65		58		51		48		61		52		47		51		53		56		57		55		65		64		54	
Rock	2.55	60.00		2.55				3						3		3		2		7		11						7		7				2		1				3				2	
TOTALS	100.00		100.00	100.05	100.00	100	0	100	0	100	1	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0
TOTAL VEGETATION COVER	24.50	s=(3.95)		24.55	s=(3.99)	31	0	31	0	27	1	30	0	22	0	20	0	25	0	24	0	21	0	23	0	27	0	26	0	22	0	26	0	18	0	28	0	23	0	18	0	21	0	27	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	45.75	s=(6.09)		45.80	s=(6.1)	45	0	54	0	46	1	54	0	53	0	35	0	42	0	49	0	52	0	39	0	48	0	53	0	49	0	47	0	44	0	43	0	45	0	35	0	36	0	46	0
SPECIES DENSITY (# of species/100 sq.m.)	8.65	s=(2.39)				5		6		7		7		12		10		7		8		7		12		9		6		9		10		12		8		12		5		10		11	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
NATIVE ANNUAL & BIENNIAL FORBS					
Machaeranthera canescens	0.00	5.00	0.00	0.00	0.00
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	5.00	0.00	0.00	0.00
INTRODUCED ANNUAL & BIENNIAL FORBS					
Amaranthus albus	0.00	5.00	0.00	0.00	0.00
Halogeton glomeratus	0.00	10.00	0.00	0.00	0.00
Kochia scoparia	8.10	35.00	19.64	8.10	18.49
Melilotus officinalis	0.00	10.00	0.00	0.00	0.00
Salsola iberica	3.45	45.00	8.36	3.45	7.88
TOTAL INTRO. ANN. & BIEN. FORBS	11.55	55.00	28.00	11.55	26.37
INTRODUCED ANNUAL GRASSES					
Bromus japonicus	0.05	5.00	0.12	0.05	0.11
Bromus tectorum	0.30	25.00	0.73	0.30	0.68
TOTAL INTRODUCED ANNUAL GRASSES	0.35	30.00	0.85	0.35	0.80
NATIVE PERENNIAL FORBS					
Gaillardia aristata	0.00	5.00	0.00	0.00	0.00
Ratibida columnaris	0.00	5.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL FORBS	0.00	10.00	0.00	0.00	0.00
INTRODUCED PERENNIAL FORBS					
Onobrychis viciifolia	0.05	15.00	0.12	0.05	0.11
Sanguisorba minor	0.25	10.00	0.61	0.25	0.57
TOTAL INTRO. PERENNIAL FORBS	0.30	15.00	0.73	0.30	0.68
NATIVE PERENNIAL GRASSES (cool)					
Agropyron dasystachyum	0.85	35.00	2.06	0.85	1.94
Agropyron smithii	2.70	75.00	6.55	2.80	6.39
Agropyron spicatum	0.55	35.00	1.33	0.65	1.48
Elymus canadensis	0.60	15.00	1.45	0.60	1.37
Hilaria jamesii	0.80	35.00	1.94	0.85	1.94
Oryzopsis hymenoides	0.00	15.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL GRASSES (c)	5.50	85.00	13.33	5.75	13.13
NATIVE PERENNIAL GRASSES (warm)					
Bouteloua curtipendula	0.55	30.00	1.33	0.55	1.26
Bouteloua gracilis	4.15	60.00	10.06	4.50	10.27
Buchloe dactyloides	0.00	10.00	0.00	0.00	0.00
Hilaria jamesii	0.20	15.00	0.48	0.25	0.57
Sporobolus airoides	1.70	40.00	4.12	1.80	4.11
Sporobolus cryptandrus	0.00	10.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL GRASSES (w)	6.60	65.00	16.00	7.10	16.21
INTRODUCED PERENNIAL GRASSES (cool)					
Agropyron elongatum	0.20	5.00	0.48	0.30	0.68
Agropyron intermedium	0.10	15.00	0.24	0.10	0.23
Elymus junceus	9.95	65.00	24.12	11.65	26.60
TOTAL INTRO. PERENNIAL GRASSES (c)	10.25	65.00	24.85	12.05	27.51

Percent Foliar Cover

PLANT SPECIES	1		2		3		4		5		6		7		8		9		10	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																				
Machaeranthera canescens															P					
TOTAL NATIVE ANN. & BIEN. FORBS															P					
INTRODUCED ANNUAL & BIENNIAL FORBS																				
Amaranthus albus																				
Halogeton glomeratus																				
Kochia scoparia																			P	
Melilotus officinalis					P														P	
Salsola iberica																			1	
TOTAL INTRO. ANN. & BIEN. FORBS					P														1	
INTRODUCED ANNUAL GRASSES																				
Bromus japonicus																			1	
Bromus tectorum																				
TOTAL INTRODUCED ANNUAL GRASSES																			1	
NATIVE PERENNIAL FORBS																				
Gaillardia aristata																			P	
Ratibida columnaris					P															
TOTAL NATIVE PERENNIAL FORBS					P														P	
INTRODUCED PERENNIAL FORBS																				
Onobrychis viciifolia																			1	
Sanguisorba minor																			5	
TOTAL INTRO. PERENNIAL FORBS																			6	
NATIVE PERENNIAL GRASSES (cool)																				
Agropyron dasystachyum	1		3		3						1									
Agropyron smithii	2		4	1	4		P				4				3				10	
Agropyron spicatum	P		P		4															
Elymus canadensis																			5	
Hilaria jamesii			P		10	1	4						P							
Oryzopsis hymenoides	P		P												P					
TOTAL NATIVE PERENNIAL GRASSES (c)	3		7	1	21	1	4				5		P		3				15	
NATIVE PERENNIAL GRASSES (warm)																				
Bouteloua curtipendula	P				6		2				P		2		1					
Bouteloua gracilis	4		7	1	8		9				23	4	13		3				1	
Buchloe dactyloides					P		P													
Hilaria jamesii	4	1									P				P					
Sporobolus airoides	P				P		10	1	1		2		16	1	3					
Sporobolus cryptandrus							P													
TOTAL NATIVE PERENNIAL GRASSES (w)	8	1	7	1	14		21	1	1		25	4	31	1	7				1	
INTRODUCED PERENNIAL GRASSES (cool)																				
Agropyron elongatum			4	2																
Agropyron intermedium					1										P					
Elymus junceus	24	2	5	3	4		7	1	36	6	4	3	14		14	6	32	5		
TOTAL INTRO. PERENNIAL GRASSES (c)	24	2	9	5	5		7	1	36	6	4	3	14		14	6	32	5		

PLANT SPECIES	11		12		13		14		15		16		17		18		19		20	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																				
Machaeranthera canescens																				
TOTAL NATIVE ANN. & BIEN. FORBS																				
INTRODUCED ANNUAL & BIENNIAL FORBS																				
Amaranthus albus																			P	
Halogeton glomeratus															P		P			
Kochia scoparia			4		P								40		42		44		32	
Melilotus officinalis																				
Salsola iberica			P				24		P		30		2		P		4		8	
TOTAL INTRO. ANN. & BIEN. FORBS			4		P		24		P		30		42		42		48		40	
INTRODUCED ANNUAL GRASSES																				
Bromus japonicus																				
Bromus tectorum									P		3				P		2		1	
TOTAL INTRODUCED ANNUAL GRASSES									P		3				P		2		1	
NATIVE PERENNIAL FORBS																				
Gaillardia aristata																				
Ratibida columnaris																				
TOTAL NATIVE PERENNIAL FORBS																				
INTRODUCED PERENNIAL FORBS																				
Onobrychis viciifolia											P								P	
Sanguisorba minor											P									
TOTAL INTRO. PERENNIAL FORBS											P								P	
NATIVE PERENNIAL GRASSES (cool)																				
Agropyron dasystachyum	6						2		1											
Agropyron smithii	8		6		2		5				2		1	1	2		1			
Agropyron spicatum	5	2	1		1				P											
Elymus canadensis							7				P									
Hilaria jamesii	1		1		P															
Oryzopsis hymenoides																				
TOTAL NATIVE PERENNIAL GRASSES (c)	20	2	8		3		14		1		2		1	1	2		1			
NATIVE PERENNIAL GRASSES (warm)																				
Bouteloua curtipendula																				
Bouteloua gracilis			1		6	1	1		7	1										
Buchloe dactyloides																				
Hilaria jamesii																				
Sporobolus airoides			2																	
Sporobolus cryptandrus							P													
TOTAL NATIVE PERENNIAL GRASSES (w)			3		6	1	1		7	1										
INTRODUCED PERENNIAL GRASSES (cool)																				
Agropyron elongatum																				
Agropyron intermedium	1																			
Elymus junceus	11	5	17		22				9	3										
TOTAL INTRO. PERENNIAL GRASSES (c)	12	5	17		22				9	3										

J19 RLRA - Fall 2016 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE SUBSHRUBS																									
Ceratoides lanata	0.00	25.00	0.00	0.00	0.00	P	P										P	P		P					
Gutierrezia sarothrae	0.20	35.00	0.48	0.20	0.46	P	P	2	P		P		2		P										
TOTAL NATIVE SUBSHRUBS	0.20	50.00	0.48	0.20	0.46	P	P	2	P		P		2		P		P	P		P					
INTRODUCED SUBSHRUBS																									
Kochia prostrata	0.25	30.00	0.61	0.25	0.57	P						P	4	P	1				P						
TOTAL INTRO. SUBSHRUBS FORBS	0.25	30.00	0.61	0.25	0.57	P						P	4	P	1				P						
NATIVE SHRUBS																									
Atriplex canescens	6.10	75.00	14.79	6.10	13.93	15	13	4	4	10	9	5	6	8	P	10	10	13	P	15					
Atriplex confertifolia	0.00	5.00	0.00	0.00	0.00																				P
Chrysothamnus nauseosus	0.15	5.00	0.36	0.15	0.34								3												
TOTAL NATIVE SHRUBS	6.25	80.00	15.15	6.25	14.27	15	13	4	4	10	9	5	9	8	P	10	10	13	P	15					P
Standing dead	1.55	70.00		1.55		2	3	4	4	2	2	2	1	4	1	1	1	1		3					
Litter	20.90	100.00		20.90		11	13	16	16	12	7	2	10	8	12	30	29	28	19	56	26	37	31	30	25
Bare ground	34.50	100.00		34.50		34	48	34	42	34	47	38	50	46	58	27	23	27	40	9	39	17	25	19	33
Rock	1.80	55.00		1.80		3			2	5	1	8		2	4		5		2			3			1
TOTALS	100.00		100.00	102.55	100.00	100 3	100 7	100 1	100 2	100 6	100 7	100 1	100 6	100 5	100 0	100 7	100 0	100 1	100 0	100 4	100 0	100 1	100 0	100 0	100 0
TOTAL VEGETATION COVER	41.25	s=(6.41)		43.80	s=(6.93)	50 3	36 7	46 1	36 2	47 6	43 7	50 1	39 6	40 5	25 0	42 7	42 0	44 1	39 0	32 4	35 0	43 1	44 0	51 0	41 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	65.50	s=(12.39)		68.05	s=(11.99)	66 3	52 7	66 1	58 2	66 6	53 7	62 1	50 6	54 5	42 0	73 7	77 0	73 1	60 0	91 4	61 0	83 1	75 0	81 0	67 0
SPECIES DENSITY (# of species/100 sq.m.)	8.10	s=(3.49)				13	11	14	10	3	9	7	13	3	13	7	10	8	8	8	6	3	5	5	6

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	P101	P102	P108	P109
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																													
Descurainia pinnata	0.00	8.33	0.00	0.00	0.00				P		P																		
Descurainia richardsonii	0.25	58.33	0.97	0.25	0.96	P		1		P		P		2	P		P		1		P		2	P		P		P	P
Gilia leptomeria	0.00	4.17	0.00	0.00	0.00																								P
Gilia pumila	0.00	4.17	0.00	0.00	0.00																								P
Lappula redowskii	0.00	41.67	0.00	0.00	0.00		P	P			P						P	P	P		P	P	P						P
Polygonum ramosissimum	0.00	4.17	0.00	0.00	0.00																			P					
TOTAL NATIVE ANN. & BIEN. FORBS	0.25	79.17	0.97	0.25	0.96	P	P	1	P	P	P	P		2	P		P	P	1		P	P	2	P		P		P	P
INTRODUCED ANNUAL & BIENNIAL FORBS																													
Carduus nutans	0.04	4.17	0.16	0.04	0.16																		1						
Chenopodium album	0.00	8.33	0.00	0.00	0.00		P														P								
Erodium cicutarium	0.00	4.17	0.00	0.00	0.00												P												
Kochia scoparia	2.21	50.00	8.58	2.25	8.64	P			4					P	P	1	P	P	1		P	4 1	16	27					
Lactuca serriola	0.00	8.33	0.00	0.00	0.00			P																					P
Melilotus officinalis	0.00	12.50	0.00	0.00	0.00															P					P			P	
Salsola iberica	0.13	25.00	0.49	0.13	0.48			P									P	P		P	P			3					
Sisymbrium altissimum	1.25	54.17	4.85	1.25	4.80	P			8	1				8	1	3		4	3	P	1	P		1				P	
TOTAL INTRO. ANN. & BIEN. FORBS	3.63	79.17	14.08	3.67	14.08	P	P	P	12	1				8	1	4	P	4	4	P	1	4 1	17	31	P			P	P
INTRODUCED ANNUAL GRASSES																													
Bromus tectorum	6.38	79.17	24.76	6.42	24.64	8	P	7	1	37		1	P	5	18	2		5 1	31	2	1	2	9			2	20		2
TOTAL INTRODUCED ANNUAL GRASSES	6.38	79.17	24.76	6.42	24.64	8	P	7	1	37		1	P	5	18	2		5 1	31	2	1	2	9			2	20		2
NATIVE PERENNIAL FORBS																													
Astragalus calycosus var. scaposus	0.00	4.17	0.00	0.00	0.00																	P							
Astragalus praelongus	0.00	12.50	0.00	0.00	0.00			P				P					P												
Astragalus wingatanus	0.13	25.00	0.49	0.13	0.48			P	P											P		1			2				P
Erigeron concinnus	0.00	4.17	0.00	0.00	0.00	P																							
Gaillardia aristata	0.04	16.67	0.16	0.04	0.16			P														P			P				1
Linum lewisii	0.00	8.33	0.00	0.00	0.00			P										P											
Penstemon eatonii	0.00	4.17	0.00	0.00	0.00																	P							
Ratibida columnaris	0.00	8.33	0.00	0.00	0.00			P				P																	
Sphaeralcea coccinea	0.00	20.83	0.00	0.00	0.00	P		P														P				P	P		
TOTAL NATIVE PERENNIAL FORBS	0.17	50.00	0.65	0.17	0.64	P		P	P			P					P	P		P		1			2	P	P		1
INTRODUCED PERENNIAL FORBS																													
Sanguisorba minor	0.04	29.17	0.16	0.04	0.16	P		P									1			P		P			P				P
TOTAL INTRO. PERENNIAL FORBS	0.04	29.17	0.16	0.04	0.16	P		P									1			P		P			P				P
NATIVE PERENNIAL GRASSES (cool)																													
Agropyron smithii	1.21	87.50	4.69	1.25	4.80	1	P	5	P	1	P	4	P	P	P		P	1 1	P	2	P	1			2	2	P	3	7
Agropyron spicatum	0.13	41.67	0.49	0.13	0.48	3	P		P			P	P	P		P	P			P		P							
Agropyron trachycaulum	0.29	16.67	1.13	0.29	1.12							4					2										P		1
Hilaria jamesii	1.13	54.17	4.37	1.21	4.64		4			P	P	P	P		P		P		2		7	1				12 2	P	1	
Hordeum jubatum	0.04	12.50	0.16	0.04	0.16	P		1															P						
Oryzopsis hymenoides	0.46	50.00	1.78	0.46	1.76	1		1	1					1	1	1		2			1	P			1			1	P
TOTAL NATIVE PERENNIAL GRASSES (c)	3.25	95.83	12.62	3.38	12.96	5	4	7	1	1	P	8	P	1	1	1	2	3 1	2	2	8	2	P		3	14 2	P	5	8
NATIVE PERENNIAL GRASSES (warm)																													
Bouteloua gracilis	1.50	91.67	5.83	1.50	5.76	P	5	1	3	2	1	1	1	1	P	4	1	3	1	1	P	2			5	2	1	1	P
Buchloe dactyloides	0.00	4.17	0.00	0.00	0.00																								P
Sporobolus airoides	0.13	12.50	0.49	0.13	0.48						P							3							P				
Sporobolus cryptandrus	0.00	4.17	0.00	0.00	0.00		P																						
TOTAL NATIVE PERENNIAL GRASSES (w)	1.63	91.67	6.31	1.63	6.24	P	5	1	3	2	1	1	1	1	P	4	1	6	1	1	P	2			5	2	1	1	P

J19 RLRA - Spring 2019 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	P101	P102	P108	P109
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
INTRODUCED PERENNIAL GRASSES (cool)																													
Elymus junceus	6.17	100.00	23.95	6.25	24.00	11	9	6	3	6	11	3	7	4	1	9	11 2	7	2	11	5	2	3	1	8	11	P	13	4
TOTAL INTRO. PERENNIAL GRASSES (c)	6.17	100.00	23.95	6.25	24.00	11	9	6	3	6	11	3	7	4	1	9	11 2	7	2	11	5	2	3	1	8	11	P	13	4
NATIVE SUBSHRUBS																													
Ceratoides lanata	0.08	45.83	0.32	0.08	0.32	P		P		1	P	P					P		1		P	P						P	P
Chrysothamnus greenei	0.00	4.17	0.00	0.00	0.00																	P							
Gutierrezia sarothrae	0.04	12.50	0.16	0.04	0.16			P														1				P			
TOTAL NATIVE SUBSHRUBS	0.13	50.00	0.49	0.13	0.48	P		P		1	P	P					P		1		P	1				P		P	P
INTRODUCED SUBSHRUBS																													
Kochia prostrata	0.04	8.33	0.16	0.04	0.16						1											P							
TOTAL INTRO. SUBSHRUBS FORBS	0.04	8.33	0.16	0.04	0.16						1											P							
NATIVE SHRUBS																													
Artemisia tridentata	0.04	4.17	0.16	0.04	0.16						1																		
Atriplex canescens	3.67	87.50	14.24	3.67	14.08	1	4	2	3	8	6	3	6	P	7	1	7	6	7		P	7			5	9	2	3	1
Atriplex confertifolia	0.08	8.33	0.32	0.08	0.32			P									2												
Atriplex obovata	0.04	8.33	0.16	0.04	0.16															P		1							
Chrysothamnus nauseosus	0.25	16.67	0.97	0.25	0.96	1					3							P				2							
TOTAL NATIVE SHRUBS	4.08	91.67	15.86	4.08	15.68	2	4	2	3	8	10	3	6	P	7	1	9	6	7	P	P	10			5	9	2	3	1
SUCCULENTS																													
Mammillaria sp.	0.00	4.17	0.00	0.00	0.00						P																		
TOTAL SUCCULENTS	0.00	4.17	0.00	0.00	0.00						P																		
Standing dead	0.00	0.00		0.00																									
Litter	16.42	100.00		16.42		19	8	10	17	7	7	35	9	21	18	16	11	8	11	19	27	14	16	32	16	32	5	28	8
Bare ground	55.13	100.00		55.17		55	70	43	60	37	70 1	48	77	58	54	63	65	59	38	64	57	61	53	8	60	28	69	50	76
Rock	2.71	45.83		2.71				23				1						2	2	1	1	1		28	1	2	3		
TOTALS	100.00		100.00	100.33	100.00	100 0	100 0	100 0	100 0	100 0	100 1	100 0	100 0	100 0	100 0	100 0	100 2	100 2	100 0	100 0	100 0	100 1	100 0	100 0	100 0	100 2	100 0	100 0	100 0
TOTAL VEGETATION COVER	25.75	s=(10.12)		26.04	s=(10.27)	26 0	22 0	24 0	23 0	56 0	23 0	16 0	14 0	21 0	28 0	21 0	24 2	31 2	49 0	16 0	15 0	24 1	31 0	32 0	23 0	38 2	23 0	22 0	16 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	44.88	s=(15.75)		45.17	s=(15.82)	45 0	30 0	57 0	40 0	63 0	30 0	52 0	23 0	42 0	46 0	37 0	35 2	41 2	62 0	36 0	43 0	39 1	47 0	92 0	40 0	72 2	31 0	50 0	24 0
SPECIES DENSITY (# of species/100 sq.m.)	11.75	s=(4.29)				16	10	21	11	9	13	12	7	10	10	8	16	13	11	11	14	23	7	6	10	9	8	10	17

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																									
Descurainia pinnata	0.15	25.00	0.58	0.15	0.57		P				P	1			P						2				
Lappula redowskii	0.00	15.00	0.00	0.00	0.00			P					P												P
Machaeranthera canescens	0.00	10.00	0.00	0.00	0.00			P																P	
TOTAL NATIVE ANN. & BIEN. FORBS	0.15	45.00	0.58	0.15	0.57		P	P			P	1	P		P						2			P	P
INTRODUCED ANNUAL & BIENNIAL FORBS																									
Chenopodium album	0.20	15.00	0.77	0.20	0.77							P					P								4
Kochia scoparia	1.75	50.00	6.72	1.75	6.70					17	1			P	3		P	1	10		3			P	P
Melilotus officinalis	0.00	10.00	0.00	0.00	0.00																		P	P	
Salsola iberica	0.00	10.00	0.00	0.00	0.00								P		P										
Sisymbrium altissimum	0.00	60.00	0.00	0.00	0.00	P				P		P		P	P	P	P	P		P			P	P	P
Tragopogon dubius	0.00	10.00	0.00	0.00	0.00						P													P	
TOTAL INTRO. ANN. & BIEN. FORBS	1.95	80.00	7.49	1.95	7.47	P				17	1	P	P	P	3	P	P	1	10	P	3		P	P	4
INTRODUCED ANNUAL GRASSES																									
Bromus tectorum	1.50	80.00	5.76	1.50	5.75	8	1			1	P	P		P	P	P		5	6	P	P	4	P	P	5
TOTAL INTRODUCED ANNUAL GRASSES	1.50	80.00	5.76	1.50	5.75	8	1			1	P	P		P	P	P		5	6	P	P	4	P	P	5
NATIVE PERENNIAL FORBS																									
Astragalus wingatanus	0.00	5.00	0.00	0.00	0.00					P															
Gaillardia aristata	0.00	5.00	0.00	0.00	0.00					P															
Penstemon palmeri	0.00	5.00	0.00	0.00	0.00			P																	
Sphaeralcea coccinea	0.00	15.00	0.00	0.00	0.00			P												P				P	
TOTAL NATIVE PERENNIAL FORBS	0.00	20.00	0.00	0.00	0.00			P		P										P				P	
NATIVE PERENNIAL GRASSES (cool)																									
Agropyron spicatum	0.05	10.00	0.19	0.05	0.19		P			1															
Agropyron smithii	1.20	80.00	4.61	1.20	4.60	3	2	P		1	8	P		2	2	1		3	P	P		2	P	P	P
Hilaria jamesii	3.25	80.00	12.48	3.25	12.45	1	9	2	P			7	1	P	2	1	P			9	P	4	14	14	1
Oryzopsis hymenoides	0.00	20.00	0.00	0.00	0.00			P			P				P				P						
Sitanion hystrix	0.00	10.00	0.00	0.00	0.00													P	P						
TOTAL NATIVE PERENNIAL GRASSES (c)	4.50	100.00	17.27	4.50	17.24	4	11	2	P	2	8	7	1	2	4	2	P	3	P	9	P	6	14	14	1
NATIVE PERENNIAL GRASSES (warm)																									
Bouteloua curtipendula	0.30	25.00	1.15	0.30	1.15		3								P					1		P	2		
Bouteloua gracilis	0.55	70.00	2.11	0.55	2.11	P	2	P	1	P		P		2	1	P				P	1	P	2	2	
Buchloe dactyloides	0.10	5.00	0.38	0.10	0.38						2														
Sporobolus airoides	0.00	5.00	0.00	0.00	0.00			P																	
Sporobolus cryptandrus	2.10	70.00	8.06	2.10	8.05	P	P	2	23	3	P	1	4		P		3			2	P		P	4	
TOTAL NATIVE PERENNIAL GRASSES (w)	3.05	85.00	11.71	3.05	11.69	P	5	2	24	3	2	1	4	2	1	P	3			3	1	P	4	6	
INTRODUCED PERENNIAL GRASSES (cool)																									
Elymus junceus	9.00	100.00	34.55	9.05	34.67	6	5	11 1	P	1	11	6	17	3	7	21	13	12	1	6	24	16	7	1	12
TOTAL INTRO. PERENNIAL GRASSES (c)	9.00	100.00	34.55	9.05	34.67	6	5	11 1	P	1	11	6	17	3	7	21	13	12	1	6	24	16	7	1	12
NATIVE SUBSHRUBS																									
Ceratoides lanata	0.00	50.00	0.00	0.00	0.00	P						P		P	P	P	P			P	P	P		P	
Gutierrezia sarothrae	0.00	10.00	0.00	0.00	0.00			P															P		
TOTAL NATIVE SUBSHRUBS	0.00	60.00	0.00	0.00	0.00	P		P				P		P	P	P	P			P	P	P	P	P	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
INTRODUCED SUBSHRUBS																									
Kochia prostrata	0.10	30.00	0.38	0.10	0.38								P	P			1			P		P		1	
TOTAL INTRO. SUBSHRUBS FORBS	0.10	30.00	0.38	0.10	0.38								P	P			1			P		P		1	
NATIVE SHRUBS																									
Artemisia tridentata	0.00	5.00	0.00	0.00	0.00								P												
Atriplex canescens	5.75	95.00	22.07	5.75	22.03	6	6	7	3	7	P	17	5	17	12	5	9	P		2	P	8	1	8	2
Atriplex confertifolia	0.05	5.00	0.19	0.05	0.19																				1
TOTAL NATIVE SHRUBS	5.80	95.00	22.26	5.80	22.22	6	6	7	3	7	P	17	5	17	12	5	9	P		2	P	8	1	8	3
SUCCULENTS																									
Mammillaria sp.	0.00	5.00	0.00	0.00	0.00			P																	
TOTAL SUCCULENTS	0.00	5.00	0.00	0.00	0.00			P																	
Standing dead	0.00	0.00		0.00																					
Litter	16.05	100.00		16.05		19	8	10	17	7	7	35	9	21	18	16	11	8	11	19	27	14	16	32	16
Bare ground	55.00	100.00		55.05		55	70	43	60	37	70 1	48	77	58	54	63	65	59	38	64	57	61	53	8	60
Rock	3.00	45.00		3.00				23				1						2	2	1	1	1		28	1
TOTALS	100.10		100.00	100.20	100.00	98 0	106 0	98 1	104 0	75 0	99 1	116 0	113 0	103 0	99 0	107 0	102 0	90 0	68 0	104 0	115 0	110 0	95 0	98 0	102 0
TOTAL VEGETATION COVER	26.05	s=(4.3)		26.10	s=(4.25)	24 0	28 0	22 1	27 0	31 0	22 0	32 0	27 0	24 0	27 0	28 0	26 0	21 0	17 0	20 0	30 0	34 0	26 0	30 0	25 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	45.10	s=(14.22)		45.15	s=(14.25)	43 0	36 0	55 1	44 0	38 0	29 0	68 0	36 0	45 0	45 0	44 0	37 0	31 0	30 0	40 0	58 0	49 0	42 0	90 0	42 0
SPECIES DENSITY (# of species/100 sq.m.)	9.90	s=(2.57)				9	10	14	5	11	10	11	8	10	14	8	9	7	6	12	9	9	11	15	10

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																							
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																													
Amaranthus retroflexus	0.00	10.00	0.00	0.00	0.00																									P						P									
Coreopsis tinctoria	0.00	10.00	0.00	0.00	0.00																											P				P									
Dyssodia papposa	0.00	5.00	0.00	0.00	0.00					P																																			
Machaeranthera canescens	0.00	20.00	0.00	0.00	0.00																			P								P						P				P			
Portulaca oleracea	0.05	5.00	0.12	0.05	0.11			1																																					
Verbesina enceliodes	0.00	5.00	0.00	0.00	0.00					P																																			
TOTAL NATIVE ANN. & BIEN. FORBS	0.05	40.00	0.12	0.05	0.11			1		P														P						P		P				P		P				P			
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Amaranthus albus	0.00	10.00	0.00	0.00	0.00																													P				P							
Camelina microcarpa	0.00	5.00	0.00	0.00	0.00																													P											
Kochia scoparia	2.00	70.00	4.83	2.00	4.60	P				1		P		2		9		6				P		P		P				2		1		P		8		11							
Melilotus officinalis	0.00	10.00	0.00	0.00	0.00					P														P																					
Salsola iberica	0.90	50.00	2.17	0.90	2.07	1				1		P								P				P		P						P		1		2		13							
TOTAL INTRO. ANN. & BIEN. FORBS	2.90	75.00	7.00	2.90	6.67	1				2		P		2		9		6		P		P		P		P				2		1		1		10		24							
INTRODUCED ANNUAL GRASSES																																													
Bromus japonicus	1.90	35.00	4.59	1.95	4.48									P										P						P		P		28	1	8		2							
Bromus tectorum	0.90	15.00	2.17	0.90	2.07																									17		P										1			
TOTAL INTRODUCED ANNUAL GRASSES	2.80	40.00	6.76	2.85	6.55									P										P						17		P		28	1	8		2				1			
NATIVE PERENNIAL FORBS																																													
Achillea lanulosa	0.00	10.00	0.00	0.00	0.00																			P						P															
Gaillardia aristata	0.00	15.00	0.00	0.00	0.00																			P								P		P											
Linum lewisii	0.00	25.00	0.00	0.00	0.00																	P		P										P		P		P							
Ratibida columnaris	0.10	15.00	0.24	0.10	0.23																			2								P				P									
Sphaeralcea coccinea	0.00	10.00	0.00	0.00	0.00																	P						P																	
Sphaeralcea grossulariaefolia	0.00	10.00	0.00	0.00	0.00					P																								P											
TOTAL NATIVE PERENNIAL FORBS	0.10	45.00	0.24	0.10	0.23					P												P		2				P		P		P		P		P		P							
INTRODUCED PERENNIAL FORBS																																													
Onobrychis viciifolia	0.00	20.00	0.00	0.00	0.00																			P										P		P		P							
Sanguisorba minor	0.25	30.00	0.60	0.35	0.80																			1						P		P		2	2	2		P							
Trifolium pratense	0.00	5.00	0.00	0.00	0.00																																	P							
TOTAL INTRO. PERENNIAL FORBS	0.25	30.00	0.60	0.35	0.80																			1						P		P		2	2	2		P							
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron dasystachyum	0.00	10.00	0.00	0.00	0.00																									P		P													
Agropyron smithii	5.70	95.00	13.77	6.15	14.14	2				P		4		14		2		P		8	3	8	1	4	2	P		P		1		16		10	3	11		11		13		2		8	
Agropyron spicatum	1.60	65.00	3.86	1.65	3.79	P		3		3		1								9		P		10	1	1								P		P				2		1		2	
Agropyron trachycaulum	0.35	20.00	0.85	0.35	0.80					1		2										1		3																					
Hilaria jamesii	1.20	65.00	2.90	1.25	2.87			10		2		P		P		P						P		1		2		5		1										P		3		P	1
Oryzopsis hymenoides	0.70	50.00	1.69	0.80	1.84	1						P		P		P				P								P				P								11		P	1	2	1
TOTAL NATIVE PERENNIAL GRASSES (c)	9.55	100.00	23.07	10.20	23.45	3		13		6		7		14		2		P		17	3	9	1	18	3	3		5		2		16		10	3	11		11		26		6	1	12	2

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																							
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE PERENNIAL GRASSES (warm)																																													
Bouteloua curtipendula	0.25	40.00	0.60	0.25	0.57	P				P		1										4		P		P														P		P			
Bouteloua gracilis	5.10	85.00	12.32	5.50	12.64	1		8		1		1		7		8		8	2			6		10		12	1	27	2	P		9	2	1	1	P				P		3			
Buchloe dactyloides	0.10	30.00	0.24	0.15	0.34									1		P		P								P										P		1	1						
Sporobolus airoides	2.15	50.00	5.19	2.15	4.94			12		2				1		6		5				4				4		1		1		7													
Sporobolus cryptandrus	0.00	15.00	0.00	0.00	0.00					P																		P								P									
TOTAL NATIVE PERENNIAL GRASSES (w)	7.60	90.00	18.36	8.05	18.51	1		20		3		2		9		14		13	2			14		10		16	1	28	2	1		16	2	1	1	P		1	1	P		3			
INTRODUCED PERENNIAL GRASSES (cool)																																													
Agropyron elongatum	0.00	5.00	0.00	0.00	0.00																															P									
Agropyron intermedium	0.15	15.00	0.36	0.20	0.46					2												P		1	1																				
Bromus inermis	0.10	10.00	0.24	0.10	0.23																									1				1											
Elymus junceus	12.20	100.00	29.47	13.00	29.89	30		8		25	2	25	3	22	2	19	1	22	3	10		15		1		21		12	2	P		15	2	P		P		P		9		4	1	6	
TOTAL INTRO. PERENNIAL GRASSES (c)	12.45	100.00	30.07	13.30	30.57	30		8		27	2	25	3	22	2	19	1	22	3	10		15		2	1	21		12	2	1		15	2	1		P		P		9		4	1	6	
NATIVE SUBSHRUBS																																													
Ceratoides lanata	0.10	40.00	0.24	0.10	0.23	P						2						P				P				P		P		P		P													
Gutierrezia sarothrae	0.05	25.00	0.12	0.05	0.11					P								P						P				P														1			
TOTAL NATIVE SUBSHRUBS	0.15	55.00	0.36	0.15	0.34	P				P		2						P				P		P		P		P		P		P										1			
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	0.25	45.00	0.60	0.25	0.57							4				P						P				P		P		P		P										P		1	
TOTAL INTRO. SUBSHRUBS FORBS	0.25	45.00	0.60	0.25	0.57							4				P						P				P		P		P		P										P		1	
NATIVE SHRUBS																																													
Artemisia tridentata	0.05	5.00	0.12	0.05	0.11															1																									
Atriplex canescens	5.10	90.00	12.32	5.10	11.72	4		1		3		8		3		1		8		6		10		6		2		11		P		3				P				6		18		12	
Atriplex confertifolia	0.15	40.00	0.36	0.15	0.34	1		P				P								P						P														P		P		2	
TOTAL NATIVE SHRUBS	5.30	90.00	12.80	5.30	12.18	5		1		3		8		3		1		8		7		10		6		2		11		P		3				P				6		18		14	
Standing dead	4.15	60.00		4.15		8		3						9				8		10		5				2		6				8								10		6		8	
Litter	22.20	100.00		22.20		22		12		32		6		18		31		17		13		7		34		27		7		70		16		45		17		19		9		25		17	
Bare ground	31.05	100.00		31.05		28		42		22		45		23		24		26		43		39		20		27		31		6		25		12		49		43		40		35		41	
Rock	1.15	45.00		1.15		2				5		1										1		7		2										3						1		1	
TOTALS	99.95		100.00	102.05	100.00	100	0	100	0	100	2	100	3	100	2	100	1	100	5	100	3	100	1	100	4	100	1	100	4	99	0	100	4	100	7	100	0	100	1	100	0	100	2	100	2
TOTAL VEGETATION COVER	41.40	s=(7.96)		43.50	s=(8.96)	40	0	43	0	41	2	48	3	50	2	45	1	49	5	34	3	48	1	39	4	42	1	56	4	23	0	51	4	43	7	31	0	38	1	41	0	33	2	33	2
GROUND COVER (Veg+Litter+St.Dead+Rock)	68.90	s=(11.53)		71.00	s=(12.35)	72	0	58	0	78	2	55	3	77	2	76	1	74	5	57	3	61	1	80	4	73	1	69	4	93	0	75	4	88	7	51	0	57	1	60	0	65	2	59	2
SPECIES DENSITY (# of species/100 sq.m.)	12.90	s=(3.84)				11		8		18		14		10		10		9		8		15		21		14		12		16		18		15		17		12		9		13		8	

J21 RLRA - Spring 2019

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																															
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		P100		P103		P110		P111	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																																					
Chenopodium berlandieri	0.00	8.33	0.00	0.00	0.00					P																P																											
Chenopodium leptophyllum	0.00	4.17	0.00	0.00	0.00					P																																											
Cirsium undulatum	0.00	8.33	0.00	0.00	0.00													P																														P					
Corydalis aurea	0.00	4.17	0.00	0.00	0.00																																					P											
Descurainia pinnata	0.00	37.50	0.00	0.00	0.00					P				P		P						P						P		P												P						P				P	
Descurainia richardsonii	0.04	12.50	0.15	0.04	0.14			P												P								1																									
Gilia pumila	0.00	4.17	0.00	0.00	0.00																													P																			
Lappula redowskii	0.17	33.33	0.60	0.17	0.57			1		P						P				2						1				P		P										P											
Polygonum douglasii	0.00	4.17	0.00	0.00	0.00																																									P							
TOTAL NATIVE ANN. & BIEN. FORBS	0.21	66.67	0.75	0.21	0.72			1		P				P		P		P		2		P				1		1		P		P		P								P				P		P				P	
INTRODUCED ANNUAL & BIENNIAL FORBS																																																					
Chenopodium album	0.00	8.33	0.00	0.00	0.00			P																										P																			
Erodium cicutarium	0.00	8.33	0.00	0.00	0.00			P												P																																	
Kochia scoparia	0.29	37.50	1.04	0.29	1.00	6		1		P				P						P						P		P				P																		P			
Lactuca serriola	0.00	12.50	0.00	0.00	0.00					P								P																P																			
Melilotus officinalis	0.00	4.17	0.00	0.00	0.00																																									P							
Ranunculus testiculatus	0.00	4.17	0.00	0.00	0.00											P																																					
Salsola iberica	0.00	4.17	0.00	0.00	0.00			P																																													
Sisymbrium altissimum	0.08	62.50	0.30	0.08	0.29					P		P				P		1		P		P		P				1		P		P		P				P				P		P				P					
Sisymbrium irio	0.00	16.67	0.00	0.00	0.00					P								P								P																								P			
Tragopogon dubius	0.00	4.17	0.00	0.00	0.00					P																																											
TOTAL INTRO. ANN. & BIEN. FORBS	0.38	87.50	1.34	0.38	1.29	6		1		P		P		P		P		1		P		P		P		P		1		P		P		P				P				P		P		P		P		P			
INTRODUCED ANNUAL GRASSES																																																					
Bromus tectorum	5.21	66.67	18.63	5.83	20.09	5		17						2	1	1		9		3		7		3		18				1				1		P								34	13	7		7				10	1
TOTAL INTRODUCED ANNUAL GRASSES	5.21	66.67	18.63	5.83	20.09	5		17						2	1	1		9		3		7		3		18				1				1		P								34	13	7		7				10	1
NATIVE PERENNIAL FORBS																																																					
Astragalus wingatanus	0.04	8.33	0.15	0.04	0.14	1																																				P											
Gaillardia aristata	0.00	4.17	0.00	0.00	0.00															P																																	
Linum lewisii	0.00	4.17	0.00	0.00	0.00																							P																									
Ratibida columnaris	0.00	8.33	0.00	0.00	0.00																			P				P																									
Sisymbrium linifolium	0.04	20.83	0.15	0.04	0.14			P												P																						1				P						P	
Sphaeralcea coccinea	0.00	45.83	0.00	0.00	0.00			P										P		P						P		P		P										P		P		P				P		P			
TOTAL NATIVE PERENNIAL FORBS	0.08	62.50	0.30	0.08	0.29	1		P										P		P				P		P		P		P										P		1		P		P		P		P		P	
INTRODUCED PERENNIAL FORBS																																																					
Marrubium vulgare	0.00	8.33	0.00	0.00	0.00			P										P																																			
Onobrychis viciifolia	0.04	12.50	0.15	0.04	0.14																	1																										P				P	
Sanguisorba minor	0.00	8.33	0.00	0.00	0.00	P																																										P					
TOTAL INTRO. PERENNIAL FORBS	0.04	25.00	0.15	0.04	0.14	P		P										P				1																										P				P	
NATIVE PERENNIAL GRASSES (cool)																																																					
Agropyron dasystachyum	0.29	29.17	1.04	0.29	1.00									1		1												P																3		1				P		1	
Agropyron smithii	3.04	95.83	10.88	3.04	10.47	1		P		P		P		5		9		4		P		4		5		2		1		P				5		1		6		3		P		4		8		6		6		3	
Agropyron spicatum	0.29	33.33	1.04	0.29	1.00									P						P		1												P								2		P				1		3			
Agropyron trachycaulum	0.13	8.33	0.45	0.13	0.43																			P										3																			
Elymus canadensis	0.08	12.50	0.30	0.08	0.29													1																										P						1			
Hilaria jamesii	0.46	54.17	1.64	0.54	1.87					1								P						1		2		P		2		P				1		P		2	1					1	1	1				P	
Oryzopsis hymenoides	0.04	4.17	0.15	0.04	0.14											1																																					
TOTAL NATIVE PERENNIAL GRASSES (c)	4.33	100.00	15.50	4.42	15.21	1		P		1		P		6		11		5		P		5		6		4		1		2		P		8		2		6		5	1	2		7		10	1	8		10		4	

J21 RLRA - Spring 2019 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	P100	P103	P110	P111
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE PERENNIAL GRASSES (warm)																													
Bouteloua curtipendula	0.00	4.17	0.00	0.00	0.00																					P			
Bouteloua gracilis	0.63	79.17	2.24	0.63	2.15	P		P		P		P	P		2	1	P	4		P	P	P	4	1	P	2	P	P	1
Sporobolus airoides	0.13	12.50	0.45	0.13	0.43			1								1		1											
Sporobolus cryptandrus	0.00	4.17	0.00	0.00	0.00										P														
TOTAL NATIVE PERENNIAL GRASSES (w)	0.75	79.17	2.68	0.75	2.58	P		1		P		P	P		2	2	P	5		P	P	P	4	1	P	2	P	P	1
INTRODUCED PERENNIAL GRASSES (cool)																													
Agropyron desertorum	0.08	12.50	0.30	0.13	0.43			P 1						P													2		
Bromus inermis	0.13	20.83	0.45	0.13	0.43							1		1											P		1		P
Elymus junceus	11.04	100.00	39.49	11.33	39.02	3	2	9	25 1	14	11 1	7	8	11	25	9	13	8	23	10	19	9 1	13 1	12	2	7 1	12	4 1	9 1
TOTAL INTRO. PERENNIAL GRASSES (c)	11.25	100.00	40.24	11.58	39.89	3	2	9 1	25 1	14	11 1	8	8	12	25	9	13	8	23	10	19	9 1	13 1	12	2	7 1	15	4 1	9 1
NATIVE SUBSHRUBS																													
Ceratoides lanata	0.00	33.33	0.00	0.00	0.00		P	P					P		P	P								P			P		P
Gutierrezia sarothrae	0.00	8.33	0.00	0.00	0.00		P						P																
TOTAL NATIVE SUBSHRUBS	0.00	33.33	0.00	0.00	0.00		P	P					P		P	P								P			P		P
INTRODUCED SUBSHRUBS																													
Kochia prostrata	0.25	37.50	0.89	0.25	0.86			1	P				P		P	4					P		P			1			P
TOTAL INTRO. SUBSHRUBS FORBS	0.25	37.50	0.89	0.25	0.86			1	P				P		P	4					P		P			1			P
NATIVE SHRUBS																													
Atriplex canescens	5.29	95.83	18.93	5.33	18.36	11	16	1	4	3	5	2	11		2	P	7	6	1	3	P	4	4	11	14	10 1	P	1	11
Atriplex confertifolia	0.04	37.50	0.15	0.04	0.14			P		P	1							P	P	P	P	P							P
Atriplex obovata	0.08	16.67	0.30	0.08	0.29			P	1		1											P							
Chrysothamnus nauseosus	0.04	4.17	0.15	0.04	0.14								1																
TOTAL NATIVE SHRUBS	5.46	95.83	19.52	5.50	18.94	11	16	1	5	3	7	2	12		2	P	7	6	1	3	P	4	4	11	14	10 1	P	1	11
Standing dead	0.88	33.33		0.88				2	1							4		3				1	6		2			2	
Litter	23.63	100.00		23.63		12	7	26	20	31	23	31	10	34	24	24	17	20	10	32	26	25	25	12	17	23	32	65	21
Bare ground	44.67	100.00		44.67		55	49	43	49	43	37	39	64	40	38	33	60	53	66	46	48	54	41	61	24	34	35	18	42
Rock	2.88	66.67		2.88		6	7	16		1	10	5	1	1		1		2			5	1	2			6	3		2
TOTALS	100.00		100.00	101.08	100.00	100 0	100 0	100 1	100 1	100 1	100 1	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 1	100 2	100 0	100 13	100 3	100 0	100 1	100 2
TOTAL VEGETATION COVER	27.96	s=(9.19)		29.04	s=(11.16)	27 0	37 0	13 1	30 1	25 1	30 1	25 0	25 0	25 0	38 0	38 0	23 0	22 0	24 0	22 0	21 0	19 1	26 2	27 0	57 13	37 3	30 0	15 1	35 2
GROUND COVER (Veg+Litter+St.Dead+Rock)	55.33	s=(12)		56.42	s=(13.43)	45 0	51 0	57 1	51 1	57 1	63 1	61 0	36 0	60 0	62 0	67 0	40 0	47 0	34 0	54 0	52 0	46 1	59 2	39 0	76 13	66 3	65 0	82 1	58 2
SPECIES DENSITY (# of species/100 sq.m.)	11.71	s=(3.54)				8	15	20	6	10	12	14	18	9	12	14	13	12	7	12	8	8	7	13	11	12	16	10	14

Appendix 3.2

Sagebrush Reference Area Raw Data

<u>J7 Sagebrush Reference Area</u>
Fall 2016
Fall 2017
Spring 2019
Fall 2019

<u>N7/8 Sagebrush Reference Area</u>
Fall 2016
Fall 2017
Spring 2019
Fall 2019

<u>N14 Sagebrush Reference Area</u>
Fall 2016
Fall 2017
Spring 2019
Fall 2019

J7 SBRA - Fall 2016

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Cordylanthus wrightii	0.00	33.33	0.00	0.00	0.00	P						P														P				P		P			
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	33.33	0.00	0.00	0.00	P						P														P				P		P			
NATIVE PERENNIAL FORBS																																			
Astragalus calycosus var. scaposus	0.00	6.67	0.00	0.00	0.00					P																									
Leucelene ericoides	0.00	40.00	0.00	0.00	0.00					P								P		P						P						P		P	
Sphaeralcea coccinea	0.07	26.67	0.18	0.07	0.17									P						1				P		P									
TOTAL NATIVE PERENNIAL FORBS	0.07	53.33	0.18	0.07	0.17					P				P				P		1				P		P						P		P	
NATIVE PERENNIAL GRASSES (cool)																																			
Hilaria jamesii	1.33	73.33	3.66	1.40	3.55	4		3				P		2		3	1	2				2				1		P		2				1	
Oryzopsis hymenoides	0.07	26.67	0.18	0.07	0.17					P										P				P		1									
Sitanion hystrix	0.53	93.33	1.46	0.73	1.86			1		P		1		3		P		1		P		P		P		P	1	P		1		1		P	2
Stipa comata	0.00	13.33	0.00	0.00	0.00					P														P											
TOTAL NATIVE PERENNIAL GRASSES (c)	1.93	100.00	5.30	2.20	5.57	4		4		P		1		5		3	1	3		P		2		P		2	1	P		3		1		1	2
NATIVE PERENNIAL GRASSES (warm)																																			
Bouteloua gracilis	17.93	100.00	49.18	20.33	51.52	23	3	17	2	20	1	14		20	4	14	1	22	4	19	3	25	3	11	4	10	1	12	1	27	2	20	3	15	4
Muhlenbergia torreyi	0.07	13.33	0.18	0.07	0.17											1																		P	
Sporobolus cryptandrus	0.13	33.33	0.37	0.13	0.34									1								P						1		P				P	
TOTAL NATIVE PERENNIAL GRASSES (w)	18.13	100.00	49.73	20.53	52.03	23	3	17	2	20	1	14		21	4	15	1	22	4	19	3	25	3	11	4	10	1	13	1	27	2	20	3	15	4
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.13	26.67	0.37	0.13	0.34							P		P												2		P							
Chrysothamnus greenei	3.33	93.33	9.14	3.53	8.95	P			2	5		2		6		6		3		5		1		5		7		4	1	1		4		1	
Gutierrezia sarothrae	0.40	100.00	1.10	0.40	1.01	P		P		3		P		P		P		P		1		P		P		2		P		P		P		P	
TOTAL NATIVE SUBSHRUBS	3.87	100.00	10.60	4.07	10.30	P		P	2	8		2		6		6		3		6		1		5		11		4	1	1		4		1	
NATIVE SHRUBS																																			
Artemisia tridentata	11.80	100.00	32.36	11.80	29.90	11		16		8		10		10		21		13		7		16		12		5		17		9		8		14	
Atriplex canescens	0.27	26.67	0.73	0.27	0.68													3		P						P						1			
TOTAL NATIVE SHRUBS	12.07	100.00	33.09	12.07	30.57	11		16		8		10		10		21		16		7		16		12		5		17		9		9		14	
SUCCULENTS																																			
Echinocereus triglochidiatus var. melanacanthu	0.00	6.67	0.00	0.07	0.17			P	1																										
Mammillaria spp.	0.00	13.33	0.00	0.00	0.00			P																		P									
Opuntia phaeacantha	0.00	20.00	0.00	0.00	0.00													P		P														P	
Opuntia whipplei	0.00	13.33	0.00	0.00	0.00					P																								P	
TOTAL SUCCULENTS	0.00	40.00	0.00	0.07	0.17			P	1	P								P		P						P								P	
BRYOPHYTES																																			
Moss spp.	0.13	80.00	0.37	0.20	0.51	P		P				2		P		P	1	P		P		P		P		P		P				P			
TOTAL BRYOPHYTES	0.13	80.00	0.37	0.20	0.51	P		P				2		P		P	1	P		P		P		P		P		P				P			
LICHEN/FUNGUS																																			
Lichen spp.	0.27	100.00	0.73	0.27	0.68	P		1		P		P		P		P		P		P		P		P		1		1		P		1		P	
TOTAL LICHEN	0.27	100.00	0.73	0.27	0.68	P		1		P		P		P		P		P		P		P		P		1		1		P		1		P	

J7 SBRA - Fall 2016 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Standing dead	2.47	86.67		2.53		2		6		1		4		2		3		3		5		2		1				3	1			2		3	
Litter	18.73	100.00		18.73		23		23		19		20		14		22		22		13		14		28		12		19		21		15		16	
Bare ground	40.73	100.00		40.73		37		33		43		47		42		30		31		46		35		43		45		43		38		48		50	
Rock	1.60	33.33		1.60						1										3		5				14				1					
TOTALS	100.00		100.00	103.07	100.00	100	3	100	5	100	1	100	0	100	4	100	3	100	4	100	3	100	3	100	4	100	2	100	3	100	2	100	3	100	6
TOTAL VEGETATION COVER	36.47	s=(5.76)		39.47	s=(6.19)	38	3	38	5	36	1	29	0	42	4	45	3	44	4	33	3	44	3	28	4	29	2	35	2	40	2	35	3	31	6
GROUND COVER (Veg+Litter+St.Dead+Rock)	59.27	s=(6.35)		62.27	s=(6.76)	63	3	67	5	57	1	53	0	58	4	70	3	69	4	54	3	65	3	57	4	55	2	57	2	62	2	52	3	50	6
SPECIES DENSITY (# of species/100 sq.m.)	10.40	s=(1.72)				8		9		11		10		11		9		11		12		9		10		15		10		9		10		12	

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						Percent Foliar Cover																													
PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Cordylanthus wrightii	0.20	33.33	0.57	0.20	0.55							1		P				P										2		P					
Eriogonum cernuum	0.00	6.67	0.00	0.00	0.00																							P							
TOTAL NATIVE ANN. & BIEN. FORBS	0.20	33.33	0.57	0.20	0.55							1		P				P										2		P					
NATIVE PERENNIAL FORBS																																			
Astragalus calycosus var. scaposus	0.07	13.33	0.19	0.07	0.18							1						P																	
Eriogonum umbellatum	0.00	13.33	0.00	0.00	0.00													P										P							
Leucelene ericoides	0.00	46.67	0.00	0.00	0.00			P		P		P										P		P		P						P			
Sphaeralcea coccinea	0.00	53.33	0.00	0.00	0.00					P		P				P		P		P				P		P		P							
TOTAL NATIVE PERENNIAL FORBS	0.07	73.33	0.19	0.07	0.18			P		P		1				P		P		P		P		P		P		P				P			
NATIVE PERENNIAL GRASSES (cool)																																			
Hilaria jamesii	1.93	100.00	5.52	2.07	5.71	P		2		1		1		P		1	1	1		7		2		2		8	1	1		2		1		P	
Oryzopsis hymenoides	0.13	33.33	0.38	0.13	0.37					1		P						1						P						P					
Sitanion hystrix	0.87	86.67	2.48	1.13	3.13			1		P		P		1		P		2	1	P		1		3		1	1			2	1	P	1	2	
Stipa comata	0.00	20.00	0.00	0.00	0.00							P												P				P							
TOTAL NATIVE PERENNIAL GRASSES (c)	2.93	100.00	8.38	3.33	9.21	P		3		2		1		1		1	1	4	1	7		3		5		9	2	1		4	1	1	1	2	
NATIVE PERENNIAL GRASSES (warm)																																			
Aristida purpurea	0.07	20.00	0.19	0.07	0.18							P						1																P	
Bouteloua gracilis	15.87	100.00	45.33	16.60	45.86	15	2	21	2	22		12		19		17	1	19		14	1	14	2	18		9	2	17		17		11	1	13	
Muhlenbergia torreyi	0.00	20.00	0.00	0.00	0.00															P						P				P					
TOTAL NATIVE PERENNIAL GRASSES (w)	15.93	100.00	45.52	16.67	46.04	15	2	21	2	22		12		19		17	1	20		14	1	14	2	18		9	2	17		17		11	1	13	
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.13	40.00	0.38	0.13	0.37			P				P		P								1								P				1	
Chrysothamnus greenei	2.40	100.00	6.86	2.40	6.63	4		3		1		2		5		1		2		P		1		5		4		3		1		1		3	
Eriogonum microthecum	0.00	20.00	0.00	0.00	0.00							P						P										P							
Gutierrezia sarothrae	0.53	53.33	1.52	0.53	1.47					P		3		P				4				P		1				P						P	
TOTAL NATIVE SUBSHRUBS	3.07	100.00	8.76	3.07	8.47	4		3		1		5		5		1		6		P		2		6		4		3		1		1		4	
INTRODUCED SUBSHRUBS																																			
Kochia prostrata	0.00	6.67	0.00	0.00	0.00					P																									
TOTAL INTRO. SUBSHRUBS FORBS	0.00	6.67	0.00	0.00	0.00					P																									
NATIVE SHRUBS																																			
Artemisia tridentata	11.47	100.00	32.76	11.47	31.68	26		14		5		8		6		20		3		15		10		8		12		7		5		15		18	
Atriplex canescens	0.60	66.67	1.71	0.67	1.84	P				3		1	1					1		2		1		P		1				P				P	
TOTAL NATIVE SHRUBS	12.07	100.00	34.48	12.13	33.52	26		14		8		9	1	6		20		4		17		11		8		13		7		5		15		18	
SUCCULENTS																																			
Opuntia fragilis var. fragilis	0.00	6.67	0.00	0.00	0.00													P																	
Opuntia phaeacantha	0.00	13.33	0.00	0.00	0.00															P						P									
TOTAL SUCCULENTS	0.00	20.00	0.00	0.00	0.00													P		P						P									
BRYOPHYTES																																			
Moss spp.	0.27	73.33	0.76	0.27	0.74	1		P		P		P								P		P		1		P		P				1		1	
TOTAL BRYOPHYTES	0.27	73.33	0.76	0.27	0.74	1		P		P		P								P		P		1		P		P				1		1	

J7 SBRA - Fall 2017 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
LICHEN/FUNGUS																																			
Lichen spp.	0.47	100.00	1.33	0.47	1.29	2		P		1		2		P		P		P		P		P		P		P		1		1		P		P	
TOTAL LICHEN	0.47	100.00	1.33	0.47	1.29	2		P		1		2		P		P		P		P		P		P		P		1		1		P		P	
Standing dead	2.53	93.33		2.53		1		4				3		2		4		2		2		8		1		1		2		4		2		2	
Litter	20.00	100.00		20.00		23		18		22		12		13		28		14		23		13		16		29		16		30		24		19	
Bare ground	39.87	100.00		39.87		28		37		44		50		52		29		29		37		49		45		35		42		38		45		38	
Rock	2.60	33.33		2.60								4		2				21										9						3	
TOTALS	100.00		100.00	101.20	100.00	100	2	100	2	100	0	100	1	100	0	100	2	100	1	100	1	100	2	100	0	100	4	100	0	100	1	100	2	100	0
TOTAL VEGETATION COVER	35.00	s=(5.4)		36.20	s=(5.71)	48	2	41	2	34	0	31	1	31	0	39	2	34	1	38	1	30	2	38	0	35	4	31	0	28	1	29	2	38	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	60.13	s=(7.71)		61.33	s=(8.22)	72	2	63	2	56	0	50	1	48	0	71	2	71	1	63	1	51	2	55	0	65	4	58	0	62	1	55	2	62	0
SPECIES DENSITY (# of species/100 sq.m.)	11.27	s=(3.1)				7		9		13		18		9		7		16		11		11		13		12		13		11		8		11	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																				
Cryptantha minima	0.07	66.67	0.17	0.07	0.17		P	P	P	P	1		P	P	P			P	P	
Descurainia pinnata	0.87	100.00	2.15	0.87	2.15	P	1	P	1	1	3	P	1	1	1	1	2	P	P	1
Gilia pumila	0.13	6.67	0.33	0.13	0.33												2			
Lappula redowskii	0.00	73.33	0.00	0.00	0.00	P		P	P		P	P	P		P	P		P	P	P
Lupinus brevicaulis	0.13	86.67	0.33	0.13	0.33	P	P	P	1		P	P	1	P	P	P	P		P	P
Oenothera albicaulis	0.00	60.00	0.00	0.00	0.00	P		P	P			P		P	P	P		P	P	
Townsendia annua	0.60	93.33	1.49	0.60	1.49	P	P	P	1	2	1	P	1	P	P		1	P	1	2
TOTAL NATIVE ANN. & BIEN. FORBS	1.80	100.00	4.47	1.80	4.47	P	1	P	3	3	5	P	3	1	1	1	5	P	1	3
INTRODUCED ANNUAL & BIENNIAL FORBS																				
Chenopodium album	0.07	66.67	0.17	0.07	0.17			1		P	P		P	P	P	P		P	P	P
Salsola iberica	0.07	26.67	0.17	0.07	0.17				P			1					P		P	
TOTAL INTRO. ANN. & BIEN. FORBS	0.13	86.67	0.33	0.13	0.33			1	P	P	P	1	P	P	P	P	P	P	P	P
NATIVE PERENNIAL FORBS																				
Allium sp.	0.07	53.33	0.17	0.07	0.17	P	P	P			P			P	1		P			P
Calochortus nuttallii	0.00	13.33	0.00	0.00	0.00						P						P			
Cymopterus purpureus	0.27	93.33	0.66	0.27	0.66		P	P	P	P	3	P	1	P	P	P	P	P	P	P
Delphinium nuttallianum	0.00	6.67	0.00	0.00	0.00	P														
Delphinium scaposum	0.07	20.00	0.17	0.07	0.17		P		P								1			
Eriogonum alatum	0.00	20.00	0.00	0.00	0.00				P				P				P			
Leucelene ericoides	0.27	86.67	0.66	0.27	0.66	1	1	P	P	P		P	1	P	P	P		P	P	1
Lupinus argenteus	0.07	26.67	0.17	0.07	0.17						P		P				P		1	
Phlox longifolia	0.00	20.00	0.00	0.00	0.00										P		P		P	
Sphaeralcea coccinea	0.00	13.33	0.00	0.00	0.00	P				P										
TOTAL NATIVE PERENNIAL FORBS	0.73	100.00	1.82	0.73	1.82	1	1	P	P	P	3	P	2	P	1	P	1	P	1	1
INTRODUCED PERENNIAL FORBS																				
Taraxacum officinale	0.00	6.67	0.00	0.00	0.00									P						
TOTAL INTRO. PERENNIAL FORBS	0.00	6.67	0.00	0.00	0.00									P						
NATIVE PERENNIAL GRASSES (cool)																				
Agropyron smithii	0.00	26.67	0.00	0.00	0.00	P						P				P				P
Hilaria jamesii	1.27	73.33	3.15	1.27	3.15			1	P	1	1		P	4	1	1		5	4	1
Oryzopsis hymenoides	0.07	20.00	0.17	0.07	0.17			1		P						P				
Poa sp.	0.13	93.33	0.33	0.13	0.33	1	P	P	P	1	P	P	P	P	P	P		P	P	P
Stipa comata	0.07	13.33	0.17	0.07	0.17			1								P				
TOTAL NATIVE PERENNIAL GRASSES (c)	1.53	93.33	3.81	1.53	3.81	1	P	3	P	2	1	P	P	4	1	1		5	4	1
NATIVE PERENNIAL GRASSES (warm)																				
Aristida purpurea	0.67	93.33	1.66	0.67	1.66	1	P	1	P	P	2	P	1	1	P		P	P	3	1
Bouteloua curtipendula	0.13	13.33	0.33	0.13	0.33							1								1
Bouteloua gracilis	14.40	100.00	35.76	14.40	35.76	12	15	13	15	11	19	12	24	16	14	9	17	15	17	7
Sporobolus cryptandrus	0.00	6.67	0.00	0.00	0.00					P										
TOTAL NATIVE PERENNIAL GRASSES (w)	15.20	100.00	37.75	15.20	37.75	13	15	14	15	11	21	13	25	17	14	9	17	15	20	9

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
INTRODUCED PERENNIAL GRASSES (cool)																				
Agropyron desertorum	0.07	6.67	0.17	0.07	0.17	1														
Elymus junceus	0.00	6.67	0.00	0.00	0.00	P														
TOTAL INTRO. PERENNIAL GRASSES (c)	0.07	6.67	0.17	0.07	0.17	1														
NATIVE SUBSHRUBS																				
Ceratoides lanata	0.27	66.67	0.66	0.27	0.66		P		1	P	P		1		1	1	P	P	P	
Gutierrezia sarothrae	3.47	100.00	8.61	3.47	8.61	P	5	2	2	5	3	1	7	2	4	6	11	3	1	P
TOTAL NATIVE SUBSHRUBS	3.73	100.00	9.27	3.73	9.27	P	5	2	3	5	3	1	8	2	5	7	11	3	1	P
INTRODUCED SUBSHRUBS																				
Kochia prostrata	0.13	40.00	0.33	0.13	0.33		1	P				P	1		P				P	
TOTAL INTRO. SUBSHRUBS FORBS	0.13	40.00	0.33	0.13	0.33		1	P				P	1		P				P	
NATIVE SHRUBS																				
Artemisia tridentata	15.47	100.00	38.41	15.47	38.41	13	26	23	19	10	21	13	10	7	21	9	17	10	18	15
Atriplex canescens	0.20	33.33	0.50	0.20	0.50		1	P	1					P		1				
TOTAL NATIVE SHRUBS	15.67	100.00	38.91	15.67	38.91	13	27	23	20	10	21	13	10	7	21	10	17	10	18	15
SUCCULENTS																				
Echinocereus triglochidiatus var. melanacanthu	0.00	33.33	0.00	0.00	0.00	P		P	P		P							P		
Opuntia fragilis var. fragilis	0.00	26.67	0.00	0.00	0.00				P		P	P	P							
Opuntia phaeacantha	0.00	20.00	0.00	0.00	0.00								P		P		P			
Opuntia polyacantha	0.00	26.67	0.00	0.00	0.00	P				P								P		P
TOTAL SUCCULENTS	0.00	73.33	0.00	0.00	0.00	P		P	P	P	P	P	P		P		P	P		P
BRYOPHYTES																				
Moss sp.	0.27	46.67	0.66	0.27	0.66		P		P			3		1	P		P		P	
TOTAL BRYOPHYTES	0.27	46.67	0.66	0.27	0.66		P		P			3		1	P		P		P	
LICHEN/FUNGUS																				
Lichen sp.	1.00	46.67	2.48	1.00	2.48		P		1		3		4		1		3		3	
TOTAL LICHEN	1.00	46.67	2.48	1.00	2.48		P		1		3		4		1		3		3	
Standing dead	2.53	53.33		2.53		3		3		3		6		8		6		5		4
Litter	11.47	93.33		11.47		16		8	8	17	5	16	8	18	4	10	14	15	13	20
Bare ground	44.47	100.00		44.47		52	50	46	43	49	38	47	36	40	51	50	32	47	39	47
Rock	1.27	33.33		1.27					7				3	2	1	6				
TOTALS	100.00		100.00	100.00	100.00	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
TOTAL VEGETATION COVER	40.27	s=(10.37)		40.27	s=(10.37)	29 0	50 0	43 0	42 0	31 0	57 0	31 0	53 0	32 0	44 0	28 0	54 0	33 0	48 0	29 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	55.53	s=(6.12)		55.53	s=(6.12)	48 0	50 0	54 0	57 0	51 0	62 0	53 0	64 0	60 0	49 0	50 0	68 0	53 0	61 0	53 0
SPECIES DENSITY (# of species/100 sq.m.)	19.33	s=(2.09)				19	18	21	23	17	20	18	21	18	22	17	20	17	22	17

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Chenopodium berlandieri	0.00	13.33	0.00	0.00	0.00									P										P											
Chenopodium fremontii	0.07	20.00	0.22	0.07	0.21	P								P																		1			
Chenopodium leptophyllum	0.20	20.00	0.65	0.20	0.62			P								P																3			
Cordylanthus w rightii	0.27	73.33	0.86	0.40	1.24	P		P		P		P		P				P		P		1						3	2	P				P	
Descurainia pinnata	0.13	46.67	0.43	0.20	0.62			P		P								1				P		P	1	P				1					
Eriogonum cernuum	0.00	13.33	0.00	0.00	0.00					P																		P							
Gilia pumila	0.27	66.67	0.86	0.27	0.83	P				1		P		P				2		P		P				1				P				P	
Lupinus brevicaulis	0.00	13.33	0.00	0.00	0.00																	P				P									
Phacelia crenulata	0.00	13.33	0.00	0.00	0.00																	P				P									
Plantago patagonica	0.13	80.00	0.43	0.13	0.41	P		P				P		P		P		P		P		P		1		1				P		P			
Tow nsendia annua	0.20	53.33	0.65	0.20	0.62	P										P		P				P				1				1		1		P	
TOTAL NATIVE ANN. & BIEN. FORBS	1.27	100.00	4.09	1.47	4.55	P		P		1		P		P		P		3		P		1		1	1	3		3	2	2		5		P	
INTRODUCED ANNUAL & BIENNIAL FORBS																																			
Chenopodium album	0.00	53.33	0.00	0.00	0.00	P						P		P				P		P		P				P				P					
TOTAL INTRO. ANN. & BIEN. FORBS	0.00	53.33	0.00	0.00	0.00	P						P		P				P		P		P				P				P					
NATIVE ANNUAL GRASSES																																			
Festuca octoflora	0.00	6.67	0.00	0.00	0.00																			P											
TOTAL NATIVE ANNUAL GRASSES	0.00	6.67	0.00	0.00	0.00																			P											
INTRODUCED ANNUAL GRASSES																																			
Bromus tectorum	0.00	20.00	0.00	0.00	0.00					P												P								P					
TOTAL INTRODUCED ANNUAL GRASSES	0.00	20.00	0.00	0.00	0.00					P												P								P					
NATIVE PERENNIAL FORBS																																			
Astragalus calycosus var. scaposus	0.00	6.67	0.00	0.00	0.00																							P							
Calochortus nuttallii	0.00	20.00	0.00	0.00	0.00			P																P		P									
Cryptantha flavoculata	0.13	6.67	0.43	0.13	0.41																											2			
Delphinium scaposum	0.00	6.67	0.00	0.00	0.00																					P									
Leucelene ericoides	0.40	60.00	1.29	0.40	1.24			1		1		P		P		2				P								P				P		2	
Sphaeralcea coccinea	0.00	40.00	0.00	0.00	0.00			P		P						P		P						P		P									
TOTAL NATIVE PERENNIAL FORBS	0.53	80.00	1.72	0.53	1.65			1		1		P		P		2		P		P				P		P		P				2		2	
NATIVE PERENNIAL GRASSES (cool)																																			
Hilaria jamesii	0.87	60.00	2.80	0.87	2.69	5						1		2		2		2				P				1				P		P			
Oryzopsis hymenoides	0.13	33.33	0.43	0.13	0.41			P		1						1				P										P					
Poa fendleriana	0.00	20.00	0.00	0.00	0.00													P								P				P					
Sitanion hystrix	0.47	93.33	1.51	0.80	2.48			P	2	1		P		P		2	1	P		P		P		1		P		2	2	P		1		P	
Stipa comata	0.00	26.67	0.00	0.00	0.00			P		P						P														P					
TOTAL NATIVE PERENNIAL GRASSES (c)	1.47	100.00	4.73	1.80	5.58	5		P	2	2		1		2		5	1	2		P		P		1		1		2	2	P		1		P	
NATIVE PERENNIAL GRASSES (w arm)																																			
Bouteloua gracilis	10.80	100.00	34.84	11.27	34.92	13		15		4		20		6		10	1	10		15	1	12		14	3	8		13	2	5		7		10	
Muhlenbergia torreyi	0.07	20.00	0.22	0.07	0.21													1				P								P					
Sporobolus cryptandrus	0.00	6.67	0.00	0.00	0.00					P																									
TOTAL NATIVE PERENNIAL GRASSES (w)	10.87	100.00	35.05	11.33	35.12	13		15		4		20		6		10	1	11		15	1	12		14	3	8		13	2	5		7		10	

J7 SBRA - Fall 2019 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.33	66.67	1.08	0.40	1.24	P				1		P		1		1	1	P				1				P				1				P	
Chrysothamnus greenei	1.13	40.00	3.66	1.20	3.72			2								7	1							7				P				1		P	
Gutierrezia sarothrae	1.53	86.67	4.95	1.53	4.75			1		6		2		2		P		2		1		1		P		1		P		6				1	
TOTAL NATIVE SUBSHRUBS	3.00	100.00	9.68	3.13	9.71	P		3		7		2		3		8	2	2		1		2		7		1		P		7		1		1	
NATIVE SHRUBS																																			
Artemisia tridentata	12.27	100.00	39.57	12.40	38.43	18		14		4		14		12		9	1	6		21		7		17		9		11	1	11		17		14	
Atriplex canescens	0.53	40.00	1.72	0.53	1.65					1														1		1		1		1		3			
TOTAL NATIVE SHRUBS	12.80	100.00	41.29	12.93	40.08	18		14		5		14		12		9	1	6		21		7		18		10		12	1	12		20		14	
SUCCULENTS																																			
Opuntia phaeacantha	0.00	13.33	0.00	0.00	0.00											P												P							
Opuntia polyacantha	0.00	53.33	0.00	0.00	0.00	P				P				P				P		P		P				P								P	
Opuntia w hipplei	0.00	6.67	0.00	0.00	0.00					P																									
TOTAL SUCCULENTS	0.00	66.67	0.00	0.00	0.00	P				P				P		P		P		P		P				P		P						P	
BRYOPHYTES																																			
Moss spp.	0.67	40.00	2.15	0.67	2.07			2		2						1								3		1		1							
TOTAL BRYOPHYTES	0.67	40.00	2.15	0.67	2.07			2		2						1								3		1		1							
LICHEN/FUNGUS																																			
Lichen spp.	0.40	73.33	1.29	0.40	1.24	1		2		P				1		P				1				P		1		P				P		P	
TOTAL LICHEN	0.40	73.33	1.29	0.40	1.24	1		2		P				1		P				1				P		1		P				P		P	
Standing dead	4.80	100.00		4.80		3		3		6		7		8		5		4		10		4		2		7		3		3		3		4	
Litter	22.73	100.00		22.73		11		20		25		30		25		17		29		18		24		12		27		21		25		38		19	
Bare ground	40.67	100.00		40.67		49		40		47		26		43		42		43		34		48		42		41		39		43		23		50	
Rock	0.80	26.67		0.80												1						2						6		3					
TOTALS	100.00		100.00	101.27	100.00	100	0	100	2	100	0	100	0	100	0	100	5	100	0	100	1	100	0	100	4	100	0	100	7	100	0	100	0	100	0
TOTAL VEGETATION COVER	31.00	s=(7.09)		32.27	s=(8.27)	37	0	37	2	22	0	37	0	24	0	35	5	24	0	38	1	22	0	44	4	25	0	31	7	26	0	36	0	27	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	59.33	s=(7.77)		60.60	s=(8.16)	51	0	60	2	53	0	74	0	57	0	58	5	57	0	66	1	52	0	58	4	59	0	61	7	57	0	77	0	50	0
SPECIES DENSITY (# of species/100 sq.m.)	15.13	s=(3.07)				12		16		20		11		15		17		16		12		17		14		21		13		18		13		12	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Chenopodium berlandieri	0.00	6.67	0.00	0.00	0.00																							P							
Euphorbia serpyllifolia	0.07	46.67	0.21	0.07	0.19	P		P				P				P								P						P		1			
Portulaca oleracea	0.00	40.00	0.00	0.00	0.00			P		P						P						P						P		P					
Salvia reflexa	0.00	6.67	0.00	0.00	0.00																									P					
TOTAL NATIVE ANN. & BIEN. FORBS	0.07	66.67	0.21	0.07	0.19	P		P		P		P				P						P		P				P		P		1			
NATIVE PERENNIAL FORBS																																			
Astragalus calycosus var. scaposus	0.00	6.67	0.00	0.00	0.00			P																											
Cryptantha flavoculata	0.00	13.33	0.00	0.00	0.00			P																						P					
Leucelene ericoides	0.00	40.00	0.00	0.00	0.00	P		P		P						P						P						P							
Mirabilis multiflora	0.13	13.33	0.41	0.13	0.39							1		1																					
Mirabilis oxybaphoides	0.00	26.67	0.00	0.00	0.00			P		P												P								P					
Penstemon linarioides	0.00	6.67	0.00	0.00	0.00					P																									
Psilostrophe sparsiflora	0.07	6.67	0.21	0.07	0.19																									1					
Sphaeralcea coccinea	0.00	46.67	0.00	0.00	0.00	P		P		P						P						P						P		P					
Sphaeralcea grossulariaefolia	0.13	26.67	0.41	0.13	0.39							1												P								P		1	
Stanleya pinnata	0.00	6.67	0.00	0.00	0.00					P																									
TOTAL NATIVE PERENNIAL FORBS	0.33	80.00	1.04	0.33	0.96	P		P		P		2		1		P						P		P				P		1		P		1	
NATIVE PERENNIAL GRASSES (cool)																																			
Hilaria jamesii	2.73	53.33	8.49	3.00	8.67									13	1			17	2	7	1			3		1		P				P		P	
Oryzopsis hymenoides	0.27	66.67	0.83	0.40	1.16	P		P		P	1					P		1			1	1				1		1		P				P	
Sitanion hystrix	0.20	40.00	0.62	0.27	0.77			P		P												P						1	1	P		2			
Stipa comata	0.20	6.67	0.62	0.20	0.58																											3			
TOTAL NATIVE PERENNIAL GRASSES (c)	3.40	93.33	10.56	3.87	11.18	P		P		P	1			13	1	P		18	2	7	2	1		3		2		2	1	P		5		P	
NATIVE PERENNIAL GRASSES (warm)																																			
Bouteloua gracilis	6.93	100.00	21.53	7.33	21.19	5		P		2		15		2	1	6		12		6		3		2		9	1	5	1	P		16	3	21	
TOTAL NATIVE PERENNIAL GRASSES (w)	6.93	100.00	21.53	7.33	21.19	5		P		2		15		2	1	6		12		6		3		2		9	1	5	1	P		16	3	21	
INTRODUCED PERENNIAL GRASSES (cool)																																			
Agropyron desertorum	0.00	6.67	0.00	0.00	0.00																											P			
TOTAL INTRO. PERENNIAL GRASSES (c)	0.00	6.67	0.00	0.00	0.00																											P			
NATIVE SUBSHRUBS																																			
Chrysothamnus depressus	1.40	46.67	4.35	1.47	4.24									2				6	1	1				2		2						5		3	
Chrysothamnus greenei	0.60	33.33	1.86	0.60	1.73	4		1								1												P		3					
Gutierrezia sarothrae	2.00	93.33	6.21	2.87	8.29	1	1	1	1	1	1	2		3	2	3		1		1	1	3	1	3	2	2	1	4	2	3		2			1
TOTAL NATIVE SUBSHRUBS	4.00	100.00	12.42	4.93	14.26	5	1	2	1	1	1	2		5	2	4		7	1	2	1	3	1	5	2	4	1	4	2	6		7		3	1
NATIVE SHRUBS																																			
Artemisia tridentata	8.87	100.00	27.54	9.13	26.40	10		8		17		3		3		12		3		8		15	3	6		5		10	1	14		7		12	
Atriplex canescens	5.07	100.00	15.73	5.33	15.41	4		8		12		1	1	7		3		3		1		12		4		7	3	4		8		1		1	
Chrysothamnus nauseosus	0.00	6.67	0.00	0.00	0.00																									P					
Chrysothamnus viscidiflorus	0.13	13.33	0.41	0.13	0.39																	P								2					
Ephedra viridis	0.07	13.33	0.21	0.07	0.19	1																				P									
Lycium pallidum	0.13	33.33	0.41	0.13	0.39			1		P								1				P								P					
Tetradymia canescens	0.00	6.67	0.00	0.00	0.00	P																													
TOTAL NATIVE SHRUBS	14.27	100.00	44.31	14.80	42.77	15		17		29		4	1	10		15		7		9		27	3	10		12	3	14	1	24		8		13	

N7/8 SBRA - Fall 2016 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE TREES																																			
Juniperus osteosperma	0.00	20.00	0.00	0.00	0.00									P										P										P	
Pinus edulis	3.07	100.00	9.52	3.07	8.86	3		P		P		7		6		3		1		3		2		4		4		5		1		6		1	
TOTAL NATIVE TREES	3.07	100.00	9.52	3.07	8.86	3		P		P		7		6		3		1		3		2		4		4		5		1		6		1	
SUCCULENTS																																			
Opuntia polyacantha	0.00	13.33	0.00	0.00	0.00							P												P											
TOTAL SUCCULENTS	0.00	13.33	0.00	0.00	0.00							P												P											
BRYOPHYTES																																			
Moss spp.	0.13	46.67	0.41	0.20	0.58	P				P						P						P						P	1			1		1	
TOTAL BRYOPHYTES	0.13	46.67	0.41	0.20	0.58	P				P						P						P						P	1			1		1	
LICHEN/FUNGUS																																			
Lichen spp.	0.00	6.67	0.00	0.00	0.00											P																			
TOTAL LICHEN	0.00	6.67	0.00	0.00	0.00											P																			
Standing dead	1.73	53.33		1.80		4		6		5						2						2	1					5		1		1			
Litter	16.53	100.00		16.53		18		17		16		27		9		18		4		17		22		13		14		19		29		12		13	
Bare ground	30.07	100.00		30.07		31		25		25		43		31		34		21		27		28		25		34		13		27		41		46	
Rock	19.47	93.33		19.47		19		33		22				23		18		30		29		12		38		21		33		11		2		1	
TOTALS	100.00		100.00	102.47	100.00	100	1	100	1	100	2	100	1	100	4	100	0	100	3	100	3	100	5	100	2	100	5	100	6	100	0	100	3	100	1
TOTAL VEGETATION COVER	32.20	s=(7.15)		34.60	s=(7.8)	28	1	19	1	32	2	30	1	37	4	28	0	45	3	27	3	36	4	24	2	31	5	30	6	32	0	44	3	40	1
GROUND COVER (Veg+Litter+St.Dead+Rock)	69.93	s=(8.65)		72.33	s=(9.51)	69	1	75	1	75	2	57	1	69	4	66	0	79	3	73	3	72	4	75	2	66	5	87	6	73	0	59	3	54	1
SPECIES DENSITY (# of species/100 sq.m.)	12.00	s=(3.14)				13		16		15		9		9		13		9		7		14		11		9		14		18		13		10	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																				
Chenopodium leptophylum	0.00	6.67	0.00	0.00	0.00			P												
Euphorbia glyptosperma	0.07	26.67	0.21	0.07	0.21	P				P	P						1			
TOTAL NATIVE ANN. & BIEN. FORBS	0.07	33.33	0.21	0.07	0.21	P		P		P	P						1			
NATIVE PERENNIAL FORBS																				
Astragalus calycosus var. scaposus	0.00	40.00	0.00	0.00	0.00	P				P		P	P			P				P
Astragalus praelongus	0.00	26.67	0.00	0.00	0.00							P			P			P	P	
Leucelene ericoides	0.40	53.33	1.26	0.40	1.26						P	1	2	P	1	P	1			1
Penstemon linarioides	0.00	6.67	0.00	0.00	0.00												P			
Psilostrophe sparsiflora	0.07	13.33	0.21	0.07	0.21					P							1			
Sphaeralcea coccinea	0.07	80.00	0.21	0.07	0.21	P	P			P	P	P	1	P	P	P		P	P	P
Stanleya pinnata	0.00	20.00	0.00	0.00	0.00	P		P								P				
TOTAL NATIVE PERENNIAL FORBS	0.53	93.33	1.68	0.53	1.68	P	P	P		P	P	1	3	P	1	P	2	P	P	1
NATIVE PERENNIAL GRASSES (cool)																				
Hilaria jamesii	3.80	40.00	12.00	3.80	12.00								5	8			2	16	18	8
Oryzopsis hymenoides	1.20	93.33	3.79	1.20	3.79	P	5	1	P		1	2	P	P	4	P	2	P	1	2
Sitanion hystrix	0.60	60.00	1.89	0.60	1.89		P	P	1		2	P	4		1	P				1
Stipa comata	0.13	26.67	0.42	0.13	0.42					P	P			P	2					
TOTAL NATIVE PERENNIAL GRASSES (c)	5.73	100.00	18.11	5.73	18.11	P	5	1	1	P	3	2	9	8	7	P	4	16	19	11
NATIVE PERENNIAL GRASSES (w arm)																				
Bouteloua gracilis	4.07	93.33	12.84	4.07	12.84	1	2	4	3		14	4	9	3	5	5	P	4	3	4
Buchloe dactyloides	0.47	20.00	1.47	0.47	1.47					5						2	P			
Sporobolus cryptandrus	0.07	6.67	0.21	0.07	0.21						1									
TOTAL NATIVE PERENNIAL GRASSES (w)	4.60	100.00	14.53	4.60	14.53	1	2	4	3	5	15	4	9	3	5	7	P	4	3	4
NATIVE SUBSHRUBS																				
Ceratoides lanata	0.00	6.67	0.00	0.00	0.00	P														
Chrysothamnus greenei	0.73	80.00	2.32	0.73	2.32	1	1	1	3	1		P		P		1	3	P	P	P
Gutierrezia sarothrae	2.80	100.00	8.84	2.80	8.84	4	2	2	2	1	5	5	6	1	6	1	3	4	P	P
TOTAL NATIVE SUBSHRUBS	3.53	100.00	11.16	3.53	11.16	5	3	3	5	2	5	5	6	1	6	2	6	4	P	P
NATIVE SHRUBS																				
Artemisia tridentata	10.47	100.00	33.05	10.47	33.05	17	15	29	15	11	9	8	4	1	17	12	8	3	5	3
Atriplex canescens	5.07	100.00	16.00	5.07	16.00	8	10	8	11	3	4	1	3	4	1	2	5	1	2	13
Tetradymia canescens	0.00	13.33	0.00	0.00	0.00					P							P			
TOTAL NATIVE SHRUBS	15.53	100.00	49.05	15.53	49.05	25	25	37	26	14	13	9	7	5	18	14	13	4	7	16
NATIVE TREES																				
Juniperus osteosperma	0.40	26.67	1.26	0.40	1.26								3	1				1	1	
Pinus edulis	1.07	80.00	3.37	1.07	3.37	2	P			1	3	3	1	1		2	1	1	P	1
TOTAL NATIVE TREES	1.47	80.00	4.63	1.47	4.63	2	P			1	3	3	4	2		2	1	2	1	1
SUCCULENTS																				
Coryphantha vivipara	0.00	13.33	0.00	0.00	0.00													P	P	
Opuntia phaeacantha	0.00	13.33	0.00	0.00	0.00						P				P					
TOTAL SUCCULENTS	0.00	26.67	0.00	0.00	0.00						P				P			P	P	

N7/8 SBRA - Fall 2017 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
BRYOPHYTES																																			
Moss spp.	0.20	13.33	0.63	0.20	0.63											2		1																	
TOTAL BRYOPHYTES	0.20	13.33	0.63	0.20	0.63											2		1																	
Standing dead	3.40	100.00		3.40		6		1		5		2		5		3		6		4		4		1		5		1		1		4		3	
Litter	13.80	100.00		13.80		12		17		19		17		10		5		15		4		15		7		20		22		10		14		20	
Bare ground	39.60	100.00		39.60		44		45		23		28		48		50		51		50		47		51		31		29		42		36		19	
Rock	11.53	100.00		11.53		5		2		8		18		15		1		3		4		15		4		19		21		17		16		25	
TOTALS	100.00		100.00	100.00	100.00	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0
TOTAL VEGETATION COVER	31.67	s=(7.22)		31.67	s=(7.22)	33	0	35	0	45	0	35	0	22	0	41	0	25	0	38	0	19	0	37	0	25	0	27	0	30	0	30	0	33	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	60.40	s=(10.99)		60.40	s=(10.99)	56	0	55	0	77	0	72	0	52	0	50	0	49	0	50	0	53	0	49	0	69	0	71	0	58	0	64	0	81	0
SPECIES DENSITY (# of species/100 sq.m.)	11.60	s=(1.92)				12		9		9		7		12		14		13		12		12		11		13		14		12		12		12	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Chenopodium berlandieri	0.07	13.33	0.26	0.07	0.25							1		P																					
Chenopodium fremontii	0.00	13.33	0.00	0.00	0.00											P												P							
Chenopodium leptophyllum	0.00	0.00	0.00	0.00	0.00																														
Descurainia pinnata	4.47	93.33	17.59	5.00	18.75	1		P		12	3	8	1	12		4		4		2		2	1	P				19	2	2		1	1	P	
Eriogonum cernuum	0.00	26.67	0.00	0.00	0.00					P				P						P						P									
Euphorbia serpyllifolia	0.00	6.67	0.00	0.00	0.00													P																	
Gilia aggregata	0.00	6.67	0.00	0.00	0.00			P																											
Gilia leptomeria	0.80	93.33	3.15	0.87	3.25	1		P		2		3		P		P	1	P				1		1		1		P		P		P		3	
Gilia pumila	0.20	53.33	0.79	0.20	0.75					P				P		P				2		P		P				1		P					
Lappula redowskii	0.73	93.33	2.89	0.87	3.25	P		P		2		3	1	P		P		1	1	P		1		1		P		2				P		1	
Lupinus brevicaulis	0.20	40.00	0.79	0.20	0.75			P		P		1														P						P		2	
Mentzelia pumila	0.00	13.33	0.00	0.00	0.00															P								P							
Oenothera albicaulis	0.00	20.00	0.00	0.00	0.00			P		P																		P							
Phacelia crenulata	0.13	46.67	0.52	0.13	0.50					2		P		P						P		P				P		P							
TOTAL NATIVE ANN. & BIEN. FORBS	6.60	100.00	25.98	7.33	27.50	2		P		18	3	16	2	12		4	1	5	1	4		4	1	2		1		22	2	2		1	1	6	
INTRODUCED ANNUAL & BIENNIAL FORBS																																			
Chenopodium album	0.00	0.00	0.00	0.00	0.00																														
Descurainia sophia	0.13	13.33	0.52	0.13	0.50																	2				P									
Erodium cicutarium	0.07	6.67	0.26	0.07	0.25													1																	
Sisymbrium altissimum	0.13	20.00	0.52	0.20	0.75			1				1																P	1						
TOTAL INTRO. ANN. & BIEN. FORBS	0.33	40.00	1.31	0.40	1.50			1				1						1				2				P		P	1						
NATIVE ANNUAL GRASSES																																			
Festuca octoflora	0.00	6.67	0.00	0.00	0.00							P																							
TOTAL NATIVE ANNUAL GRASSES	0.00	6.67	0.00	0.00	0.00							P																							
INTRODUCED ANNUAL GRASSES																																			
Bromus tectorum	0.00	6.67	0.00	0.00	0.00																							P							
TOTAL INTRODUCED ANNUAL GRASSES	0.00	6.67	0.00	0.00	0.00																							P							
NATIVE PERENNIAL FORBS																																			
Allium sp.	0.00	33.33	0.00	0.00	0.00	P						P				P								P						P					
Astragalus wingatanus	0.13	66.67	0.52	0.20	0.75	P		P								1		1		P	1	P		P		P				P				P	
Calochortus nuttallii	0.07	26.67	0.26	0.07	0.25							1												P						P				P	
Castilleja chromosa	0.00	6.67	0.00	0.00	0.00			P																											
Cymopterus purpureus	0.73	93.33	2.89	0.73	2.75	1		2		P				P		P		1		P		2		P		3		P		P		P		2	
Delphinium scaposum	0.00	13.33	0.00	0.00	0.00	P						P																							
Hymenopappus filifolius	0.00	6.67	0.00	0.00	0.00			P																											
Lesquerella intermedia	0.00	6.67	0.00	0.00	0.00	P																													
Leucelene ericoides	0.20	53.33	0.79	0.20	0.75	P		1		P								P				1				1						P		P	
Mirabilis multiflora	0.00	20.00	0.00	0.00	0.00							P										P						P							
Penstemon linarioides	0.00	13.33	0.00	0.00	0.00																					P				P					
Petradoria pumila	0.00	6.67	0.00	0.00	0.00			P																											
Phlox longifolia	0.13	73.33	0.52	0.13	0.50	P		1		P		P				P								P		P		1		P		P		P	
Sphaeralcea coccinea	0.20	100.00	0.79	0.20	0.75	P		P		1		1		P		P		P		P		P		1		P		P		P		P		P	
Stanleya pinnata	0.00	6.67	0.00	0.00	0.00					P																									
Townsendia exscapa	0.00	6.67	0.00	0.00	0.00	P																													
TOTAL NATIVE PERENNIAL FORBS	1.47	100.00	5.77	1.53	5.75	1		4		1		2		P		1		2		P	1	3		1		4		1		P		P		2	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE PERENNIAL GRASSES (cool)																																			
Hilaria jamesii	0.87	60.00	3.41	0.93	3.50	1				2						1		P						3	1	3				1		P		2	
Oryzopsis hymenoides	0.40	93.33	1.57	0.47	1.75	P		P		P		P		P		P		2	1			P		1		P		P		1		2		P	
Sitanion hystrix	0.27	80.00	1.05	0.27	1.00	P				P				1		P		P		P		1		1		1		P				P		P	
Stipa comata	0.00	26.67	0.00	0.00	0.00			P		P												P								P					
TOTAL NATIVE PERENNIAL GRASSES (c)	1.53	100.00	6.04	1.67	6.25	1		P		2		P		1		1		2	1	P		1		5	1	4		P		2		2		2	
NATIVE PERENNIAL GRASSES (w arm)																																			
Bouteloua gracilis	2.20	100.00	8.66	2.20	8.25	3		P		1		5		3		4		P		1		1		7		P		P		6		2		P	
TOTAL NATIVE PERENNIAL GRASSES (w)	2.20	100.00	8.66	2.20	8.25	3		P		1		5		3		4		P		1		1		7		P		P		6		2		P	
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.00	13.33	0.00	0.00	0.00																	P		P											
Chrysothamnus greenei	1.53	100.00	6.04	1.60	6.00	1		1		3	1	1		2		1		1		1		2		1		P		P		2		4		3	
Gutierrezia sarothrae	0.00	6.67	0.00	0.00	0.00			P																											
TOTAL NATIVE SUBSHRUBS	1.53	100.00	6.04	1.60	6.00	1		1		3	1	1		2		1		1		1		2		1		P		P		2		4		3	
NATIVE SHRUBS																																			
Artemisia tridentata	6.07	100.00	23.88	6.13	23.00	9		7		7		7		13		5		6		10		2		4		4		3	1	3		9		2	
Atriplex canescens	2.67	80.00	10.50	2.73	10.25	1		1		1		4		2	1	1		11		3		6						8		1				1	
Chrysothamnus viscidiflorus	0.13	20.00	0.52	0.13	0.50	1						P																				1			
Lycium pallidum	0.07	13.33	0.26	0.07	0.25			1		P																									
TOTAL NATIVE SHRUBS	8.93	100.00	35.17	9.07	34.00	11		9		8		11		15	1	6		17		13		8		4		4		11	1	4		10		3	
NATIVE TREES																																			
Juniperus osteosperma	0.07	13.33	0.26	0.07	0.25			P								1																			
Pinus edulis	2.40	93.33	9.45	2.40	9.00	1		11				4		P		3		1		2		2		2		5		1		1		P		3	
TOTAL NATIVE TREES	2.47	93.33	9.71	2.47	9.25	1		11				4		P		4		1		2		2		2		5		1		1		P		3	
SUCCULENTS																																			
Opuntia phaeacantha	0.00	13.33	0.00	0.00	0.00			P																						P					
Opuntia polyacantha	0.00	13.33	0.00	0.00	0.00											P								P											
TOTAL SUCCULENTS	0.00	26.67	0.00	0.00	0.00			P								P								P						P					
BRYOPHYTES																																			
Moss sp.	0.33	66.67	1.31	0.40	1.50					P		P		P		2		2				P		1	1			P		P		P			
TOTAL BRYOPHYTES	0.33	66.67	1.31	0.40	1.50					P		P		P		2		2				P		1	1			P		P		P			
Standing dead	8.27	100.00		8.27		2		10		17		14		15		5		4		5		7		8		3		12		4		10		8	
Litter	20.33	100.00		20.33		29		14		16		19		10		36		11		15		24		30		30		20		14		20		17	
Bare ground	22.87	100.00		22.87		32		12		24		4		20		22		33		34		20		26		17		14		37		30		18	
Rock	23.13	100.00		23.13		17		38		10		23		22		14		21		25		26		13		32		19		28		21		38	
TOTALS	100.00		100.00	101.27	100.00	100	0	100	0	100	4	100	2	100	1	100	1	100	2	100	1	100	1	100	2	100	0	100	4	100	0	100	1	100	0
TOTAL VEGETATION COVER	25.40	s=(7.2)		26.67	s=(8.21)	20	0	26	0	33	4	40	2	33	1	23	1	31	2	21	1	23	1	23	2	18	0	35	4	17	0	19	1	19	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	77.13	s=(9.26)		78.40	s=(9.58)	68	0	88	0	76	4	96	2	80	1	78	1	67	2	66	1	80	1	74	2	83	0	86	4	63	0	70	1	82	0
SPECIES DENSITY (# of species/100 sq.m.)	20.00	s=(2.78)				21		26		23		22		17		21		18		15		21		20		19		22		20		17		18	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Chenopodium berlandieri	0.07	26.67	0.29	0.07	0.28	P								P				1												P					
Chenopodium fremontii	0.00	13.33	0.00	0.00	0.00			P														P													
Chenopodium leptophyllum	0.13	66.67	0.57	0.13	0.56	P		P		P						1				P		P		P		P		P		1					
Cordylanthus wrightii	0.00	13.33	0.00	0.00	0.00			P																		P									
Descurainia pinnata	1.67	86.67	7.14	1.67	6.96	4		6		1		P		P		5		P		6		1		P		P		2						P	
Eriogonum cernuum	0.00	13.33	0.00	0.00	0.00											P										P									
Euphorbia serpyllifolia	0.00	20.00	0.00	0.00	0.00	P								P				P																	
Gilia aggregata	0.00	6.67	0.00	0.00	0.00													P																	
Gilia leptomeria	0.67	93.33	2.86	0.87	3.62	P		P		P		P		1		1		P	1	1		1	1	1				P		1	1	3		1	
Gilia pumila	0.27	66.67	1.14	0.33	1.39	1						P				P		P				P		P				1		P		1		1	1
Ipomopsis longiflora	0.00	20.00	0.00	0.00	0.00			P								P										P									
Lappula redowskii	0.87	86.67	3.71	0.87	3.62	P		1		P		P		3		1		2		2		2				P		2		P		P			
Machaeranthera canescens	0.00	26.67	0.00	0.00	0.00			P						P		P												P							
Phacelia crenulata	0.13	40.00	0.57	0.13	0.56	P				P				P				1						P				1							
TOTAL NATIVE ANN. & BIEN. FORBS	3.80	100.00	16.29	4.07	16.99	5		7		1		P		4		8		4	1	9		4	1	1		P		6		2	1	4		2	1
INTRODUCED ANNUAL & BIENNIAL FORBS																																			
Chenopodium album	0.07	20.00	0.29	0.07	0.28											P										1		P							
Sisymbrium altissimum	0.13	13.33	0.57	0.13	0.56			1																1											
TOTAL INTRO. ANN. & BIEN. FORBS	0.20	33.33	0.86	0.20	0.84			1								P								1		1		P							
INTRODUCED ANNUAL GRASSES																																			
Bromus tectorum	0.13	33.33	0.57	0.13	0.56			P						1		P				P								1							
TOTAL INTRODUCED ANNUAL GRASSES	0.13	33.33	0.57	0.13	0.56			P						1		P				P								1							
NATIVE PERENNIAL FORBS																																			
Astragalus wingatanus	0.20	40.00	0.86	0.20	0.84					1				1								P		P						P		1			
Calochortus nuttallii	0.00	60.00	0.00	0.00	0.00			P		P				P				P		P		P								P		P		P	
Cymopterus purpureus	0.00	53.33	0.00	0.00	0.00			P		P		P		P								P		P								P		P	
Delphinium scaposum	0.00	6.67	0.00	0.00	0.00																							P							
Haplopappus armerioides	0.00	13.33	0.00	0.00	0.00											P										P									
Leucelene ericoides	0.60	93.33	2.57	0.60	2.51			P		2		P		2		P		1		P		1		P		1		P		1		1		P	
Psilostrophe sparsiflora	0.00	13.33	0.00	0.00	0.00									P												P									
Sphaeralcea coccinea	0.47	100.00	2.00	0.53	2.23	P		1		1		1		P		P		P	1	P		2		2		P		P		P		P		P	
Stanleya pinnata	0.00	13.33	0.00	0.00	0.00			P								P																			
TOTAL NATIVE PERENNIAL FORBS	1.27	100.00	5.43	1.33	5.57	P		1		4		1		3		P		1	1	P		3		2		1		P		1		2		P	
NATIVE PERENNIAL GRASSES (cool)																																			
Hilaria jamesii	1.13	66.67	4.86	1.13	4.74			P		2								3				3		P		P		1		6		1		1	
Oryzopsis hymenoides	0.33	100.00	1.43	0.33	1.39	P		P		P		P		P		P		3		1		P		P		P		P		1		P		P	
Poa fendleriana	0.00	6.67	0.00	0.00	0.00			P																											
Sitanion hystrix	0.13	53.33	0.57	0.13	0.56	P		P						1				P		P										P		1		P	
Stipa comata	0.07	33.33	0.29	0.07	0.28			P										P		P						1						P			
TOTAL NATIVE PERENNIAL GRASSES (c)	1.67	100.00	7.14	1.67	6.96	P		P		2		P		1		P		6		1		3		P		1		1		7		2		1	
NATIVE PERENNIAL GRASSES (warm)																																			
Bouteloua gracilis	1.87	100.00	8.00	1.93	8.08	P		1		P		1		P		P		1		3		1		1		6		P		4		5		5	1
Sporobolus cryptandrus	0.00	0.00	0.00	0.07	0.28																				1										
TOTAL NATIVE PERENNIAL GRASSES (w)	1.87	100.00	8.00	2.00	8.36	P		1		P		1		P		P		1		3		1		1	1	6		P		4		5		5	1

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.00	20.00	0.00	0.00	0.00	P																		P								P			
Chrysothamnus greenei	2.93	80.00	12.57	2.93	12.26	3				11		1		4				3				4		2		1		2		3		3		7	
Eriogonum microthecum	0.00	6.67	0.00	0.00	0.00	P																													
Gutierrezia sarothrae	0.40	93.33	1.71	0.40	1.67	1		P		P		P		1		1		1		P		1		P		1		P		P				P	
Senecio douglasii var. longilobus	0.00	20.00	0.00	0.00	0.00			P								P										P									
TOTAL NATIVE SUBSHRUBS	3.33	100.00	14.29	3.33	13.93	4		P		11		1		5		1		4		P		5		2		2		2		3		3		7	
NATIVE SHRUBS																																			
Artemisia tridentata	5.40	100.00	23.14	5.47	22.84	13		7		5		1		1		9		8		7		5		1		2		2		7		10		3	1
Atriplex canescens	2.00	80.00	8.57	2.00	8.36	3		1		1		2		10		3		2		P		2		1				4						1	
Chrysothamnus nauseosus	0.00	20.00	0.00	0.00	0.00			P								P								P											
Chrysothamnus viscidiflorus	0.00	6.67	0.00	0.00	0.00													P																	
Ephedra viridis	0.13	13.33	0.57	0.13	0.56							1										1													
Lycium pallidum	0.00	20.00	0.00	0.00	0.00					P						P												P							
Tetradymia canescens	0.07	6.67	0.29	0.07	0.28									1																					
TOTAL NATIVE SHRUBS	7.60	100.00	32.57	7.67	32.03	16		8		6		4		12		12		10		7		8		2		2		6		7		10		4	1
NATIVE TREES																																			
Juniperus osteosperma	0.20	26.67	0.86	0.20	0.84					1				P						1		1													
Pinus edulis	3.00	100.00	12.86	3.00	12.53	P		3		3		6		5		1		2		1		P		5		5		4		4		1		5	
TOTAL NATIVE TREES	3.20	100.00	13.71	3.20	13.37	P		3		4		6		5		1		2		2		1		5		5		4		4		1		5	
SUCCULENTS																																			
Opuntia phaeacantha	0.00	6.67	0.00	0.00	0.00																									P					
Opuntia polyacantha	0.00	6.67	0.00	0.00	0.00																											P			
TOTAL SUCCULENTS	0.00	13.33	0.00	0.00	0.00																									P		P			
BRYOPHYTES																																			
Moss spp.	0.20	26.67	0.86	0.27	1.11	2						1						P	1											P					
TOTAL BRYOPHYTES	0.20	26.67	0.86	0.27	1.11	2						1						P	1											P					
LICHEN/FUNGUS																																			
Lichen spp.	0.07	6.67	0.29	0.07	0.28			1																											
TOTAL LICHEN	0.07	6.67	0.29	0.07	0.28			1																											
Standing dead	7.33	93.33		7.33		8		15		1		7		9		10		5		16		4		6				14		7		3		5	
Litter	21.00	100.00		21.00		19		29		22		23		16		21		20		13		18		28		15		15		29		23		24	
Bare ground	24.27	100.00		24.27		31		10		13		43		21		21		29		11		23		27		19		22		26		41		27	
Rock	24.07	100.00		24.07		15		24		36		13		23		26		18		38		30		25		48		29		10		6		20	
TOTALS	100.00		100.00	100.60	100.00	100	0	100	0	100	0	100	0	100	0	100	0	100	3	100	0	100	1	100	1	100	0	100	0	100	1	100	0	100	3
TOTAL VEGETATION COVER	23.33	s=(5.16)		23.93	s=(5.44)	27	0	22	0	28	0	14	0	31	0	22	0	28	3	22	0	25	1	14	1	18	0	20	0	28	1	27	0	24	3
GROUND COVER (Veg+Litter+St.Dead+Rock)	75.73	s=(9.56)		76.33	s=(9.42)	69	0	90	0	87	0	57	0	79	0	79	0	71	3	89	0	77	1	73	1	81	0	78	0	74	1	59	0	73	3
SPECIES DENSITY (# of species/100 sq.m.)	20.40	s=(3.2)				20		28		20		16		24		23		23		17		21		20		20		21		19		18		16	

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PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
NATIVE ANNUAL & BIENNIAL FORBS					
Machaeranthera canescens	0.00	6.67	0.00	0.00	0.00
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	6.67	0.00	0.00	0.00
NATIVE PERENNIAL GRASSES (cool)					
Sitanion hystrix	0.00	6.67	0.00	0.00	0.00
Stipa comata	0.00	6.67	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL GRASSES (c)	0.00	13.33	0.00	0.00	0.00
NATIVE PERENNIAL GRASSES (warm)					
Bouteloua gracilis	20.67	100.00	48.51	26.80	54.47
TOTAL NATIVE PERENNIAL GRASSES (w)	20.67	100.00	48.51	26.80	54.47
NATIVE SUBSHRUBS					
Gutierrezia sarothrae	0.87	93.33	2.03	1.00	2.03
TOTAL NATIVE SUBSHRUBS	0.87	93.33	2.03	1.00	2.03
NATIVE SHRUBS					
Artemisia tridentata	18.20	100.00	42.72	18.40	37.40
Atriplex canescens	0.07	6.67	0.16	0.07	0.14
TOTAL NATIVE SHRUBS	18.27	100.00	42.88	18.47	37.53
NATIVE TREES					
Pinus edulis	1.80	86.67	4.23	1.80	3.66
TOTAL NATIVE TREES	1.80	86.67	4.23	1.80	3.66
SUCCULENTS					
Opuntia phaeacantha	0.00	13.33	0.00	0.00	0.00
TOTAL SUCCULENTS	0.00	13.33	0.00	0.00	0.00
BRYOPHYTES					
Moss spp.	0.07	20.00	0.16	0.13	0.27
TOTAL BRYOPHYTES	0.07	20.00	0.16	0.13	0.27
LICHEN/FUNGUS					
Lichen spp.	0.93	93.33	2.19	1.00	2.03
TOTAL LICHEN	0.93	93.33	2.19	1.00	2.03
Standing dead	3.93	93.33		3.93	
Litter	13.60	100.00		13.60	
Bare ground	39.80	100.00		39.80	
Rock	0.07	6.67		0.07	
TOTALS	100.00		100.00	106.60	100.00
TOTAL VEGETATION COVER	42.60	s=(8.54)		49.20	s=(12.45)
GROUND COVER (Veg+Litter+St.Dead+Rock)	60.20	s=(10.94)		66.80	s=(14.54)
SPECIES DENSITY (# of species/100 sq.m.)	5.33	s=(0.9)			

Percent Foliar Cover

PLANT SPECIES	1		2		3		4		5		6		7		8	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																
Machaeranthera canescens																
TOTAL NATIVE ANN. & BIEN. FORBS																
NATIVE PERENNIAL GRASSES (cool)																
Sitanion hystrix																
Stipa comata											P					
TOTAL NATIVE PERENNIAL GRASSES (c)											P					
NATIVE PERENNIAL GRASSES (warm)																
Bouteloua gracilis	25	6	20	9	18	7	27	7	23	9	18	3	20	4	14	2
TOTAL NATIVE PERENNIAL GRASSES (w)	25	6	20	9	18	7	27	7	23	9	18	3	20	4	14	2
NATIVE SUBSHRUBS																
Gutierrezia sarothrae	P		3		1		P				2		1		1	1
TOTAL NATIVE SUBSHRUBS	P		3		1		P				2		1		1	1
NATIVE SHRUBS																
Artemisia tridentata	17	2	17		24		21		21		15		12		13	
Atriplex canescens																
TOTAL NATIVE SHRUBS	17	2	17		24		21		21		15		12		13	
NATIVE TREES																
Pinus edulis	7		2		P		P				1				5	
TOTAL NATIVE TREES	7		2		P		P				1				5	
SUCCULENTS																
Opuntia phaeacantha																
TOTAL SUCCULENTS																
BRYOPHYTES																
Moss spp.	P	1							1						P	
TOTAL BRYOPHYTES	P	1							1						P	
LICHEN/FUNGUS																
Lichen spp.	P		2		2		P		1		1		2	1	P	
TOTAL LICHEN	P		2		2		P		1		1		2	1	P	
Standing dead	2		6		4		1		1		2		3			
Litter	11		9		12		5		16		16		10		14	
Bare ground	38		41		39		46		37		45		51		53	
Rock													1			
TOTALS	100	9	100	9	100	7	100	7	100	9	100	3	100	5	100	3
TOTAL VEGETATION COVER	49	9	44	9	45	7	48	7	46	9	37	3	35	5	33	3
GROUND COVER (Veg+Litter+St.Dead+Rock)	62	9	59	9	61	7	54	7	63	9	55	3	49	5	47	3
SPECIES DENSITY (# of species/100 sq.m.)	6		5		5		5		4		6		4		6	

PLANT SPECIES	9		10		11		12		13		14		15	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS														
Machaeranthera canescens													P	
TOTAL NATIVE ANN. & BIEN. FORBS													P	
NATIVE PERENNIAL GRASSES (cool)														
Sitanion hystrix											P			
Stipa comata														
TOTAL NATIVE PERENNIAL GRASSES (c)											P			
NATIVE PERENNIAL GRASSES (warm)														
Bouteloua gracilis	17	2	17	3	21	5	33	18	21	6	22	4	14	7
TOTAL NATIVE PERENNIAL GRASSES (w)	17	2	17	3	21	5	33	18	21	6	22	4	14	7
NATIVE SUBSHRUBS														
Gutierrezia sarothrae	P		2		P		2	1	P		P		1	
TOTAL NATIVE SUBSHRUBS	P		2		P		2	1	P		P		1	
NATIVE SHRUBS														
Artemisia tridentata	13		15		21		31		17	1	20		16	
Atriplex canescens			1											
TOTAL NATIVE SHRUBS	13		16		21		31		17	1	20		16	
NATIVE TREES														
Pinus edulis	2		2		1		P		4		P		3	
TOTAL NATIVE TREES	2		2		1		P		4		P		3	
SUCCULENTS														
Opuntia phaeacantha	P		P											
TOTAL SUCCULENTS	P		P											
BRYOPHYTES														
Moss spp.														
TOTAL BRYOPHYTES														
LICHEN/FUNGUS														
Lichen spp.	P		1		P				4		P		1	
TOTAL LICHEN	P		1		P				4		P		1	
Standing dead	5		1		2		19		4		2		7	
Litter	15		18		26		8		11		19		14	
Bare ground	48		43		29		7		39		37		44	
Rock														
TOTALS	100	2	100	3	100	5	100	19	100	7	100	4	100	7
TOTAL VEGETATION COVER	32	2	38	3	43	5	66	19	46	7	42	4	35	7
GROUND COVER (Veg+Litter+St.Dead+Rock)	52	2	57	3	71	5	93	19	61	7	63	4	56	7
SPECIES DENSITY (# of species/100 sq.m.)	6		7		5		4		5		6		6	

N14 SBRA - Fall 2017

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE PERENNIAL FORBS																																			
Leucelene ericoides	0.07	33.33	0.16	0.07	0.16									P		1						P						P		P					
Sphaeralcea coccinea	0.00	13.33	0.00	0.00	0.00	P								P																					
TOTAL NATIVE PERENNIAL FORBS	0.07	40.00	0.16	0.07	0.16	P								P		1						P						P		P					
NATIVE PERENNIAL GRASSES (cool)																																			
Oryzopsis hymenoides	0.00	13.33	0.00	0.00	0.00							P						P																	
Sitanion hystrix	0.00	53.33	0.00	0.00	0.00	P														P		P		P		P		P		P		P			
Stipa comata	0.00	6.67	0.00	0.00	0.00							P																							
TOTAL NATIVE PERENNIAL GRASSES (c)	0.00	66.67	0.00	0.00	0.00	P						P						P		P		P		P		P		P		P		P			
NATIVE PERENNIAL GRASSES (warm)																																			
Bouteloua gracilis	20.47	100.00	49.28	21.20	50.08	13	2	21		23		16		23	1	20		26	1	26		20		18	2	20	1	22	1	23	2	17	1	19	
TOTAL NATIVE PERENNIAL GRASSES (w)	20.47	100.00	49.28	21.20	50.08	13	2	21		23		16		23	1	20		26	1	26		20		18	2	20	1	22	1	23	2	17	1	19	
NATIVE SUBSHRUBS																																			
Gutierrezia sarothrae	0.47	100.00	1.12	0.47	1.10	P		P		1		P		1		P		P		1		1		1		P		P		P		2		P	
TOTAL NATIVE SUBSHRUBS	0.47	100.00	1.12	0.47	1.10	P		P		1		P		1		P		P		1		1		1		P		P		P		2		P	
NATIVE SHRUBS																																			
Artemisia tridentata	18.20	100.00	43.82	18.27	43.15	29		10		13		16		20		17		14		15		19		22		21		20		21		20		16	1
Atriplex canescens	0.07	6.67	0.16	0.07	0.16							1																							
Chrysothamnus nauseosus	0.00	6.67	0.00	0.00	0.00							P																							
TOTAL NATIVE SHRUBS	18.27	100.00	43.98	18.33	43.31	29		10		13		17		20		17		14		15		19		22		21		20		21		20		16	1
NATIVE TREES																																			
Pinus edulis	1.47	93.33	3.53	1.47	3.46	P		4		1		1		P		1		2		2		P		1		3				P		4		3	
TOTAL NATIVE TREES	1.47	93.33	3.53	1.47	3.46	P		4		1		1		P		1		2		2		P		1		3				P		4		3	
SUCCULENTS																																			
Coryphantha vivipara	0.00	6.67	0.00	0.00	0.00							P																							
Opuntia phaeacantha	0.00	33.33	0.00	0.00	0.00	P						P								P						P								P	
TOTAL SUCCULENTS	0.00	33.33	0.00	0.00	0.00	P						P								P						P								P	
BRYOPHYTES																																			
Moss spp.	0.07	26.67	0.16	0.07	0.16	1		P						P																P					
TOTAL BRYOPHYTES	0.07	26.67	0.16	0.07	0.16	1		P						P																P					
LICHEN/FUNGUS																																			
Lichen spp.	0.73	73.33	1.77	0.73	1.73	P		2		1				P				1				1				3		P		P		2		1	
TOTAL LICHEN	0.73	73.33	1.77	0.73	1.73	P		2		1				P				1				1				3		P		P		2		1	
Standing dead	3.60	100.00		3.67		7		5		3		4		2		4		2	1	7		3		4		2		2		1		4		4	
Litter	11.67	100.00		11.67		18		19		9		9		10		5		15		8		6		17		8		8		18		11		14	
Bare ground	43.13	100.00		43.13		32		39		49		53		44		52		40		41		50		37		43		48		37		39		43	
Rock	0.07	6.67		0.07																												1			
TOTALS	100.00		100.00	100.87	100.00	100	2	100	0	100	0	100	0	100	1	100	0	100	2	100	0	100	0	100	2	100	1	100	1	100	2	100	1	100	1
TOTAL VEGETATION COVER	41.53	s=(3.4)		42.33	s=(3.87)	43	2	37	0	39	0	34	0	44	1	39	0	43	1	44	0	41	0	42	2	47	1	42	1	44	2	45	1	39	1
GROUND COVER (Veg+Litter+St.Dead+Rock)	56.87	s=(6.15)		57.67	s=(6.74)	68	2	61	0	51	0	47	0	56	1	48	0	60	1	59	0	50	0	63	2	57	1	52	1	63	2	61	1	57	1
SPECIES DENSITY (# of species/100 sq.m.)	6.67	s=(1.5)				9		6		5		10		8		5		6		6		7		5		7		6		8		6		6	

N14 SBRA - Spring 2019

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
NATIVE ANNUAL & BIENNIAL FORBS																				
Descurainia pinnata	0.00	93.33	0.00	0.00	0.00	P		P	P	P	P	P	P	P	P	P	P	P	P	P
Gilia pumila	0.00	80.00	0.00	0.00	0.00	P	P	P	P	P				P	P	P	P	P	P	P
Lappula redowskii	0.00	40.00	0.00	0.00	0.00	P		P	P				P					P		P
Lupinus brevicaulis	0.00	20.00	0.00	0.00	0.00				P		P									P
Oenothera albicaulis	0.00	20.00	0.00	0.00	0.00	P			P						P					
Townsendia annua	0.00	26.67	0.00	0.00	0.00	P					P	P				P				
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	100.00	0.00	0.00	0.00	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
INTRODUCED ANNUAL & BIENNIAL FORBS																				
Chenopodium album	0.00	6.67	0.00	0.00	0.00								P							
Lactuca serriola	0.00	13.33	0.00	0.00	0.00			P							P					
Sisymbrium altissimum	0.00	13.33	0.00	0.00	0.00	P		P												
Tragopogon dubius	0.00	6.67	0.00	0.00	0.00							P								
TOTAL INTRO. ANN. & BIEN. FORBS	0.00	33.33	0.00	0.00	0.00	P		P				P	P		P					
NATIVE PERENNIAL FORBS																				
Arabis fendleri	0.00	26.67	0.00	0.00	0.00		P			P			P							P
Calochortus nuttallii	0.00	53.33	0.00	0.00	0.00				P	P	P		P	P	P			P		P
Cymopterus purpureus	0.00	100.00	0.00	0.00	0.00	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Leucelene ericoides	0.13	100.00	0.49	0.13	0.49	P	P	P	P	1	P	P	P	P	1	P	P	P	P	P
Phlox longifolia	0.00	6.67	0.00	0.00	0.00													P		
Sphaeralcea coccinea	0.00	60.00	0.00	0.00	0.00			P	P	P	P	P		P		P	P			P
TOTAL NATIVE PERENNIAL FORBS	0.13	100.00	0.49	0.13	0.49	P	P	P	P	1	P	P	P	P	1	P	P	P	P	P
NATIVE PERENNIAL GRASSES (cool)																				
Poa sp.	0.00	6.67	0.00	0.00	0.00			P												
Sitanion hystrix	0.60	93.33	2.22	0.60	2.22	P	4	P	P	1	1	P	1	P		1	1	P	P	P
TOTAL NATIVE PERENNIAL GRASSES (c)	0.60	93.33	2.22	0.60	2.22	P	4	P	P	1	1	P	1	P		1	1	P	P	P
NATIVE PERENNIAL GRASSES (warm)																				
Bouteloua gracilis	6.80	100.00	25.12	6.80	25.12	6	5	7	4	10	6	4	3	17	9	5	8	4	9	5
TOTAL NATIVE PERENNIAL GRASSES (w)	6.80	100.00	25.12	6.80	25.12	6	5	7	4	10	6	4	3	17	9	5	8	4	9	5
NATIVE SUBSHRUBS																				
Gutierrezia sarothrae	0.07	80.00	0.25	0.07	0.25	P	P	P	P	P	P	P	P	P			P		1	P
TOTAL NATIVE SUBSHRUBS	0.07	80.00	0.25	0.07	0.25	P	P	P	P	P	P	P	P	P			P		1	P
NATIVE SHRUBS																				
Artemisia tridentata	16.07	100.00	59.36	16.07	59.36	17	16	11	18	9	15	18	24	19	16	8	16	24	18	12
Chrysothamnus nauseosus	0.07	6.67	0.25	0.07	0.25							1								
TOTAL NATIVE SHRUBS	16.13	100.00	59.61	16.13	59.61	17	16	11	18	9	15	19	24	19	16	8	16	24	18	12
NATIVE TREES																				
Pinus edulis	2.00	100.00	7.39	2.00	7.39	2	3	2	3	P	2	3	1	1	1	5	1	P	1	5
TOTAL NATIVE TREES	2.00	100.00	7.39	2.00	7.39	2	3	2	3	P	2	3	1	1	1	5	1	P	1	5

N14 SBRA - Spring 2019 (Continued)

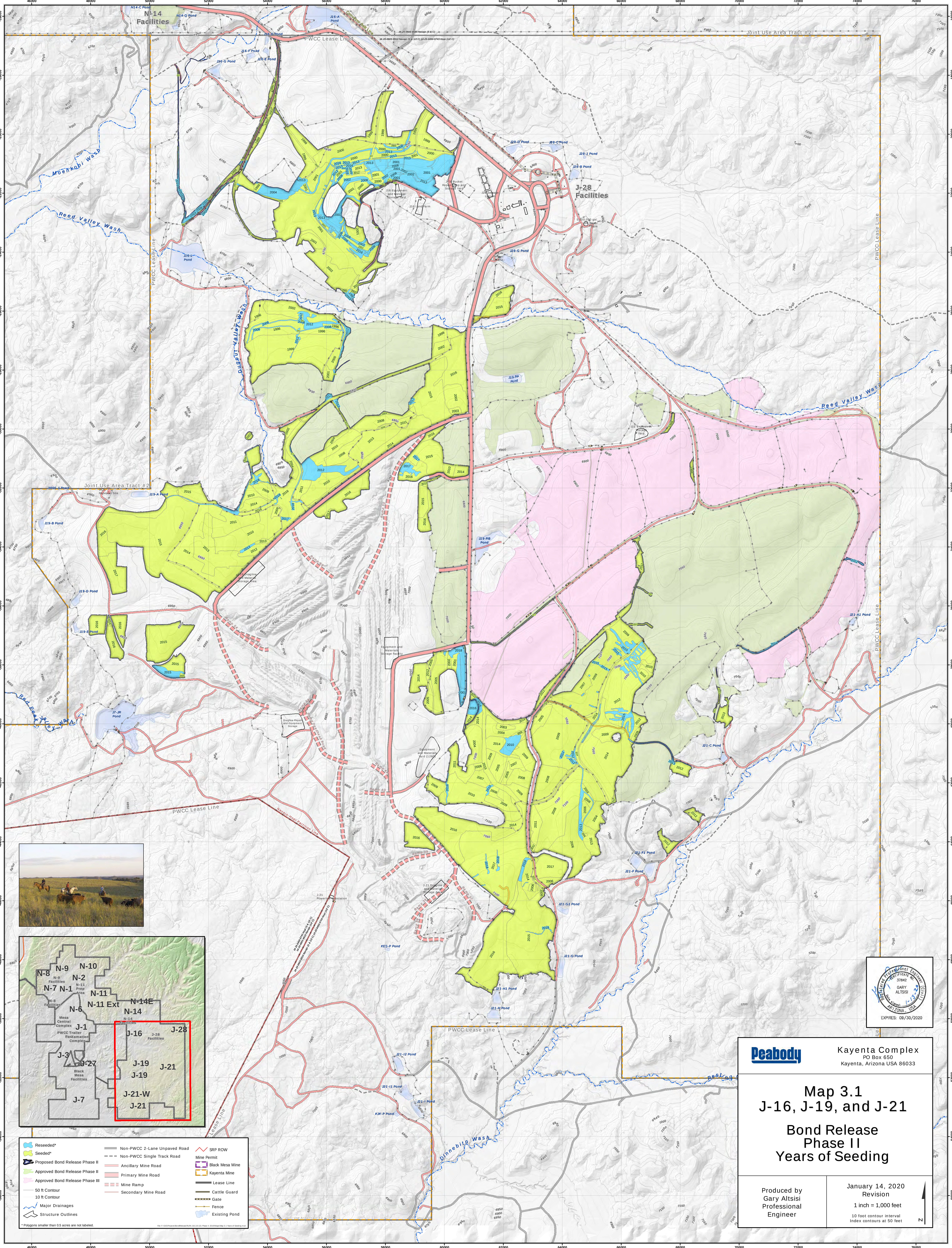
PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd	1st 2nd
SUCCULENTS																				
Coryphantha vivipara	0.00	13.33	0.00	0.00	0.00		P			P										
Opuntia phaeacantha	0.07	60.00	0.25	0.07	0.25	P	P	P		P	P	P	1			P		P		
TOTAL SUCCULENTS	0.07	60.00	0.25	0.07	0.25	P	P	P		P	P	P	1			P		P		
BRYOPHYTES																				
Moss sp.	0.13	13.33	0.49	0.13	0.49					1				1						
TOTAL BRYOPHYTES	0.13	13.33	0.49	0.13	0.49					1				1						
LICHEN/FUNGUS																				
Lichen sp.	1.13	73.33	4.19	1.13	4.19	1	1	3	1			1		3	3	1		1	1	1
TOTAL LICHEN	1.13	73.33	4.19	1.13	4.19	1	1	3	1			1		3	3	1		1	1	1
Standing dead	3.73	93.33		3.73		7	5	3	5	4	2	2	2		3	6	6	3	3	5
Litter	25.67	100.00		25.67		22	31	22	33	22	19	38	26	17	25	25	29	25	27	24
Bare ground	43.53	100.00		43.53		45	35	52	36	52	55	33	42	42	42	49	39	43	40	48
Rock	0.00	0.00		0.00																
TOTALS	100.00		100.00	100.00	100.00	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
TOTAL VEGETATION COVER	27.07	s=(4.99)		27.07	s=(4.99)	26 0	29 0	23 0	26 0	22 0	24 0	27 0	30 0	41 0	30 0	20 0	26 0	29 0	30 0	23 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	56.47	s=(6.59)		56.47	s=(6.59)	55 0	65 0	48 0	64 0	48 0	45 0	67 0	58 0	58 0	58 0	51 0	61 0	57 0	60 0	52 0
SPECIES DENSITY (# of species/100 sq.m.)	13.13	s=(1.88)				15	12	16	15	15	13	14	13	13	11	12	10	13	10	15

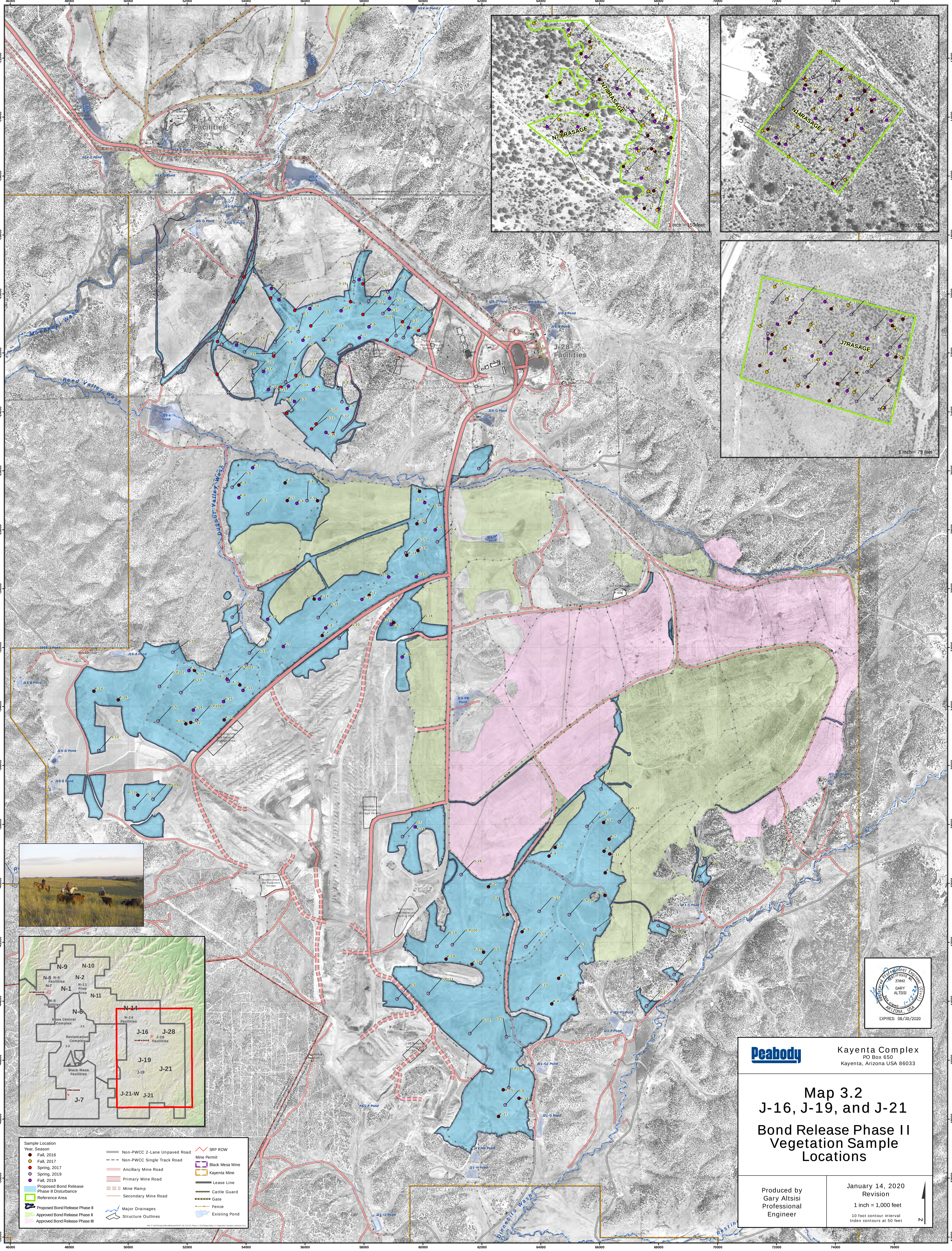
N14 SBRA - Fall 2019

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																			
Gilia pumila	0.00	33.33	0.00	0.00	0.00	P								P				P				P				P									
Machaeranthera canescens	0.00	20.00	0.00	0.00	0.00									P				P								P									
Townsendia annua	0.07	53.33	0.16	0.07	0.15	P				P				P				P				1				P				P				P	
TOTAL NATIVE ANN. & BIEN. FORBS	0.07	53.33	0.16	0.07	0.15	P				P				P				P				1				P				P				P	
NATIVE PERENNIAL FORBS																																			
Calochortus nuttallii	0.00	6.67	0.00	0.00	0.00					P																									
Sphaeralcea coccinea	0.00	33.33	0.00	0.00	0.00			P								P		P								P								P	
TOTAL NATIVE PERENNIAL FORBS	0.00	40.00	0.00	0.00	0.00			P		P						P		P								P								P	
NATIVE PERENNIAL GRASSES (cool)																																			
Oryzopsis hymenoides	0.00	33.33	0.00	0.00	0.00			P				P				P								P								P			
Sitanion hystrix	0.13	40.00	0.31	0.40	0.92			1				P				P	1			P				1	1							P	2		
Stipa comata	0.27	33.33	0.62	0.27	0.61					1				1						P												1		1	
TOTAL NATIVE PERENNIAL GRASSES (c)	0.40	60.00	0.93	0.67	1.53			1		1		P		1		P	1			P				1	1							1	2	1	
NATIVE PERENNIAL GRASSES (warm)																																			
Bouteloua gracilis	18.00	100.00	41.86	18.27	41.90	17		21		11		22	2	15		19	1	15		24		7		20		21		33		13		20	1	12	
TOTAL NATIVE PERENNIAL GRASSES (w)	18.00	100.00	41.86	18.27	41.90	17		21		11		22	2	15		19	1	15		24		7		20		21		33		13		20	1	12	
NATIVE SUBSHRUBS																																			
Ceratoides lanata	0.00	6.67	0.00	0.00	0.00																	P													
Gutierrezia sarothrae	0.60	93.33	1.40	0.60	1.38	P		P		1		P		2		1		P		P		2		2		P		P				1		P	
TOTAL NATIVE SUBSHRUBS	0.60	93.33	1.40	0.60	1.38	P		P		1		P		2		1		P		P		2		2		P		P				1		P	
NATIVE SHRUBS																																			
Artemisia tridentata	21.20	100.00	49.30	21.27	48.78	20		16		27		24		23		21		18		12	1	20		21		33		18		24		19		22	
TOTAL NATIVE SHRUBS	21.20	100.00	49.30	21.27	48.78	20		16		27		24		23		21		18		12	1	20		21		33		18		24		19		22	
NATIVE TREES																																			
Juniperus osteosperma	0.00	20.00	0.00	0.00	0.00																					P				P				P	
Pinus edulis	1.80	100.00	4.19	1.80	4.13	2		4		2		P		1		2		6		3		3		1		P		P		1		1		1	
TOTAL NATIVE TREES	1.80	100.00	4.19	1.80	4.13	2		4		2		P		1		2		6		3		3		1		P		P		1		1		1	
SUCCULENTS																																			
Opuntia polyacantha	0.07	40.00	0.16	0.07	0.15	1		P		P				P		P						P													
TOTAL SUCCULENTS	0.07	40.00	0.16	0.07	0.15	1		P		P				P		P						P													
BRYOPHYTES																																			
Moss spp.	0.07	46.67	0.16	0.07	0.15	P				P				P		1						P								P				P	
TOTAL BRYOPHYTES	0.07	46.67	0.16	0.07	0.15	P				P				P		1						P								P				P	
LICHEN/FUNGUS																																			
Lichen spp.	0.80	73.33	1.86	0.80	1.83	1				P		1		1		2		1		2		P						1		1				2	
TOTAL LICHEN	0.80	73.33	1.86	0.80	1.83	1				P		1		1		2		1		2		P						1		1				2	

N14 SBRA - Fall 2019 (Continued)

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																													
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Standing dead	3.73	100.00		3.73		4		3		3		5		5		5		3		2		3		4		4		4		5		3		3	
Litter	19.53	100.00		19.53		23		12		18		19		15		18		15		22		22		19		26		19		19		21		25	
Bare ground	33.60	100.00		33.60		32		42		37		29		37		30		42		35		42		32		16		25		37		34		34	
Rock	0.13	13.33		0.13				1								1																			
TOTALS	100.00		100.00	100.60	100.00	100	0	100	0	100	0	100	2	100	0	100	2	100	0	100	1	100	0	100	1	100	0	100	0	100	0	100	3	100	0
TOTAL VEGETATION COVER	43.00	s=(5.29)		43.60	s=(5.53)	41	0	42	0	42	0	47	2	43	0	46	2	40	0	41	1	33	0	45	1	54	0	52	0	39	0	42	3	38	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	66.40	s=(6.93)		67.00	s=(7.15)	68	0	58	0	63	0	71	2	63	0	70	2	58	0	65	1	58	0	68	1	84	0	75	0	63	0	66	3	66	0
SPECIES DENSITY (# of species/100 sq.m.)	8.33	s=(1.76)				9		8		10		7		11		10		9		7		10		6		9		5		7		7		10	


Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033
Map 3.1
J-16, J-19, and J-21
Bond Release
Phase II
Years of Seeding
Produced by
Gary Altsisi
Professional
Engineer
January 14, 2020
Revision
1 inch = 1,000 feet
10 foot contour interval
Index contours at 50 feet
N
CERTIFICATE NO.
37842
GARY
ALTSISI
ARIZONA, USA
Date signed: 1-13-20
EXPIRES: 09/30/2020
Reseeded*
Seeded*
Proposed Bond Release Phase II
Approved Bond Release Phase II
Approved Bond Release Phase III
50 ft Contour
10 ft Contour
Major Drainages
Structure Outlines
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road
SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Lease Line
Cattle Guard
Gate
Fence
Existing Pond
* Polygons smaller than 0.5 acres are not labeled.
File: F:\GIS\Projects\BondRelease\RLRA J16 J19 J21 Phase II 2019\Maps\Map 3.1 Years of Seeding.mxd
N-14 Facilities
J-28 Facilities
PWCC Lease Line
Joint Use Area Tract #2
Moenkopi Wash
Reed Valley Wash
Dinnebito Wash
N-8
N-9
N-10
N-7
N-1
N-2
N-11
N-11 Ext
N-6
N-14E
N-14
J-1
J-16
J-28
J-3
J-27
J-19
J-21
J-21-W
J-7


N-14 Facilities
J-28 Facilities
WCC Lease Line
PWCC Lease Line
Reed Valley Wash
Moenkopi Wash
Dinnebito Wash
N7/8RASAGE
N14RASAGE
J7RASAGE
1 inch = 150 feet
1 inch = 100 feet
1 inch = 75 feet
N-9
N-10
N-8
N-2
N-1
N-11
N-6
N-14
J-16
J-28
J-19
J-21
J-21-W
J-7
Black Mesa Facilities
Reclamation Complex
Sample Location
Year, Season
Fall, 2016
Fall, 2017
Spring, 2017
Spring, 2019
Fall, 2019
Proposed Bond Release Phase II Disturbance
Reference Area
Proposed Bond Release Phase II
Approved Bond Release Phase II
Approved Bond Release Phase III
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road
Major Drainages
Structure Outlines
SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Lease Line
Cattle Guard
Gate
Fence
Existing Pond
File: F:\GIS\Projects\BondRelease\RLRA J16 J19 J21 Phase II 2019\Maps\Map 3.2 Vegetation Sample Locations.mxd
Registered Professional Engineer (Civil)
Certificate No. 37842
GARY ALTSISI
Date signed: 1-13-20
ARIZONA, USA
EXPIRES: 09/30/2020
Peabody
Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033
Map 3.2
J-16, J-19, and J-21
Bond Release Phase II
Vegetation Sample Locations
Produced by
Gary Altsisi
Professional Engineer
January 14, 2020
Revision
1 inch = 1,000 feet
10 foot contour interval
Index contours at 50 feet
N

SURFACE WATER MODELING OF THE RECLAIMED J16-E AND J16-F WATERSHED AREA AT KAYENTA MINE

Prepared for

Peabody Western Coal Co.
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

AYRES ASSOCIATES

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Ayres Project No. 32-1304.00
PEAB8-TX.DOC

August 2008

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The objective defined by PWCC for this project is to use a previously calibrated and validated runoff and erosion model (EASI, Zevenbergen et al. 1990; WET 1990) for the Black Mesa and Kayenta Mines to predict mean annual runoff and sediment yields from the reclaimed J16-E and J16-F watersheds. This objective included computation of runoff and sediment yields under premine conditions for the same area. All soils and rainfall input to the model are to be taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site.

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J16-E and J16-F Watershed Area (WA) that is the focus of this project was reclaimed between 1984 and 2002. The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the reclaimed areas above each pond relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved sediment control plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, and where practicable, contour terraces. The natural watersheds on the mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adverse impact on the hydrologic balance.

This section describes the data and procedures used to evaluate the J16 WA. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the J16 WA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds, which correspond to the embankments associated with Ponds J16-E and J16-F. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the premine J16 WA.

1.3 Data

1.3.1 Soils

Soils data used for the current study (J16 WA) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of WA J16 is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of WA J16.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in WA J16 were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J16 WA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and WA J16 of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and the unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J16 WA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

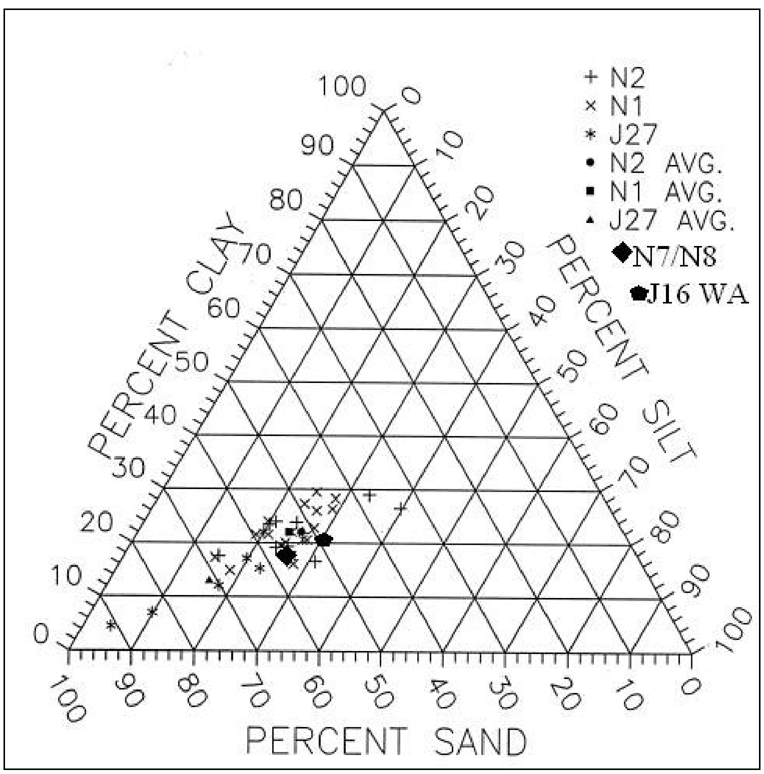

Figure 1.1. Reclaimed area soils trilinear graph.

Table 1.1. Soils Data.			
Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
	Particle Size Distribution (all conditions)		
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simaton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is perhaps a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

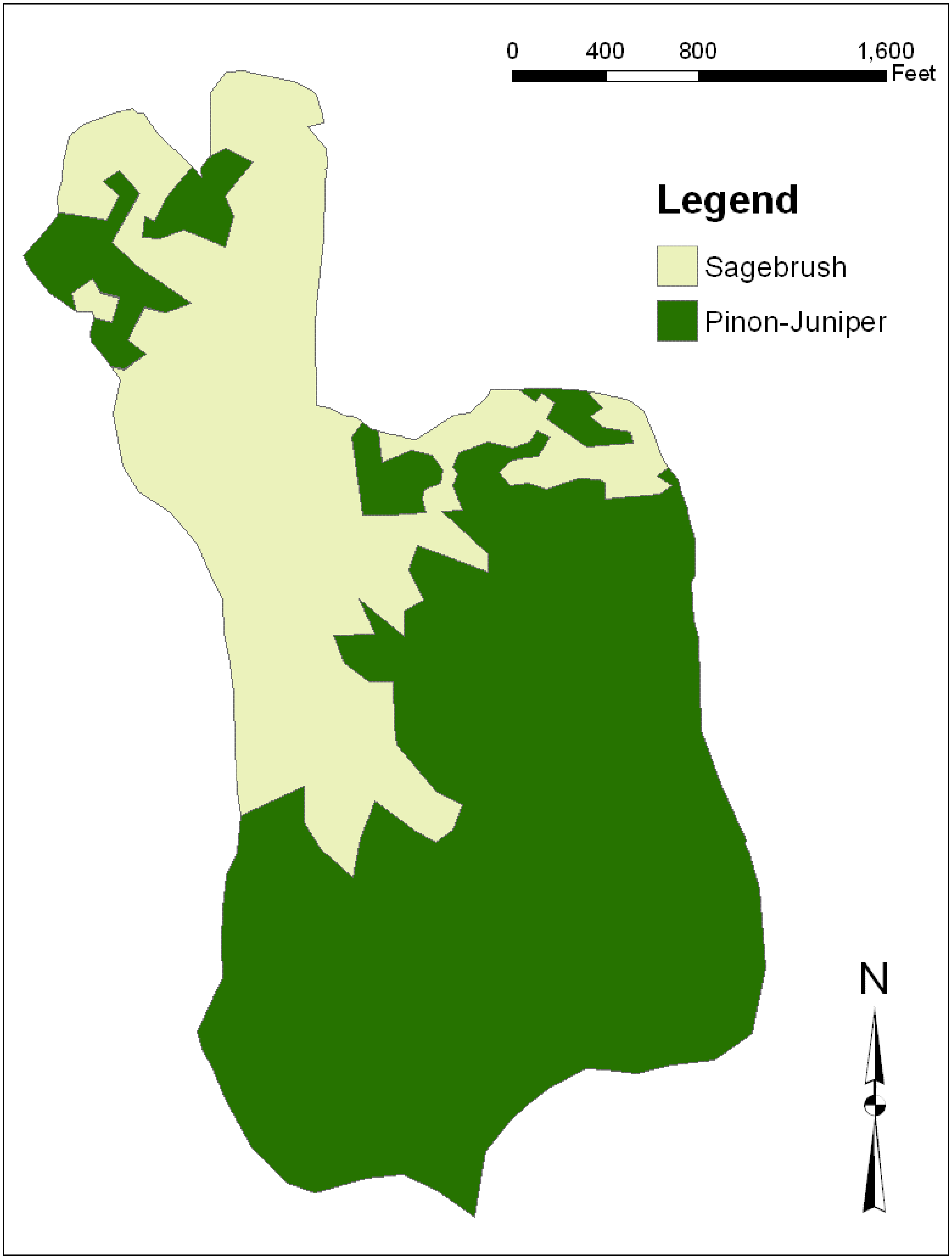

Figure 1.2. Spatial distribution of vegetative cover types for WA J16 premine condition.

Table 1.2. Cover Sampling Data.								
Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	41.9
J16 WA	Postmine	Postmine		0.3	34.7	20.2	6.1	61.0
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J16 WA	Premine	Pinon Juniper		16.8	3.9	28.8	16.7	49.3
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J16 WA	Premine	Sagebrush		1.7	15.5	30.6	1.7	47.8
*Including standing dead litter								

Table 1.3. Cover Data for J16-E and J16-F Watersheds.				
Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	16.8	1.7	9.3	0.3
Ground cover, %	49.3	47.8	48.5	61
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Black Mesa Mining Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Black Mesa Mining Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (Resource Consultants and Engineers 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in WA J16 were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to model extents for both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J16 WA dictated that some small areas would be included or excluded from the modeling. The total area modeled (combined area for both J16-E and J16-F watersheds) for premine conditions is 179.2 acres and for postmine conditions is 148.5 acres. The difference in area results from the sediment ponds in postmine conditions and the extension of J16F's premine basin. The area bounded by the disturbance limits identified by PWCC as shown in Exhibit 1 is 150.2 acres.

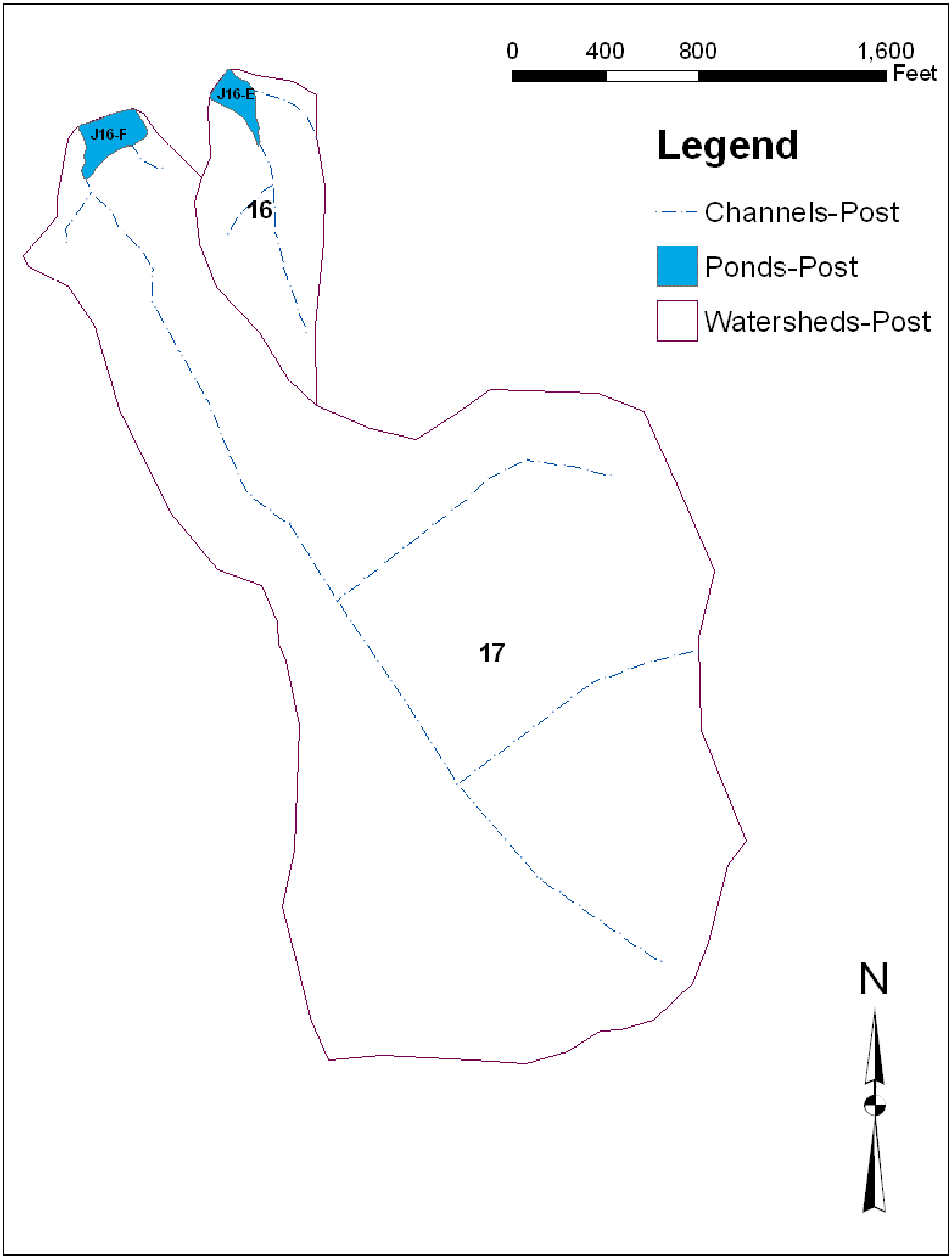

Figure 1.3. J16-E and J16-F postmine basins.

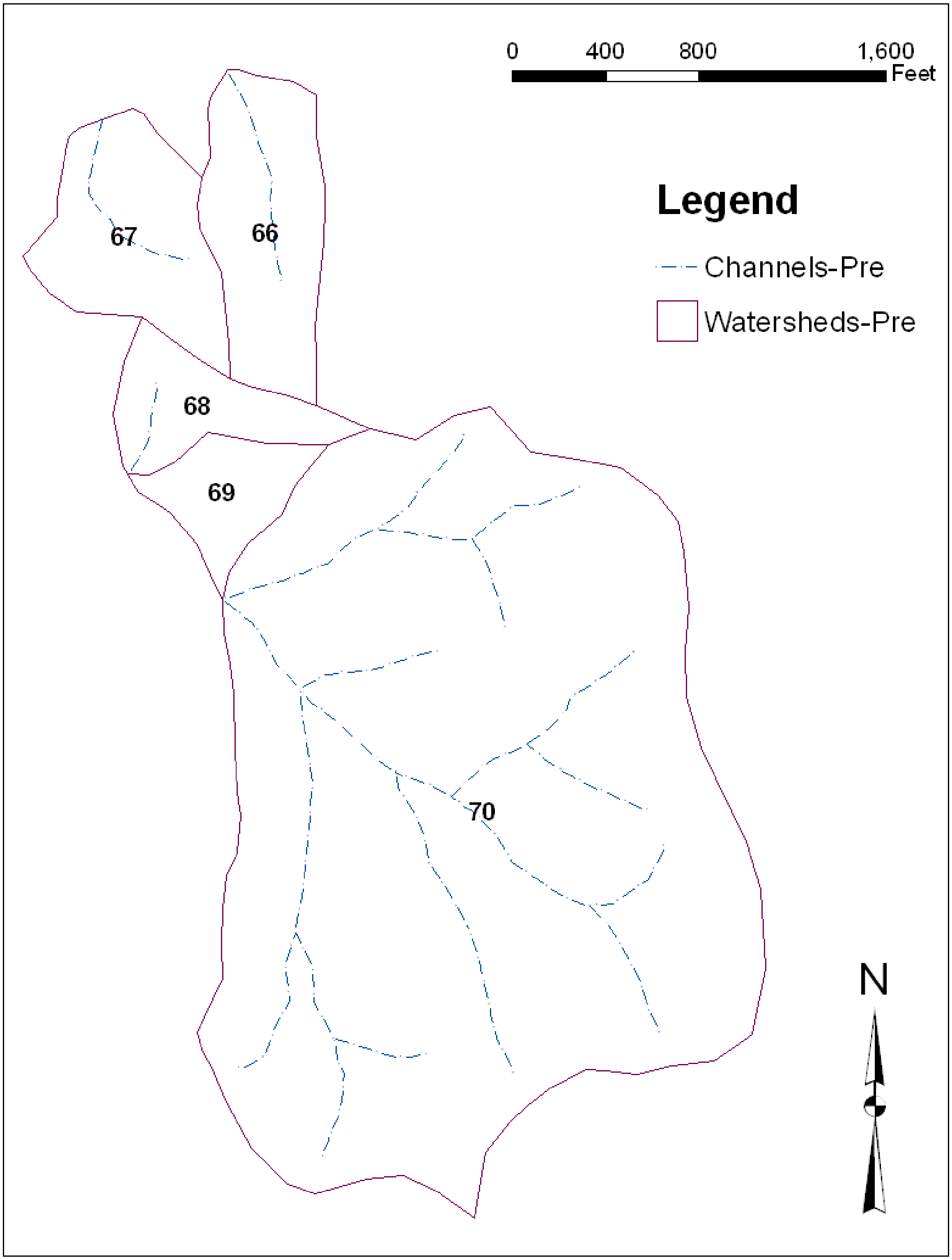

Figure 1.4. J16-E and J16-F premine basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average basis for the WA. **Table 1.4** shows pre- and postmine drainage area, runoff, and sediment yield for the J16 WA. Runoff is defined as the total volume of water leaving the WA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there are no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. No ponds or significant depressions exist within the reclaimed J16 WA that was modeled. Similarly, the sediment yield is the amount of eroded material that leaves the WA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

Table 1.4. Average Runoff and Sediment Yield Results.

Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)
J16 WA	Premine	179.2	0.42	2.28
J16 WA	Postmine	148.5	0.42	1.14
J16-E	Premine	13.8	0.42	1.50
J16-E	Postmine	11.9	0.42	1.07
J16-F	Premine	165.4	0.42	2.34
J16-F	Postmine	136.6	0.42	1.15

For the postmine condition, the overall sediment yield is less than those in the premine condition. Sediment yield is approximately one-half of the premine amount, and runoff is the same as the premine amount. The reduction of sediment yield is primarily due to the channel erosion control measures (BMP’s) for the postmine condition.

Table 1.4 also shows pre- and postmine drainage area, runoff, and sediment yield for two individual watersheds (J16-E and J16-F) within the J16 WA. Modeling results of individual watersheds are similar to the overall J16 WA.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine disturbed areas. Premine hillslopes are generally longer than postmine hillslopes, and postmine channels are not as steep as premine channels. The drainage density of the postmine condition is smaller than that of the premine condition, because the postmine topography has simple geometric characteristics and the premine topography is highly dissected.

Table 1.5. Average Physical Properties of the J16 WA.

	Premine	Postmine
Total Area (ac)	179.2	148.5
Total Channel Length (ft)	14773	8715
Mean Channel Slope	0.0733	0.0594
Drainage Density (mi/mi^2)	10.0	7.1
Mean Hillslope Length (ft)	257	248
Mean Hillslope Gradient	0.1354	0.0702

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, WA J16's modeled unmined (premine) and modeled reclaimed (postmine) data. Although there is significant scatter shown in the data (as is expected with any sediment transport conditions), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from WA J16's pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50-, and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (Figure 2.1) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (Figure 2.2) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered on 100 cfs and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From Figures 2.1 and 2.2 it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the WA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in Table 1.4.

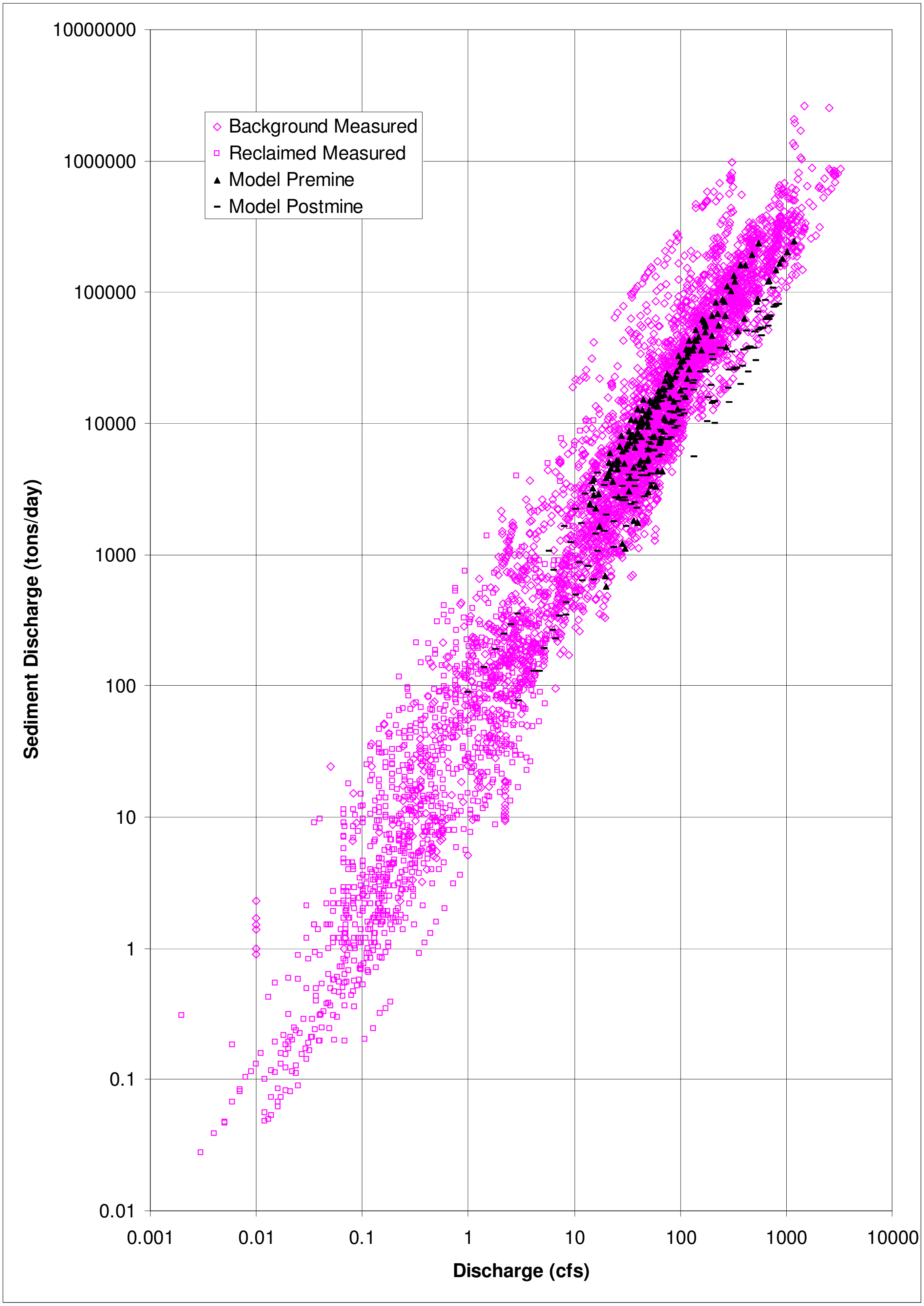

Figure 2.1. Observed and modeled sediment and water discharge.

Figure 2.2. Observed versus modeled sediment concentration and discharge.

However, the sediment yield shown in Table 1.4 is the average annual amount of sediment leaving the J16 WA whereas the sediment discharge shown in Figure 2.1 is the peak rate of sediment in transport occurring in any channel represented by the data, whether the channel is located upstream or downstream of a pond. Therefore, it should be concluded that with or without a pond left in the postmine landscape that traps sediment or stores water, the mine reclamation is not contributing additional sediment to the receiving streams and sediment impacts to the prevailing hydrologic balance have been minimized.

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in Figure 2.1 to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

They then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the J16 WA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (Figure 2.5) shows the data grouped around the Sen line and well within the bounds. The postmine data (Figure 2.6) plot most densely below the Sen line and are more scattered. On these graphs data plotting below the lines indicate that there is less sediment in transport for a given discharge. The lower sediment transport rates in the reclaimed data is probably the result of low gradient channels while low gradient channels in the premine condition are rare.

Several conclusions can be drawn from these data plots: (1) EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the WA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in J16 WA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

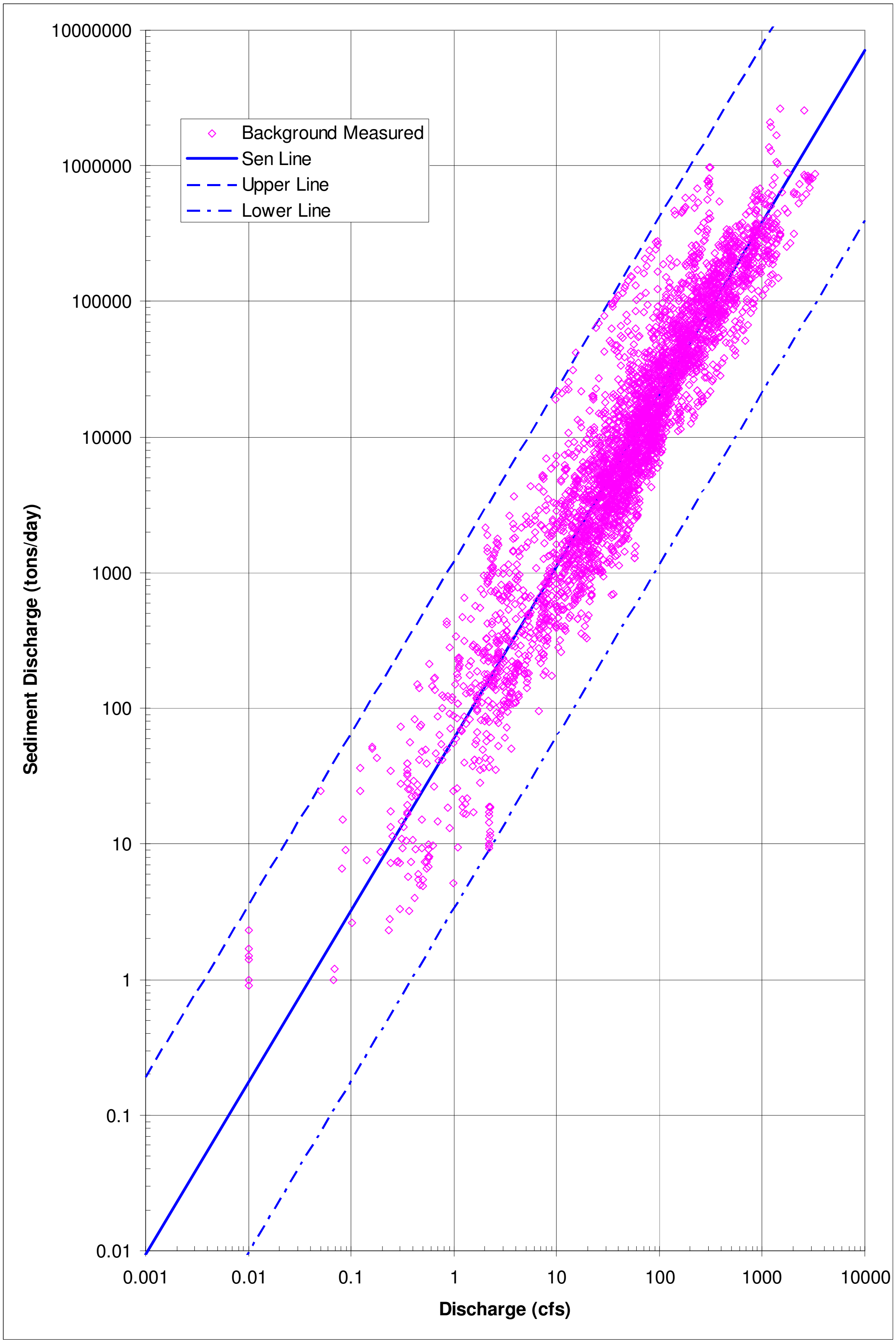

Figure 2.3. Background measured sediment and water discharge with Sen lines.

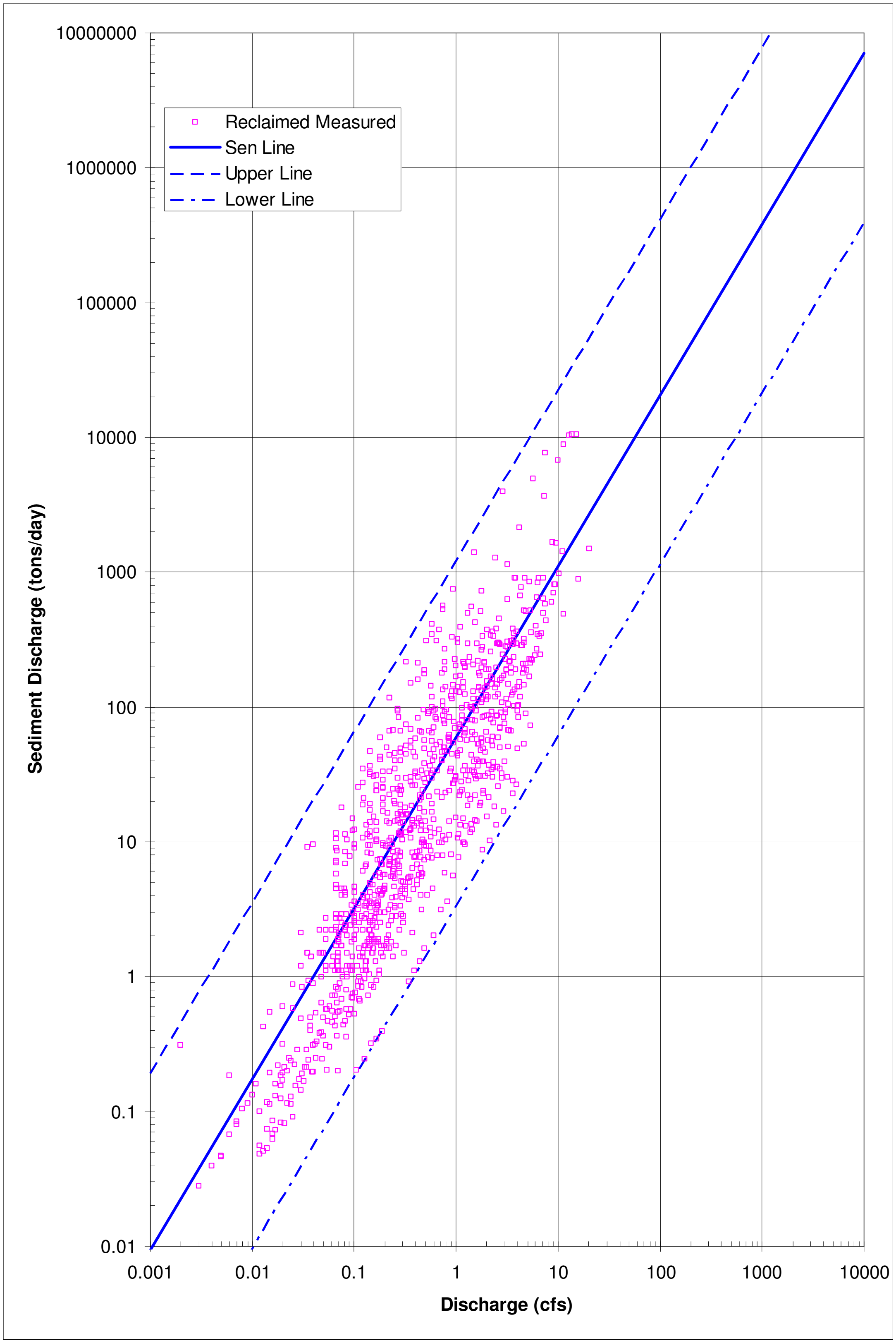

Figure 2.4. Reclaimed measured sediment and water discharge with Sen lines.

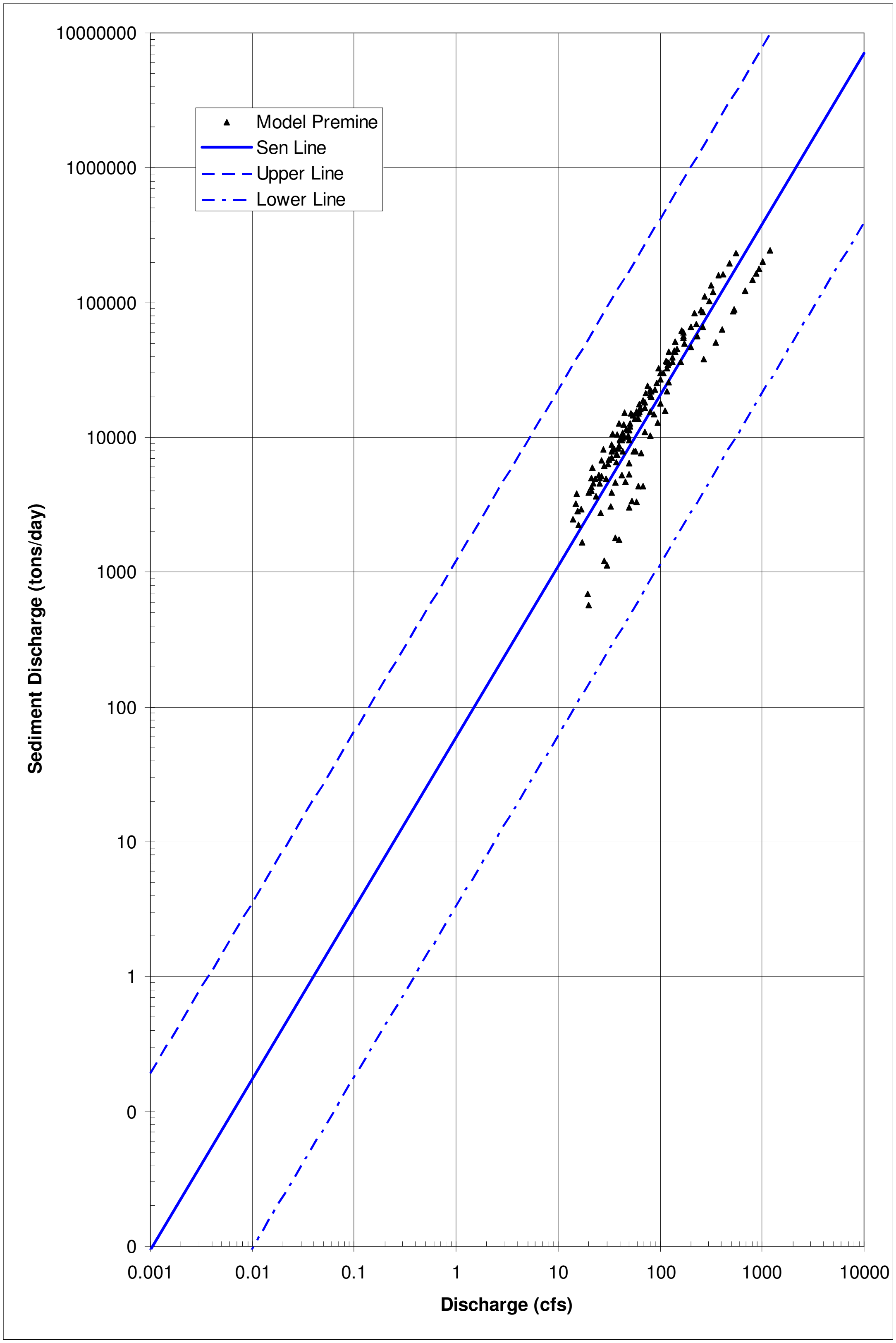

Figure 2.5. Modeled premine sediment and water discharge for the J16 WA with Sen lines.

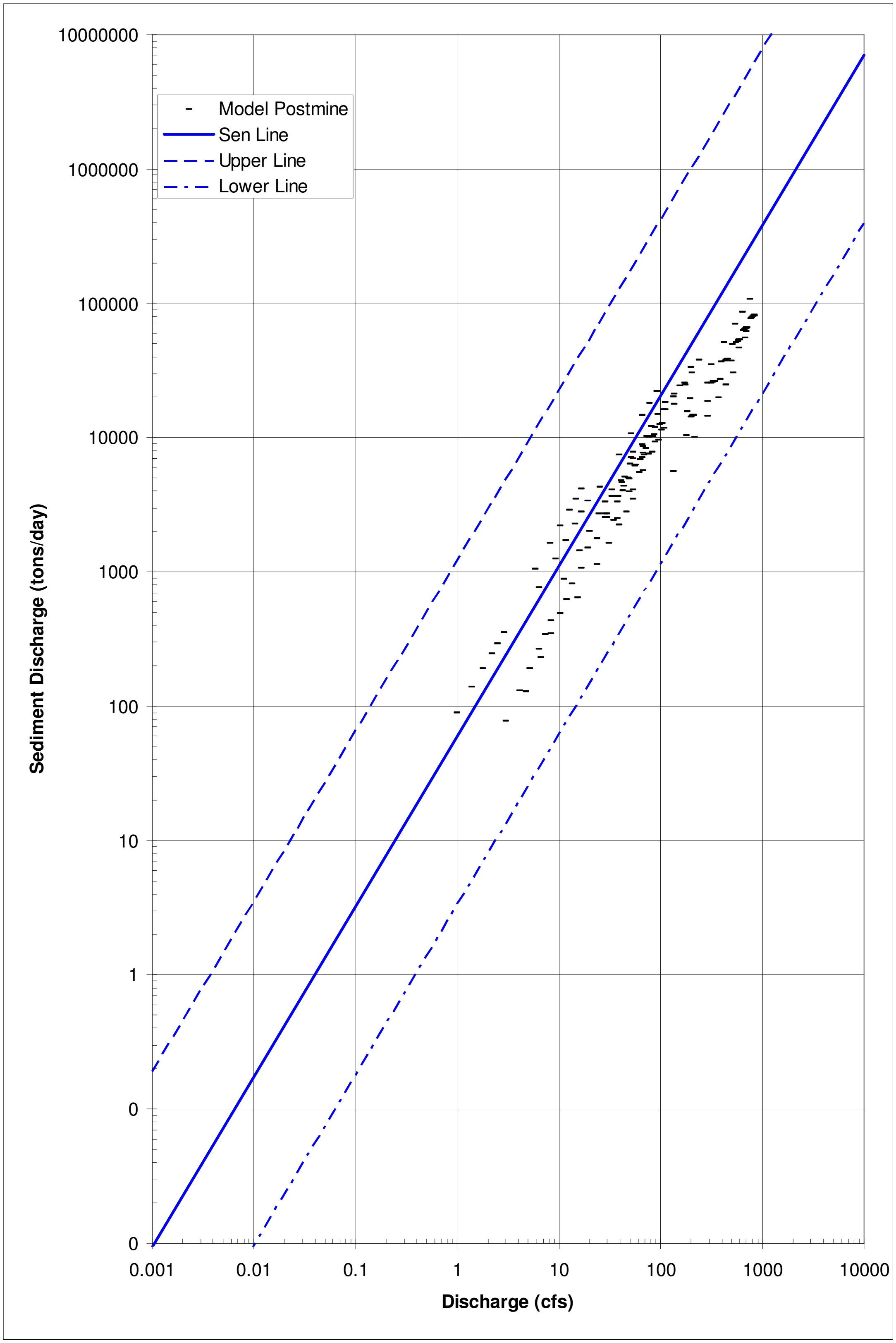

Figure 2.6. Modeled postmine sediment and water discharge for the J16 WA with Sen lines.

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EXHIBIT 1
Postmine Topography

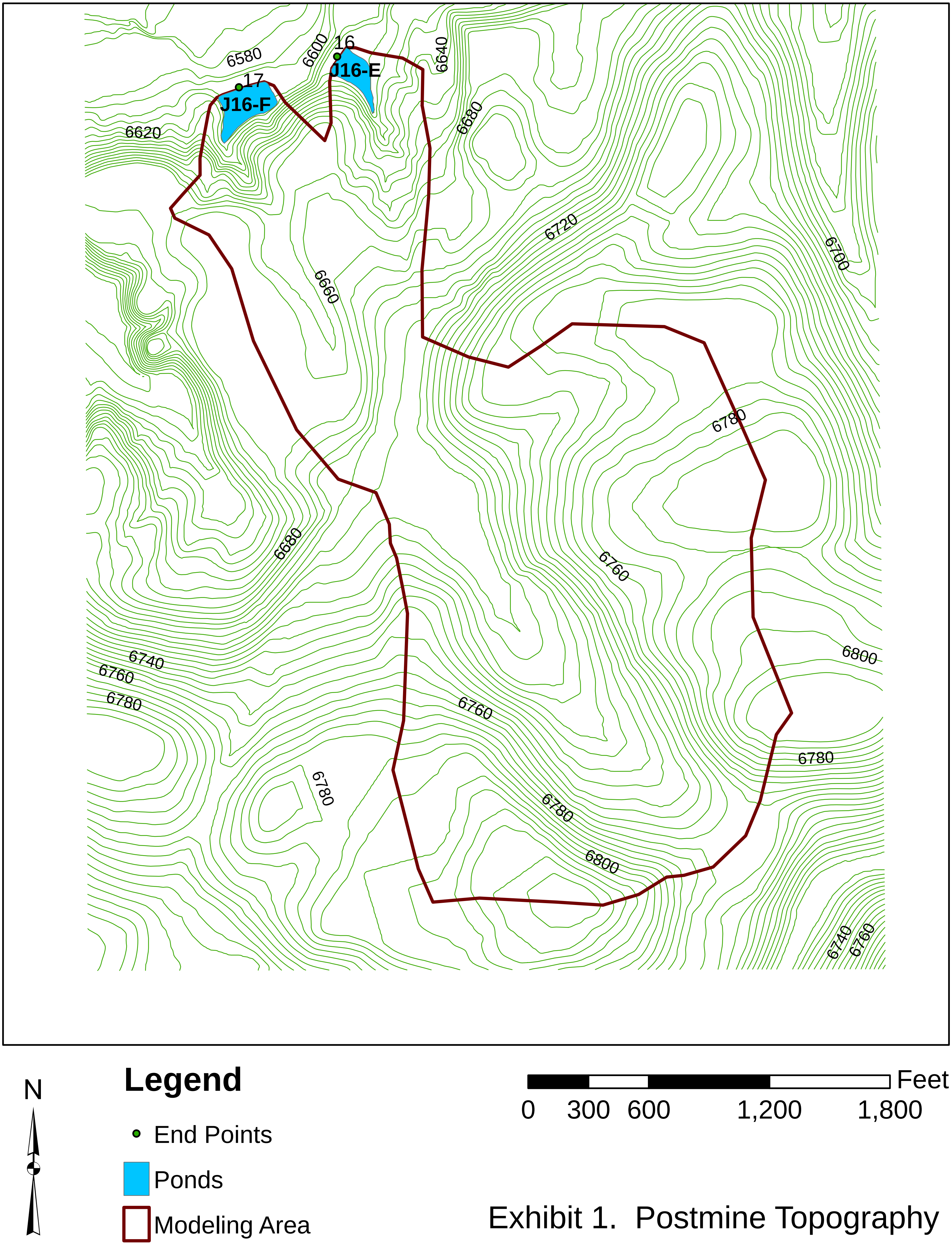
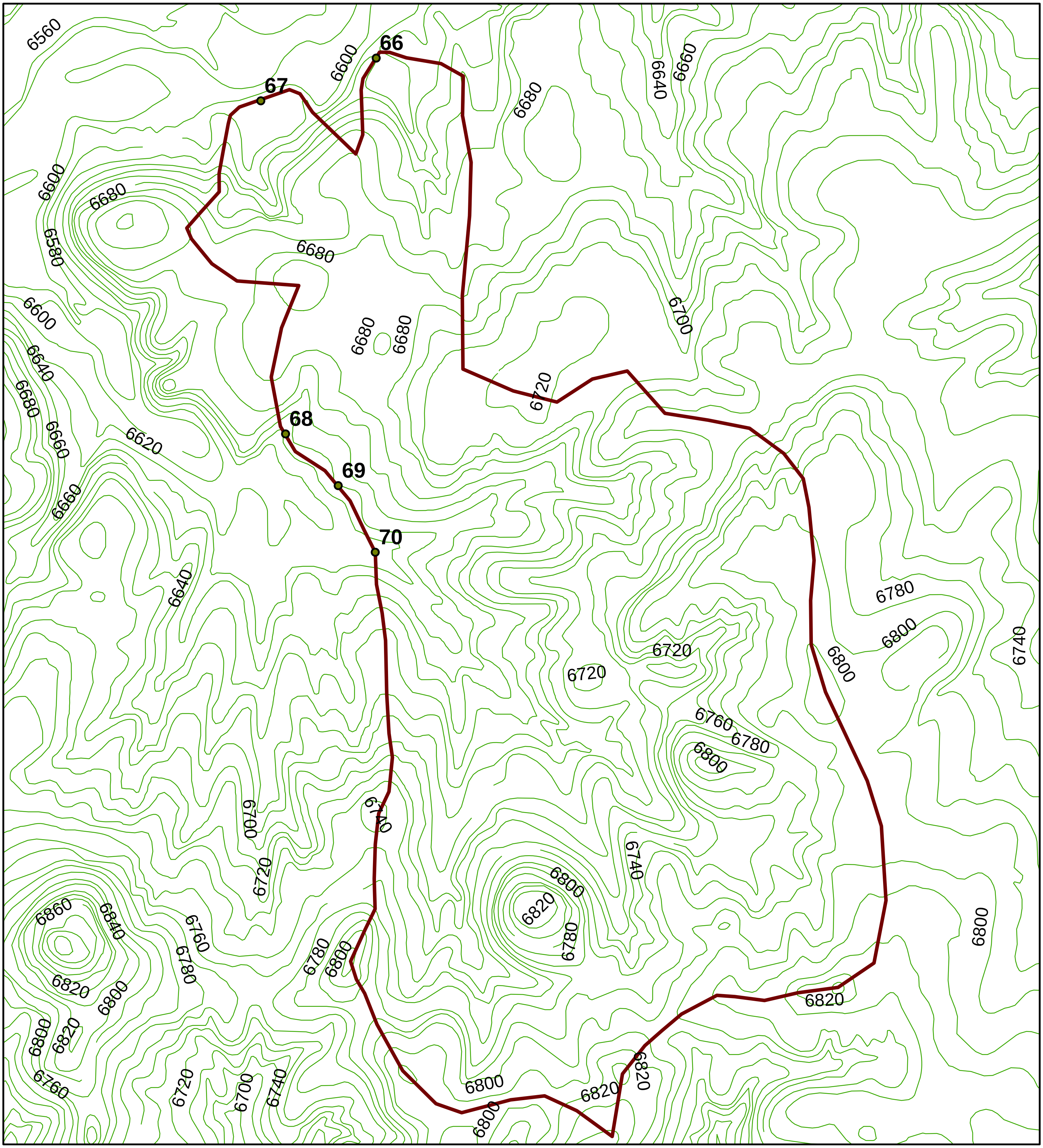


Exhibit 1. Postmine Topography

EXHIBIT 2
Premine Topography



N

Feet
0 300 600 1,200 1,800

Legend

End Points

Modeling Area

Exhibit 2. Premine Topography

SURFACE WATER MODELING OF RECLAIMED PARCELS AT THE J19 COAL RESOURCE AREA, KAYENTA COMPLEX

Peabody Western Coal Company
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

SURFACE WATER MODELING OF RECLAIMED PARCELS AT THE J19 COAL RESOURCE AREA, KAYENTA COMPLEX

Peabody Western Coal Co.
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

PEABODY WESTERN

September 2011

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The purpose of this project is to use a previously calibrated and validated runoff and erosion model EASI - Erosion And Sediment Impacts (Zevenbergen et al. 1990; WET 1990) for the Kayenta Complex (previously identified as the Black Mesa and Kayenta Mines) to predict mean annual runoff and sediment yields from the reclaimed parcel J19. The objective of this project included computation of runoff and sediment yields under premine conditions for the same area. The response of the reclaimed parcels was evaluated relative to undisturbed (premine) conditions in the corresponding undisturbed watersheds. All soils and rainfall input to the model were taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site. The model serves as a tool for assessing the success of reclamation efforts to protect the hydrologic balance (30 CFR 715.17 and 30 CFR 816.41).

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J19 Coal Resource Area (CRA) at the Kayenta Complex that is the focus of this project was reclaimed between 1989 and 2010. This reclaimed area is now eligible for Phase II Bond Release from the Office of Surface Mining Reclamation and Enforcement (OSM). The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the current conditions of reclaimed areas relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved reclamation plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, rock down drains, and where practicable, contour terraces. The natural watersheds on Black Mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adversely impacting the hydrologic balance.

The next sections describe the data and procedures used to evaluate the J19 CRA. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities and maturation of the reclaimed area vegetation taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the CRA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the J19 premining watersheds.

1.3 Data

1.3.1 Soils

Soils data used for the current study (CRA J19) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of CRA J19 is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of CRA J19.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in CRA J19 were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J19 CRA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and CRA J19 of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and any unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J19 CRA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simanton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

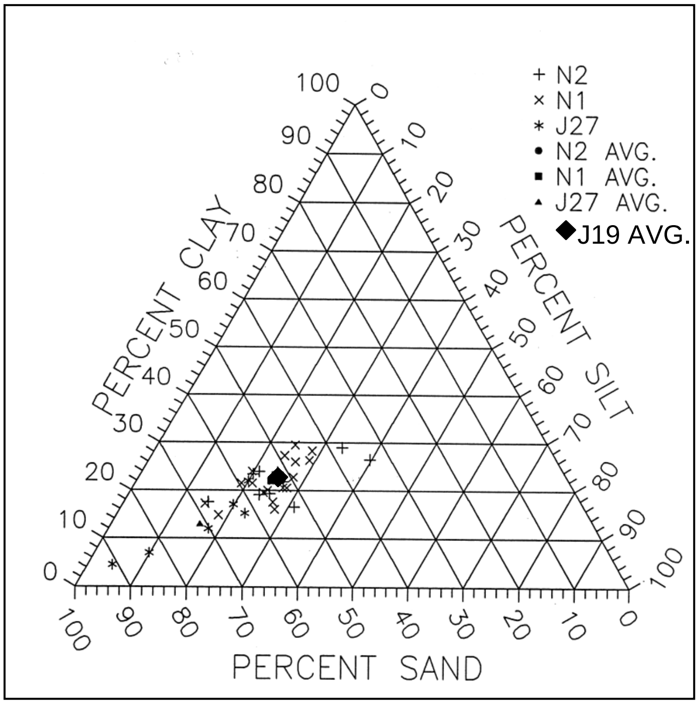

Figure 1.1. Reclaimed Area Soils Trilinear Graph.

Table 1.1. Soils Data.			
Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
	Particle Size Distribution (all conditions)		
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

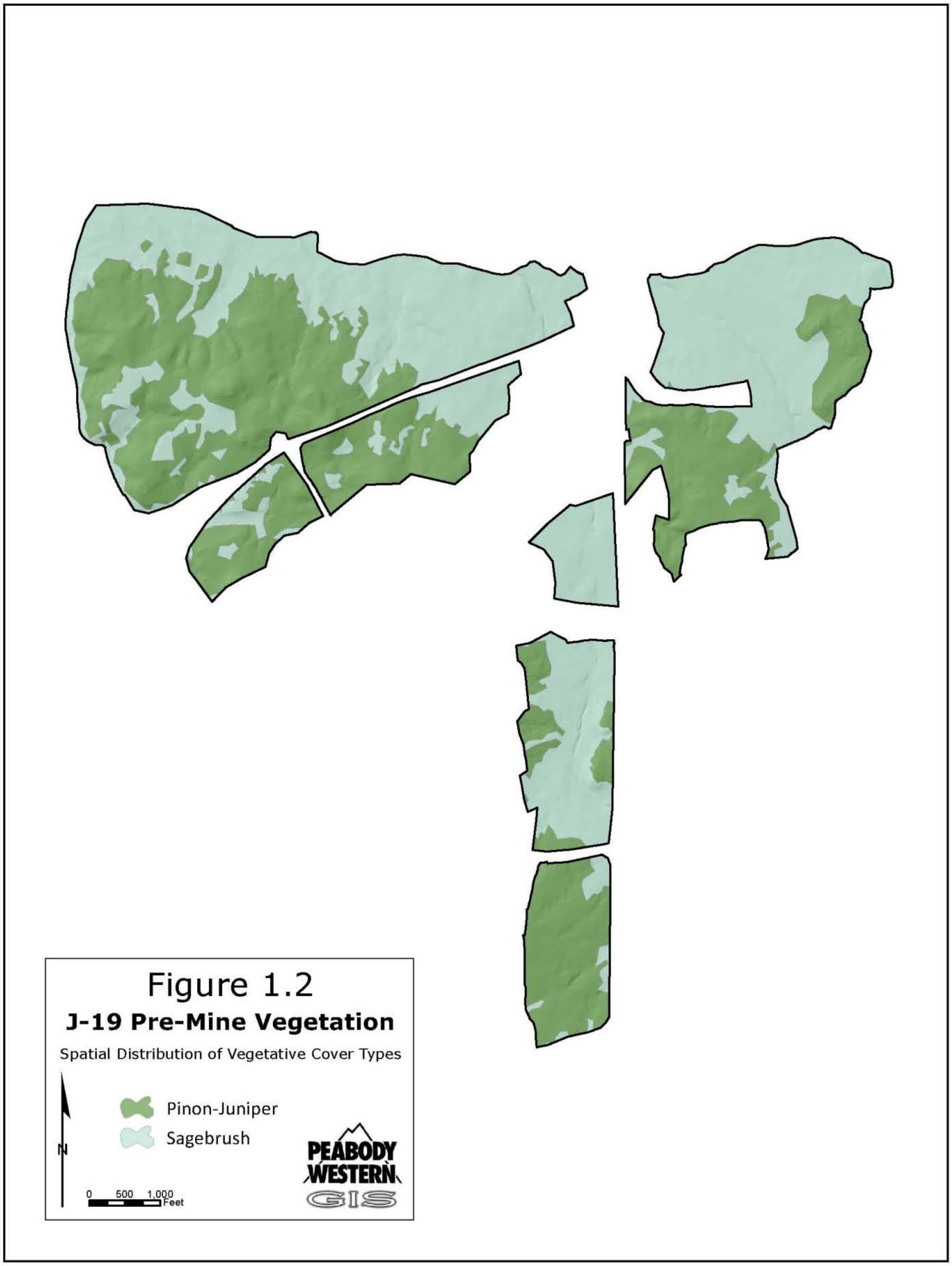

Figure 1.2. Spatial Distribution of Vegetative Cover Types for J19 Pre-Mine Condition.

Table 1.2. Cover Sampling Data.								
Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	42.0
J19	Postmine	Postmine	28.8	0.2	31.3	17.9	6.6	55.8
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J19	Premine	Pinon Juniper	19.1	17.0	2.5	28.8	16.7	48.0
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J19	Premine	Sagebrush	16.7	3.8	13.4	30.6	1.7	45.7
*Including standing dead litter								

Table 1.3. Cover Data for J19.				
Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	17.0	3.8	10.4	0.2
Ground cover, %	48.0	45.7	46.9	55.8
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Kayenta Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Kayenta Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (RCE 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in CRA J19 were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to define the extent of both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J19 CRA dictated that some areas would be included or excluded from the modeling. The total area modeled for premine conditions is 943.4 acres (Exhibit 2) and for postmine conditions is 943.4 acres (Exhibit 1).

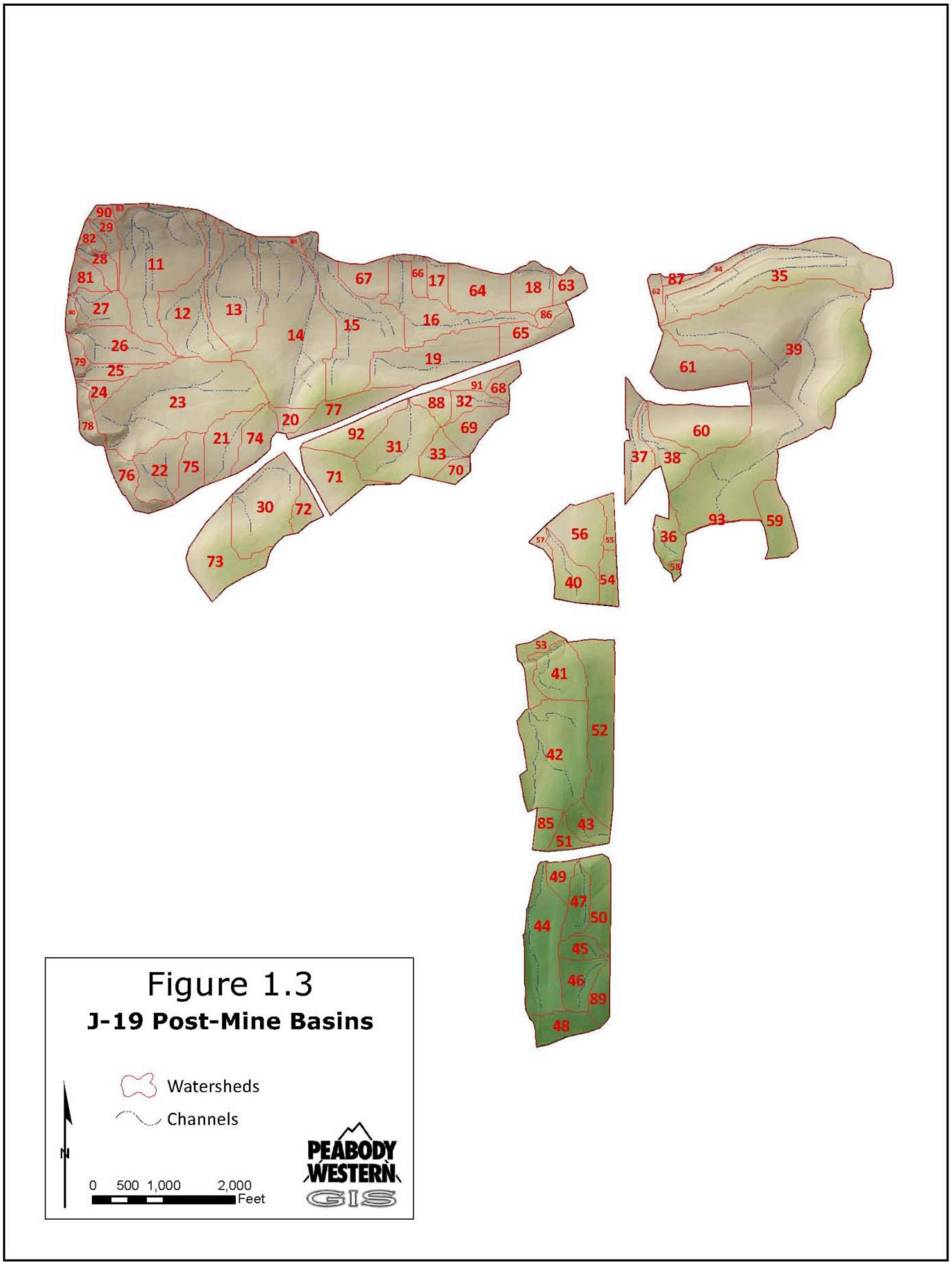

Figure 1.3. J19 Post-Mine Basins.

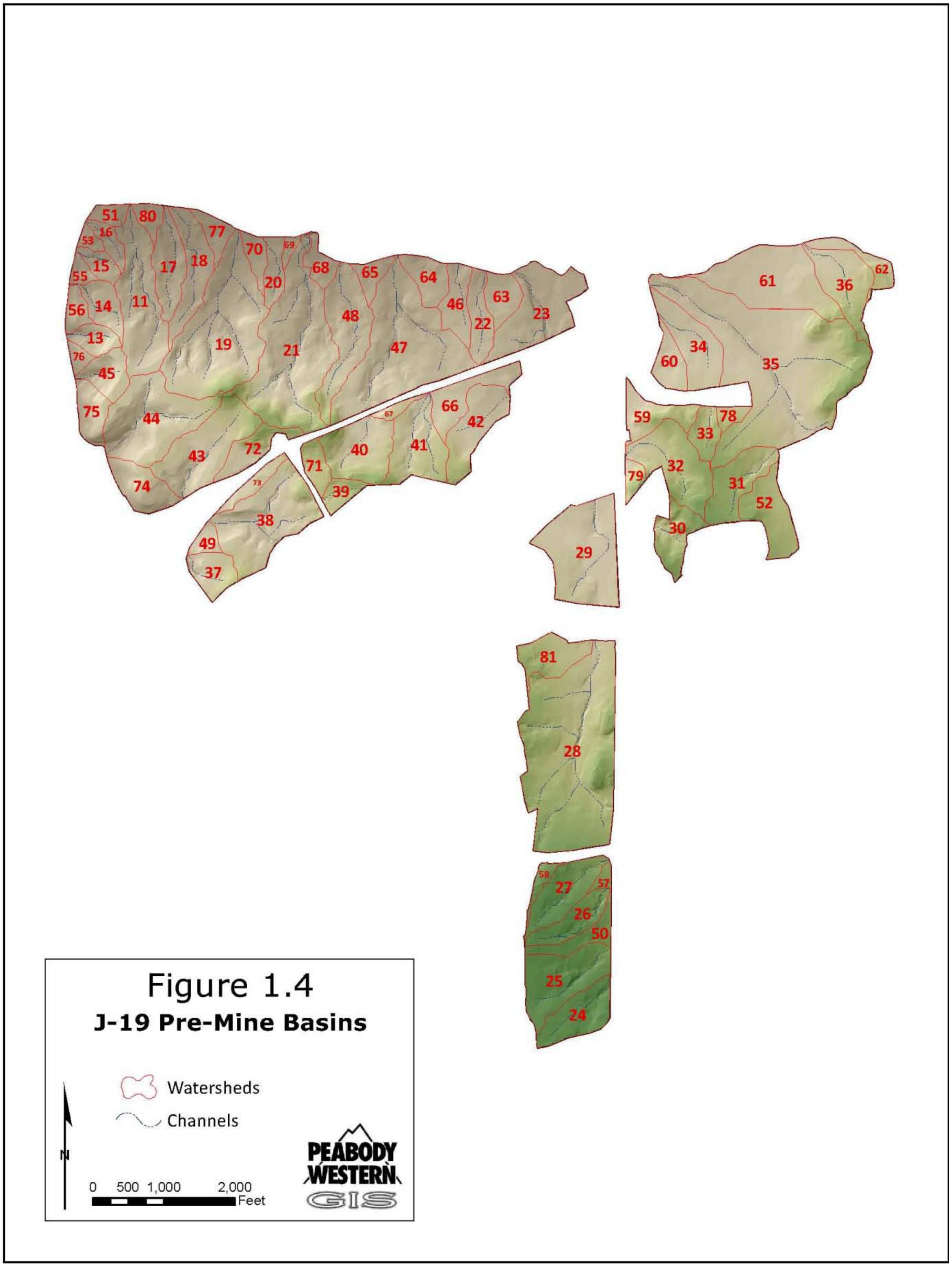

Figure 1.4. J19 Pre-Mine Basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average annual basis for the CRA. **Table 1.4** shows pre- and postmine drainage area, runoff, sediment yield, and erosion for the J19 CRA. Runoff is defined as the total volume of water leaving the CRA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there were no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. Similarly, the sediment yield is the amount of eroded material that leaves the CRA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope and subwatershed areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

For the postmine condition, sediment yield is substantially less than the premine condition. Postmining sediment yield is approximately 71% of the premine amount. Runoff is the same as the premine amount for the J19 CRA. Hillslope and subwatershed erosion rates are about 9% higher for the reclaimed (postmine) condition than the premine condition. However, the erosion rates are comparable between both conditions, and remain below 1.0 tons/acre/year. The reduction of sediment yield is due to effective hydrologic cover combined with effective channel erosion control measures in the postmining landscape.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine topographies for the J19 CRA. Postmine hillslopes are generally about 15% shorter and 7% steeper than premine hillslopes, postmine channels are slightly less steep than premine channels, and the drainage density of the postmine condition is about 13% greater than that of the premine condition. These properties agree with the postmine versus premine topography: the premine topography is fully dissected.

Table 1.4. Average Runoff and Sediment Yield Results.					
Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)	Erosion (t/ac/yr)
J19	Premine	943.4	0.42	3.13	0.75
J19	Postmine	943.4	0.42	2.22	0.82

Table 1.5. Average Physical Properties of the J19 CRA.		
	Premine	Postmine
Total Area (ac)	943.4	943.4
Total Channel Length (ft)	70,077	79,298
Mean Channel Slope	0.0662	0.0653
Drainage Density (mi/mi^2)	9.0	10.2
Mean Hillslope Length (ft)	243	206
Mean Hillslope Gradient	0.1115	0.1197

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

2.1 Sediment Discharge and Concentration

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, modeled unmined (J19 premine) and modeled reclaimed (J19 postmine) data. Although there is significant scatter shown in the data (as is expected with sediment transport), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 cfs and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from the J19 CRA pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50- and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (**Figure 2.1**) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (**Figure 2.2**) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered between 10 and 100 cfs and between 10,000 and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From **Figures 2.1 and 2.2** it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the CRA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in **Table 1.4**.

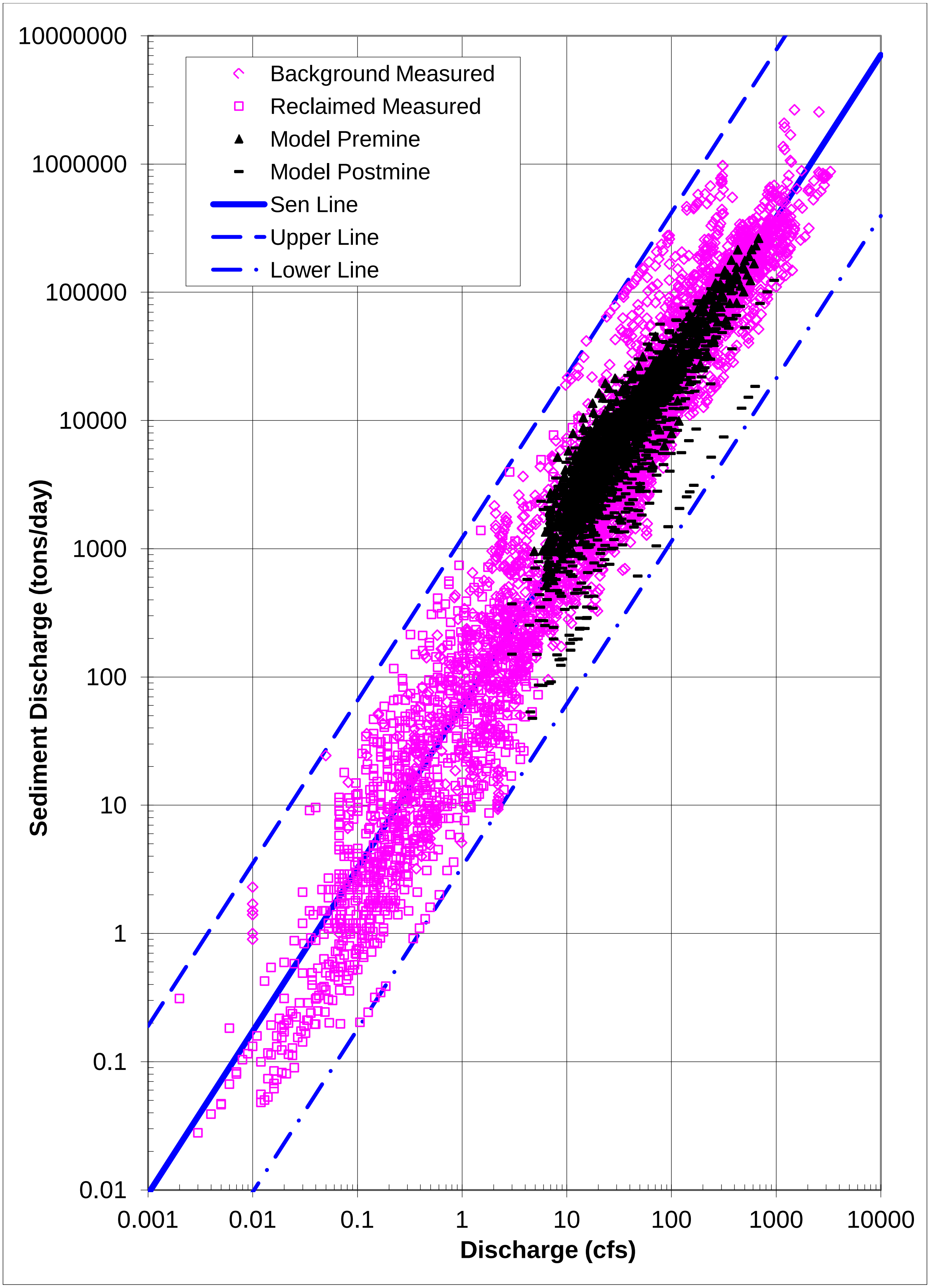

Figure 2.1. Observed and Modeled Sediment Discharge and Water Discharge.

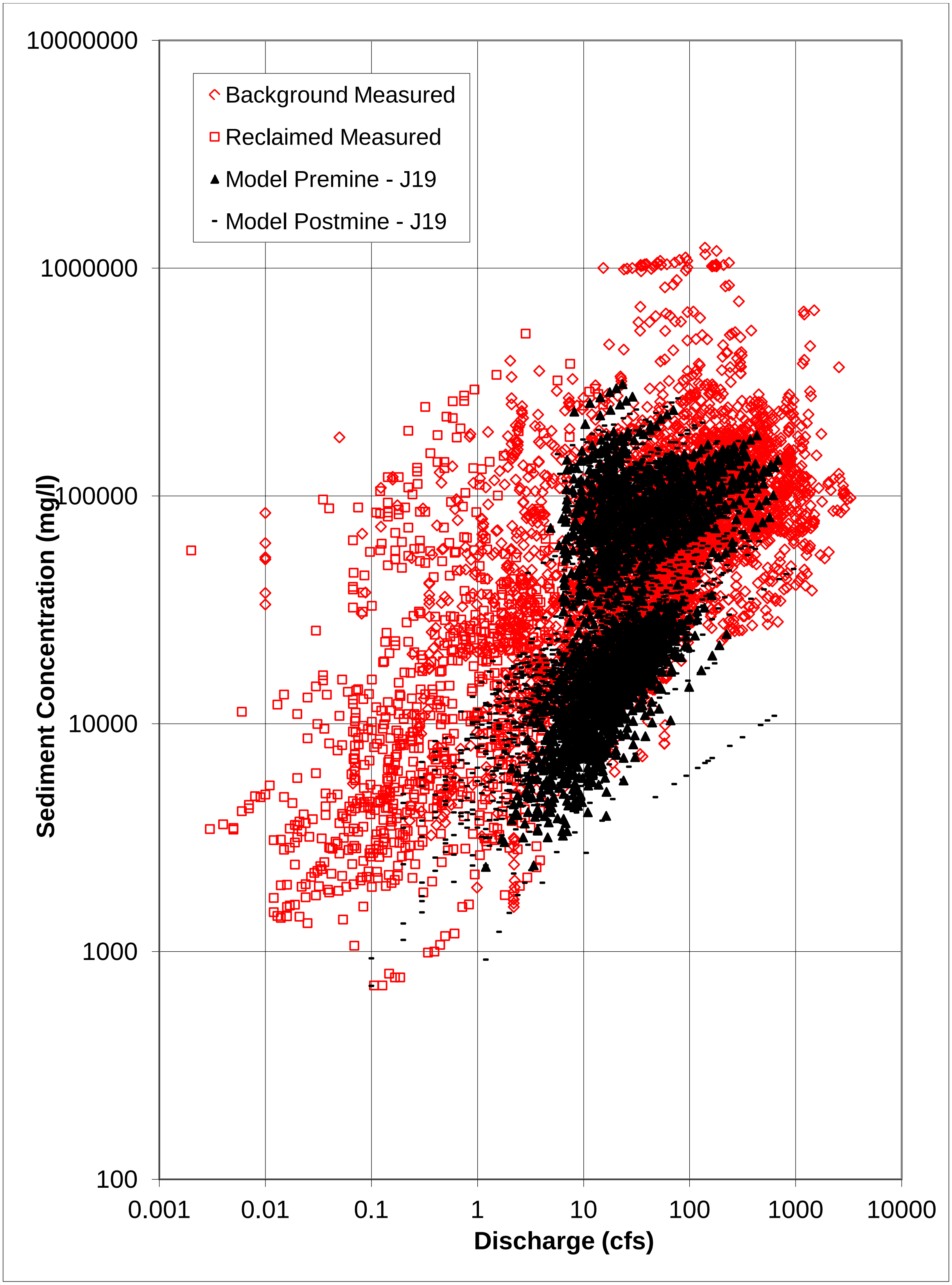

Figure 2.2. Observed versus Modeled Sediment Concentration and Discharge.

However, the sediment yield shown in **Table 1.4** is the amount of sediment leaving the CRA whereas the sediment discharge shown in **Figure 2.1** is the peak rate of sediment in transport occurring in any channel on the CRA, whether the channel is located upstream or downstream of a pond. Therefore, with or without the ponds trapping sediment or storing water, the mine reclamation is not contributing additional sediment to the receiving streams, and sediment impacts to the prevailing hydrologic balance have been minimized.

2.2 Statistical Analysis

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in **Figure 2.1** to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

Smith and Best then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the J19 CRA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds, respectively. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (**Figure 2.5**) shows the data grouped densely around the Sen line and well within the bounds. The postmine data (**Figure 2.6**) also plot closely around the Sen line and well within bounds.

2.3 Conclusions

Several conclusions can be drawn from these data plots: (1) the EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the CRA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in the J19 CRA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

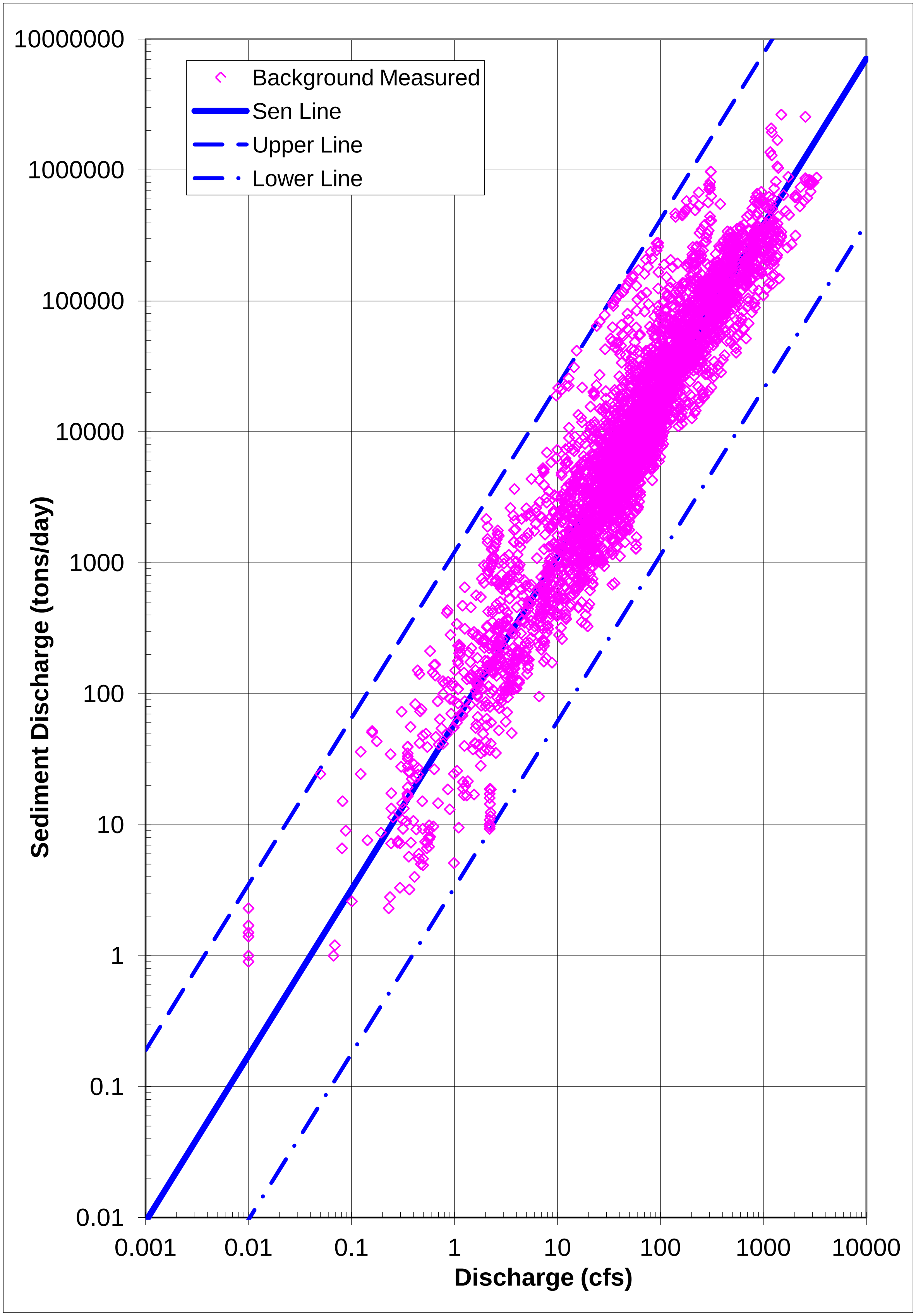

Figure 2.3. Background Measured Sediment and Water Discharge.

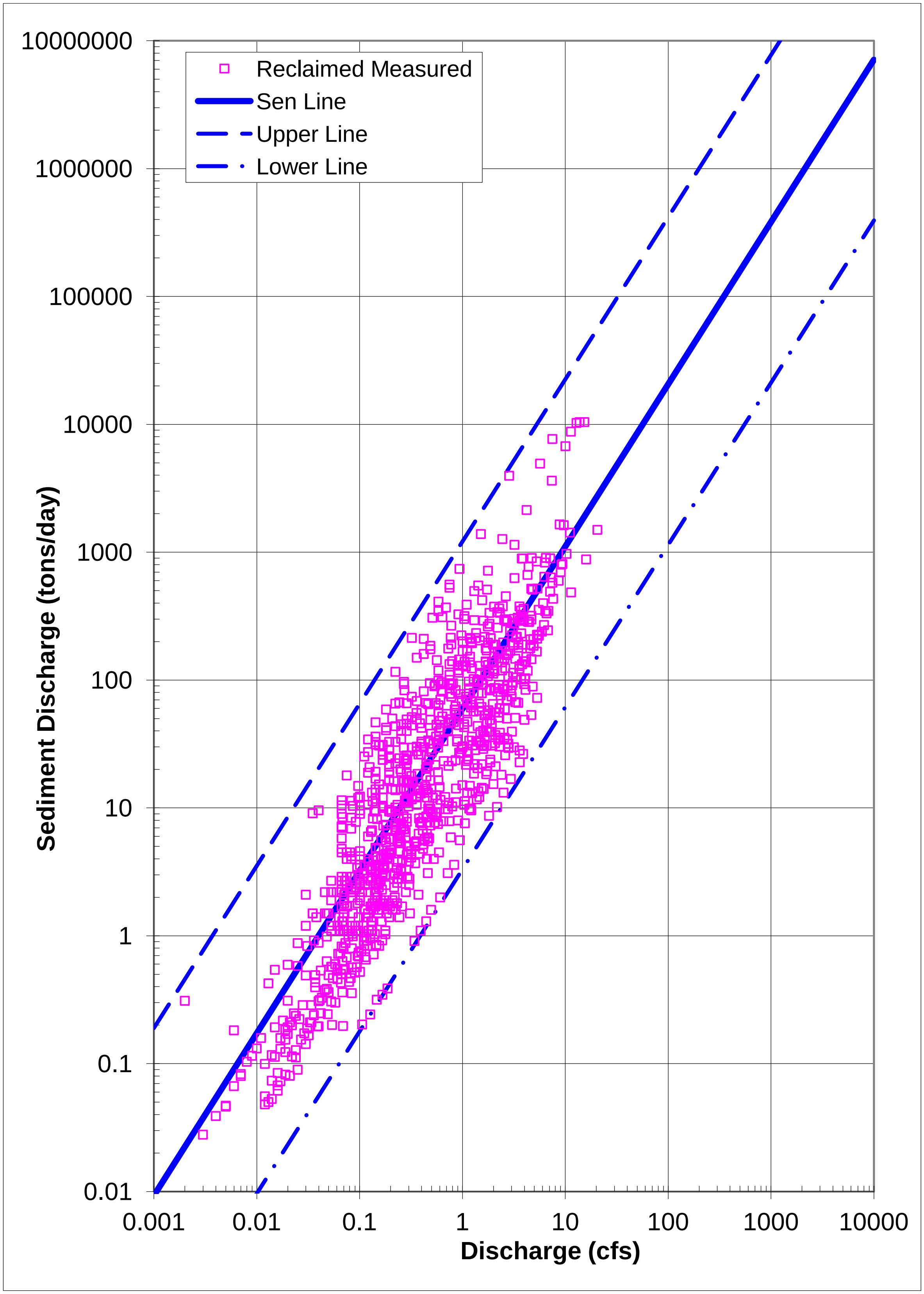

Figure 2.4. Reclaimed Measured Sediment and Water Discharge.

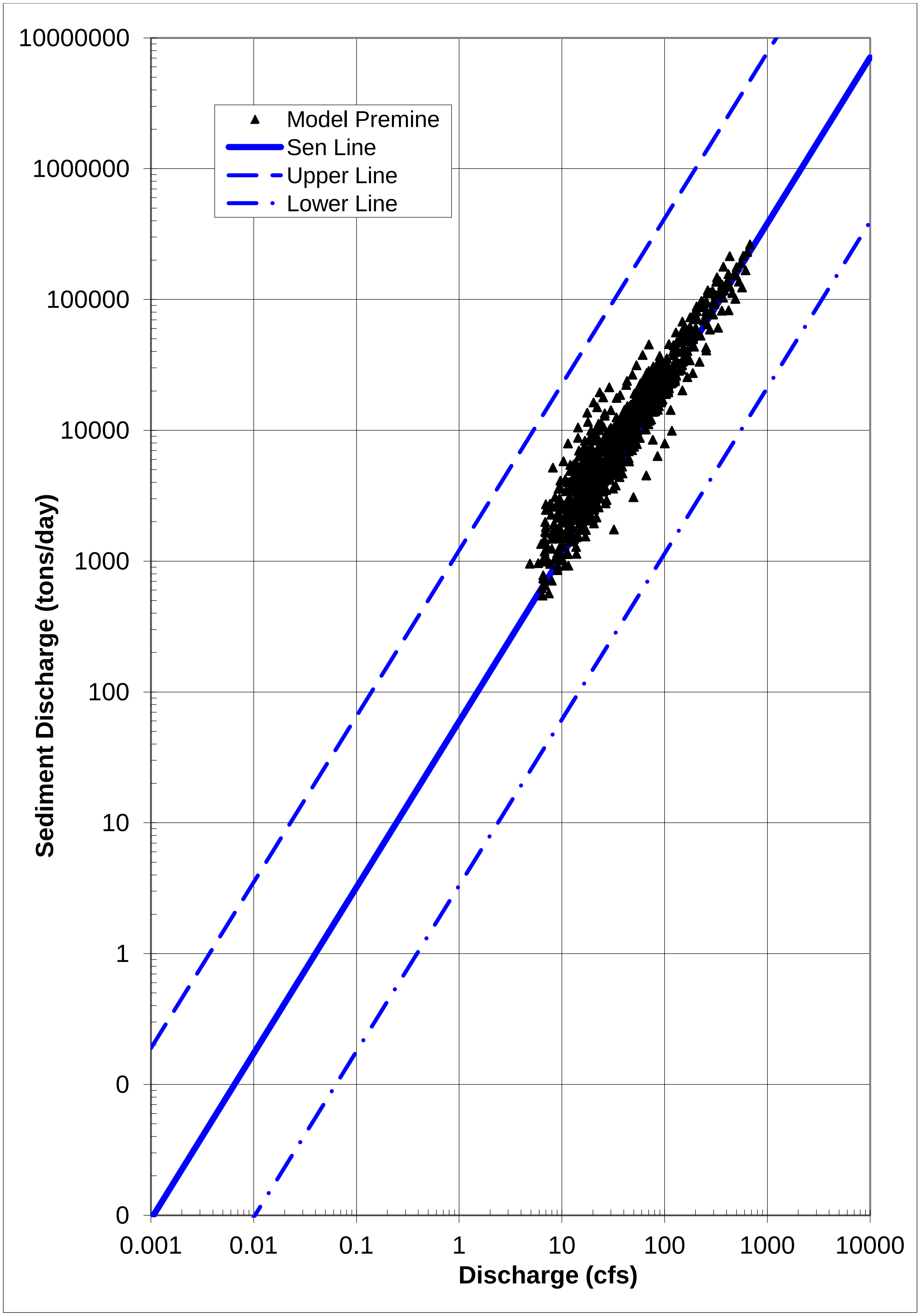

Figure 2.5. Modeled Pre-Mine Sediment and Water Discharge for J19.

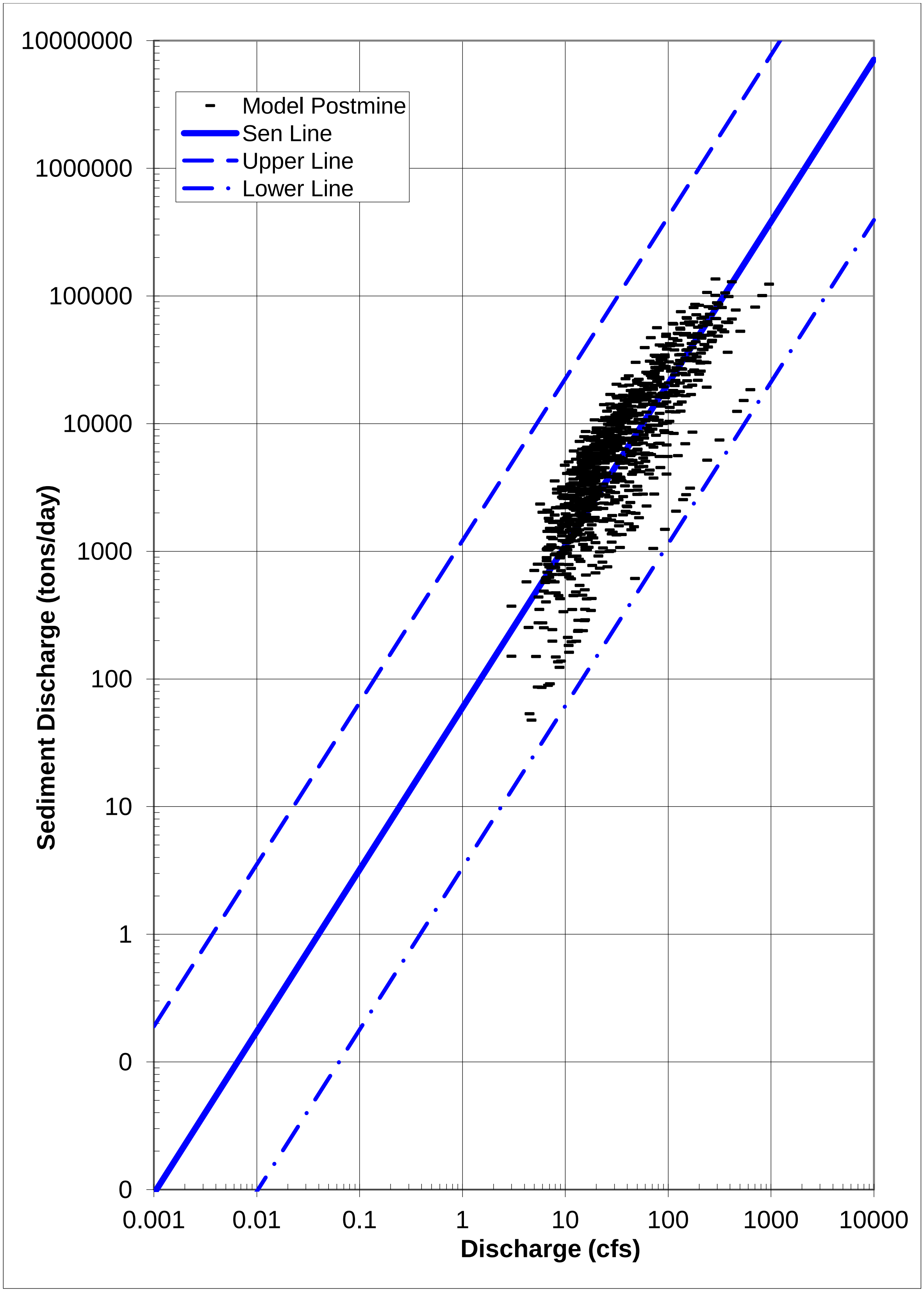

Figure 2.6. Modeled Post-Mine Sediment and Water Discharge for J19.

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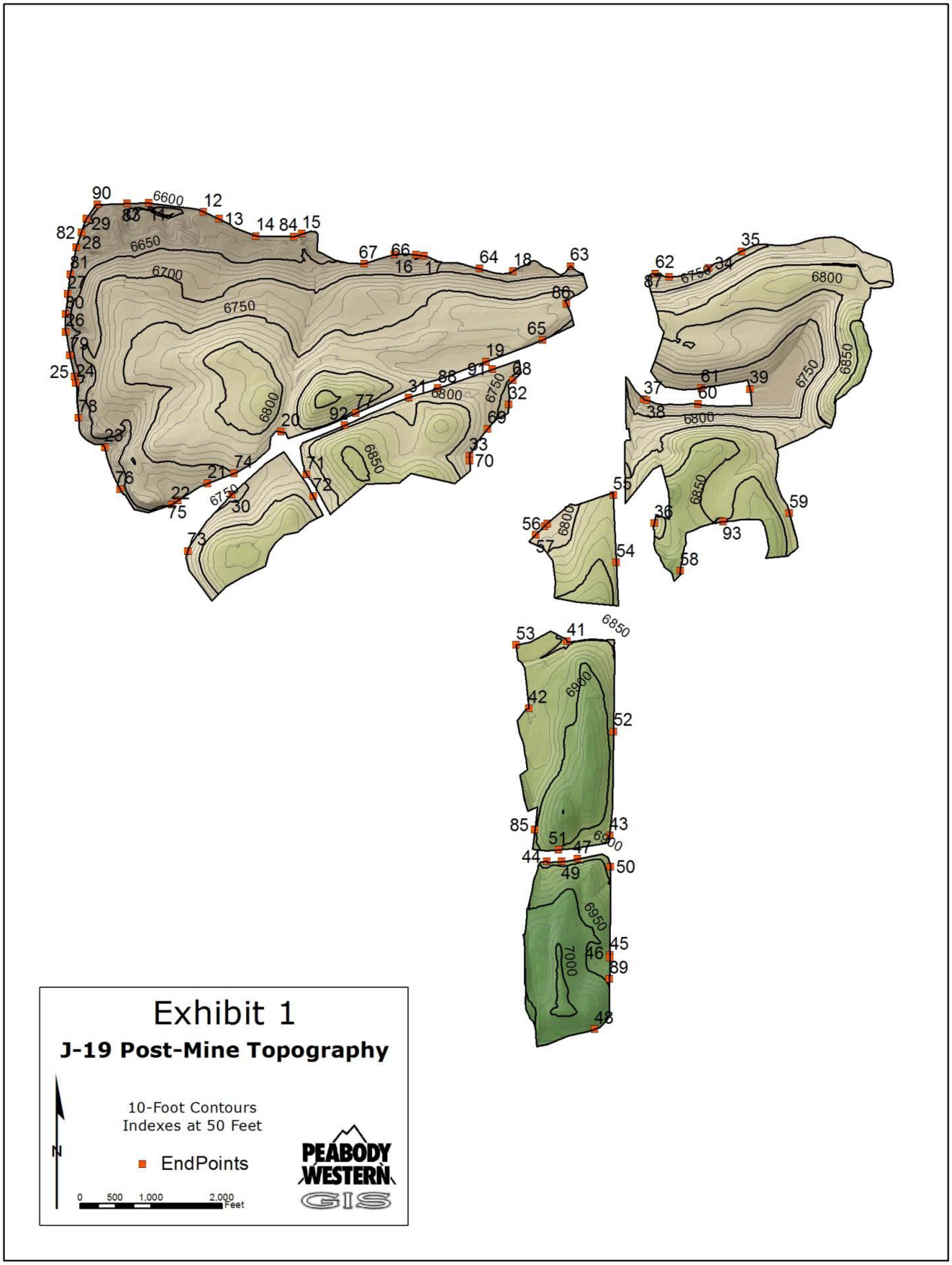
Exhibit 1
J-19 Post-Mine Topography
10-Foot Contours
Indexes at 50 Feet
EndPoints
0 500 1,000 2,000 Feet
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PEABODY WESTERN
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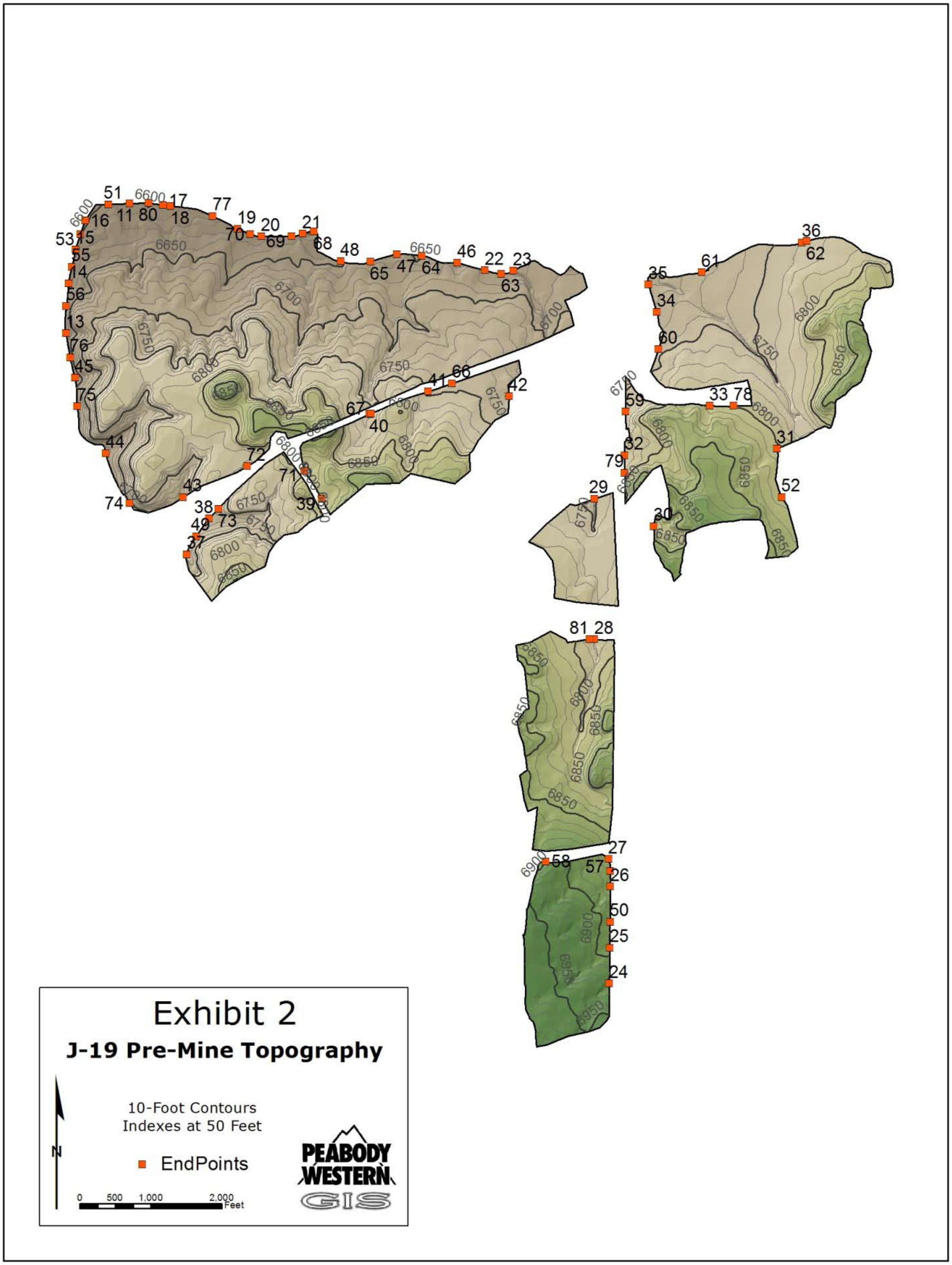
Exhibit 2
J-19 Pre-Mine Topography
10-Foot Contours
Indexes at 50 Feet
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N
0 500 1,000 2,000
Feet
PEABODY
WESTERN
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SURFACE WATER MODELING OF RECLAIMED PARCELS AT THE J21 COAL RESOURCE AREA, KAYENTA MINE

Prepared for

Peabody Western Coal Company
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

AYRES ASSOCIATES

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Ayres Project No. 32-1304.02
PEA-J21-9A.DOC

September 2010

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The purpose of this project is to use a previously calibrated and validated runoff and erosion model EASI - Erosion And Sediment Impacts (Zevenbergen et al. 1990; WET 1990) for the Black Mesa and Kayenta Mines to predict mean annual runoff and sediment yields from the reclaimed parcel J21. The objective of this project included computation of runoff and sediment yields under premine conditions for the same area. The response of the reclaimed parcels was evaluated relative to undisturbed (premine) conditions in the corresponding undisturbed watersheds. All soils and rainfall input to the model were taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site. The model serves as a tool for assessing the success of reclamation efforts to protect hydrologic balance (30 CFR 715.17 and 30 CFR 816.41).

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J21 Coal Resource Area (CRA) that is the focus of this project was reclaimed between 1986 and 2009. This reclaimed area is now eligible for Phase II Bond Release from the Office of Surface Mining Regulation and Enforcement (OSM). The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the current conditions of reclaimed areas relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved sediment control plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, rock down drains, and where practicable, contour terraces. The natural watersheds on the mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adversely impacting the hydrologic balance.

The next sections describe the data and procedures used to evaluate the J21 CRA. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities and maturation of the reclaimed area vegetation taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the CRA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the J21 premining watersheds.

1.3 Data

1.3.1 Soils

Soils data used for the current study (CRA J21) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of CRA J21 is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of CRA J21.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in CRA J21 were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J21 CRA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and CRA J21 of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and any unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J21 CRA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simanton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

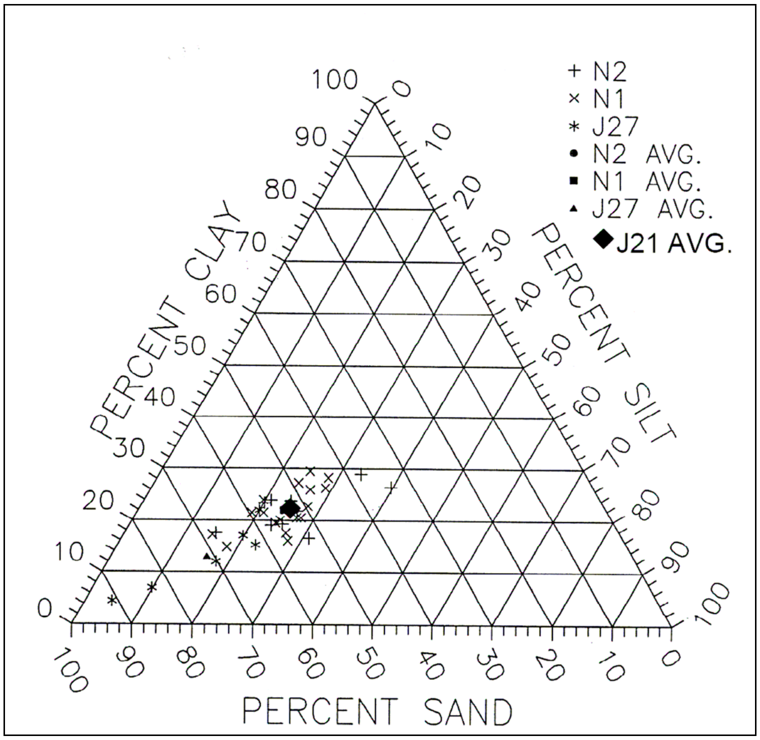

Figure 1.1. Reclaimed area soils trilinear graph.

Table 1.1. Soils Data.			
Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
	Particle Size Distribution (all conditions)		
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

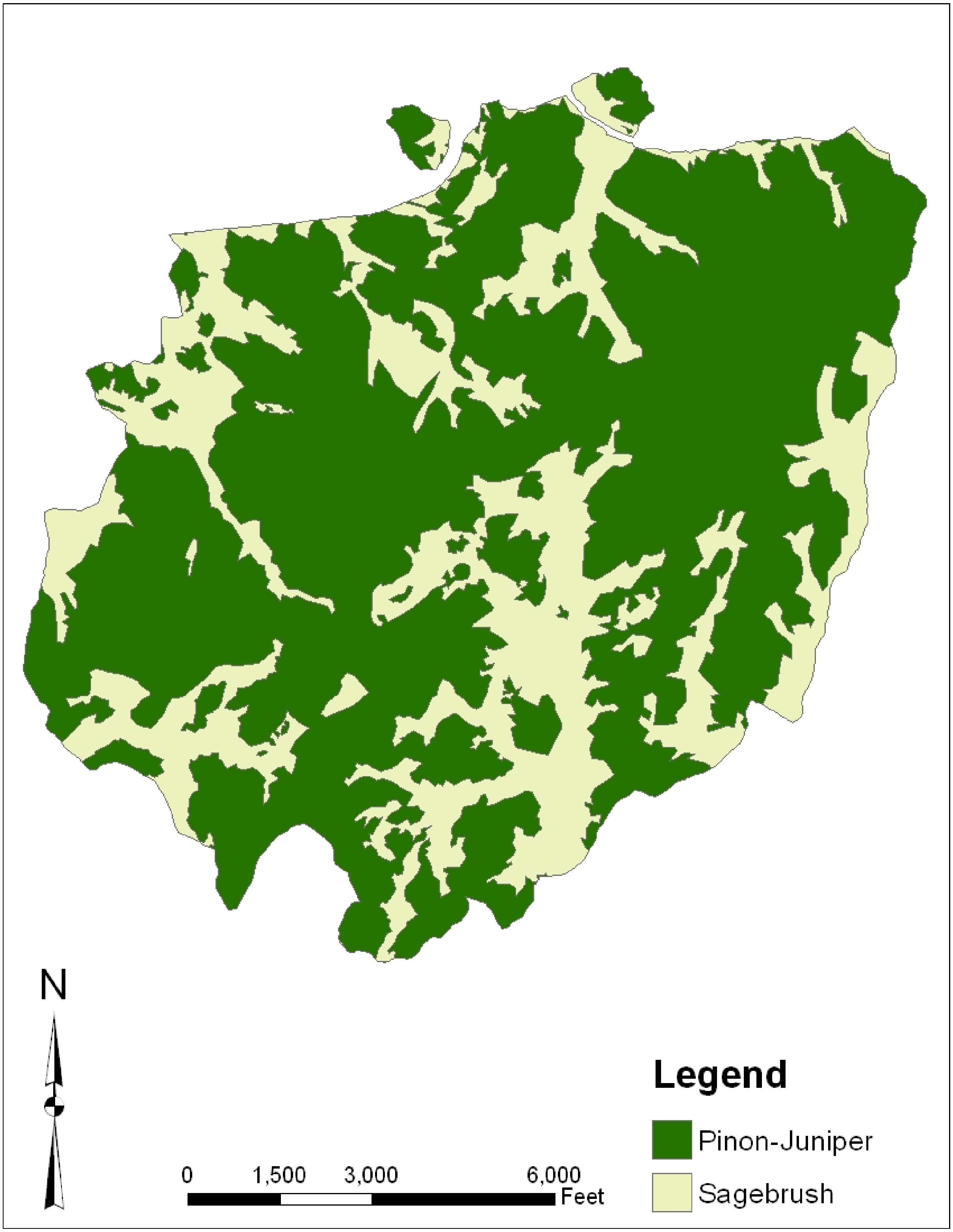

Figure 1.2. Spatial distribution of vegetative cover types for J21 premine condition.

Table 1.2. Cover Sampling Data.								
Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	42.0
J21	Postmine	Postmine	28.8	0.2	28.7	29.0	1.7	59.4
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J21	Premine	Pinon Juniper	19.1	17.0	2.5	28.8	16.7	48.0
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J21	Premine	Sagebrush	16.7	3.8	13.4	30.6	1.7	45.7
*Including standing dead litter								

Table 1.3. Cover Data for J21.				
Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	17.0	3.8	10.4	0.2
Ground cover, %	48.0	45.7	46.9	59.4
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Kayenta Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Kayenta Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (RCE 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in CRA J21 were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to define the extent of both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J21 CRA dictated that some areas would be included or excluded from the modeling. The total area modeled for premine conditions is 3172.4 acres (Exhibit 2) and for postmine conditions is 2832.0 acres (Exhibit 1).

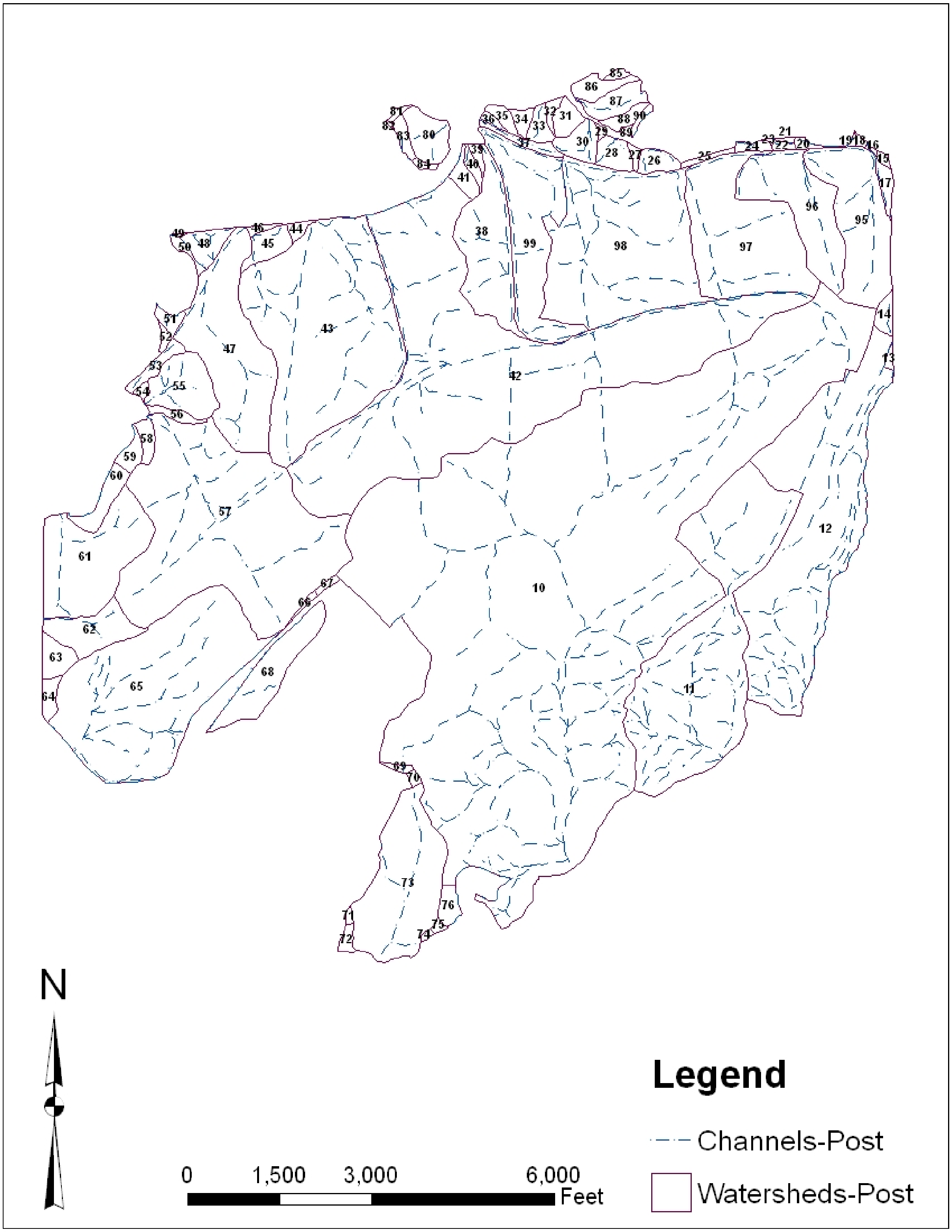

Figure 1.3. J21 postmine basins.

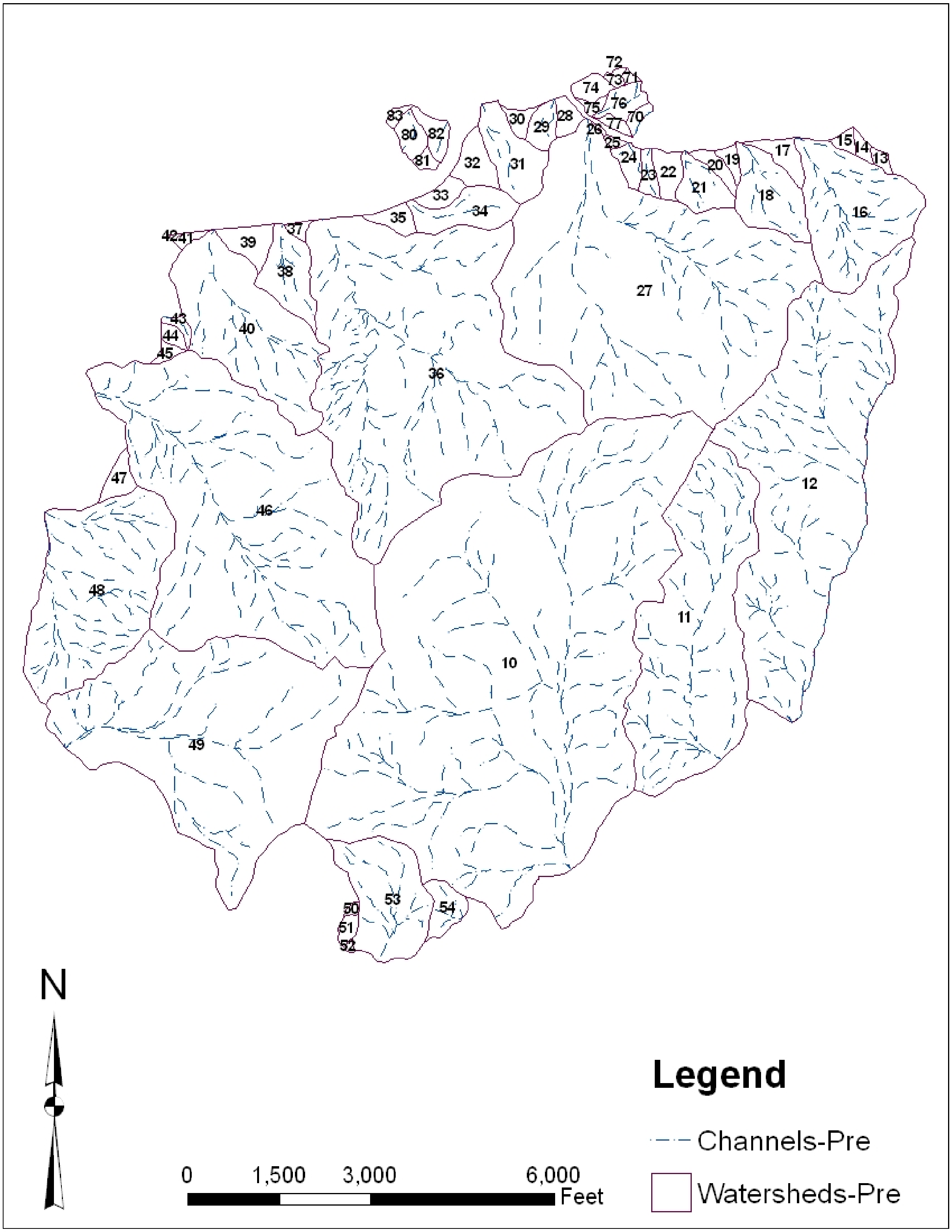

Figure 1.4. J21 premine basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average annual basis for the CRA. **Table 1.4** shows pre- and postmine drainage area, runoff, sediment yield, and erosion for the J21 CRA. Runoff is defined as the total volume of water leaving the CRA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there were no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. Similarly, the sediment yield is the amount of eroded material that leaves the CRA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

For the postmine condition, sediment yield is substantially less than the premine condition. Sediment yield is approximately two-thirds of the premine amount. Runoff is the same as the premine amount for the J21 CRA. Hillslope and subwatershed erosion rates are about 10% lower for the reclaimed (postmine) condition than the premine condition. The reduction of sediment yield is due to more effective hydrologic cover and channel erosion control measures.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine topographies for the J21 CRA. Postmine hillslopes are generally about 15% longer and steeper than premine hillslopes, postmine channels are about 25% less steep as premine channels, and the drainage density of the postmine condition is about 10% less than that of the premine condition. These properties agree with the postmine versus premine topography: the premine topography is fully dissected. The removal of most terraces in the J21 CRA results in the slightly longer postmine hillslopes.

Table 1.4. Average Runoff and Sediment Yield Results.					
Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)	Erosion (t/ac/yr)
J21	Premine	3172.4	0.42	4.15	0.61
J21	Postmine	2832.0	0.42	2.99	0.56

Table 1.5. Average Physical Properties of the J21 CRA.		
	Premine	Postmine
Total Area (ac)	3172.4	2832.0
Total Channel Length (ft)	387,248	306,501
Mean Channel Slope	0.0629	0.0466
Drainage Density (mi/mi^2)	14.8	13.1
Mean Hillslope Length (ft)	169	193
Mean Hillslope Gradient	0.0838	0.0965

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

2.1 Sediment Discharge and Concentration

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, modeled unmined (J21 premine) and modeled reclaimed (J21 postmine) data. Although there is significant scatter shown in the data (as is expected with sediment transport), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 cfs and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from the J21 CRA pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50- and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (**Figure 2.1**) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (**Figure 2.2**) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered on 100 cfs and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From **Figures 2.1 and 2.2** it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the CRA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in **Table 1.4**.

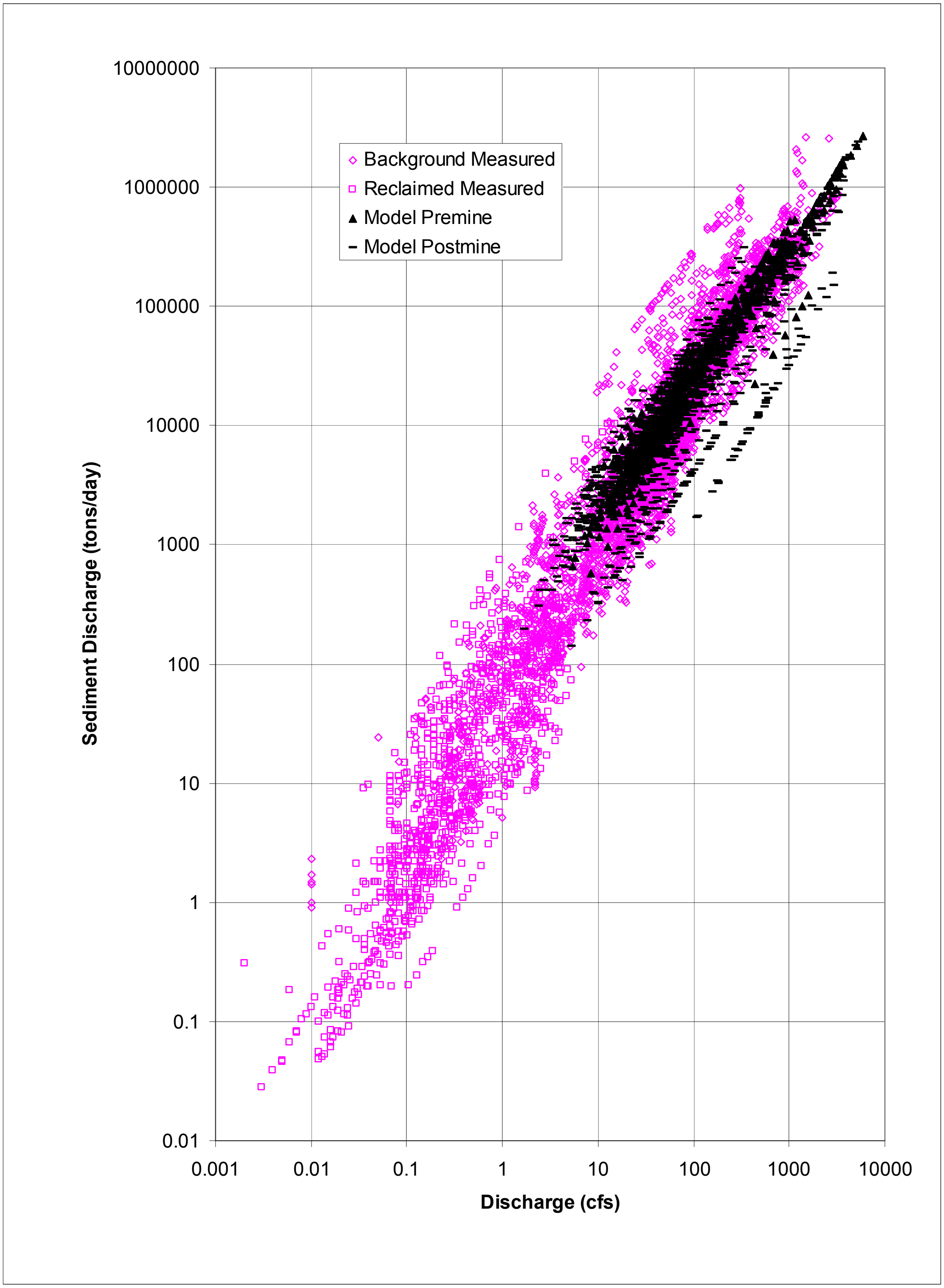

Figure 2.1. Observed and modeled sediment discharge and water discharge.

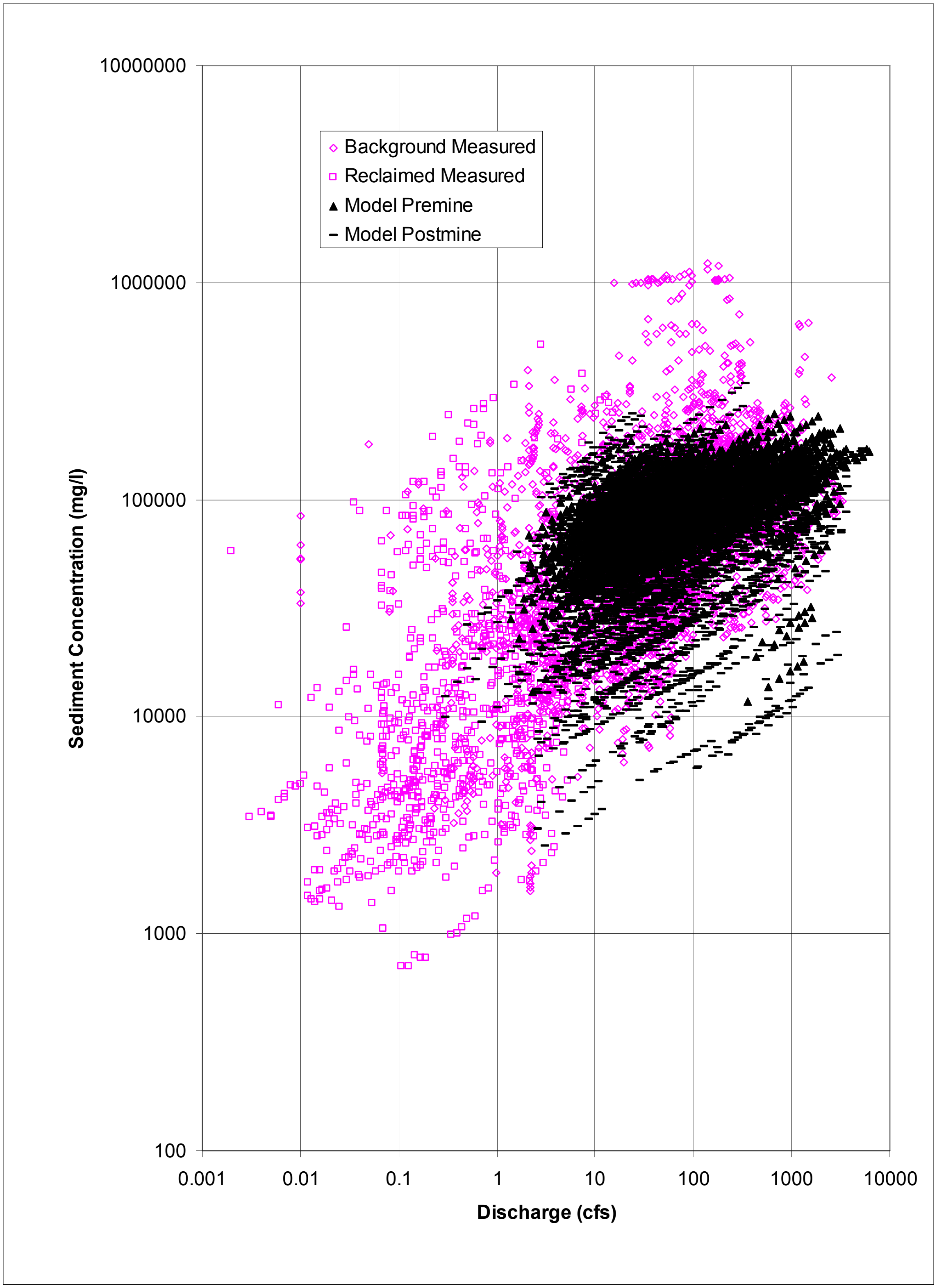

Figure 2.2. Observed versus modeled sediment concentration and discharge.

However, the sediment yield shown in **Table 1.4** is the amount of sediment leaving the CRA whereas the sediment discharge shown in **Figure 2.1** is the peak rate of sediment in transport occurring in any channel on the CRA, whether the channel is located upstream or downstream of a pond. Therefore, with or without the ponds trapping sediment or storing water, the mine reclamation is not contributing additional sediment to the receiving streams, and sediment impacts to the prevailing hydrologic balance have been minimized.

2.2 Statistical Analysis

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in **Figure 2.1** to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

Smith and Best then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the J21 CRA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (**Figure 2.5**) shows the data grouped densely around the Sen line and well within the bounds. The postmine data (**Figure 2.6**) also plot closely around the Sen line and well within bounds.

2.3 Conclusions

Several conclusions can be drawn from these data plots: (1) the EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the CRA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in the J21 CRA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

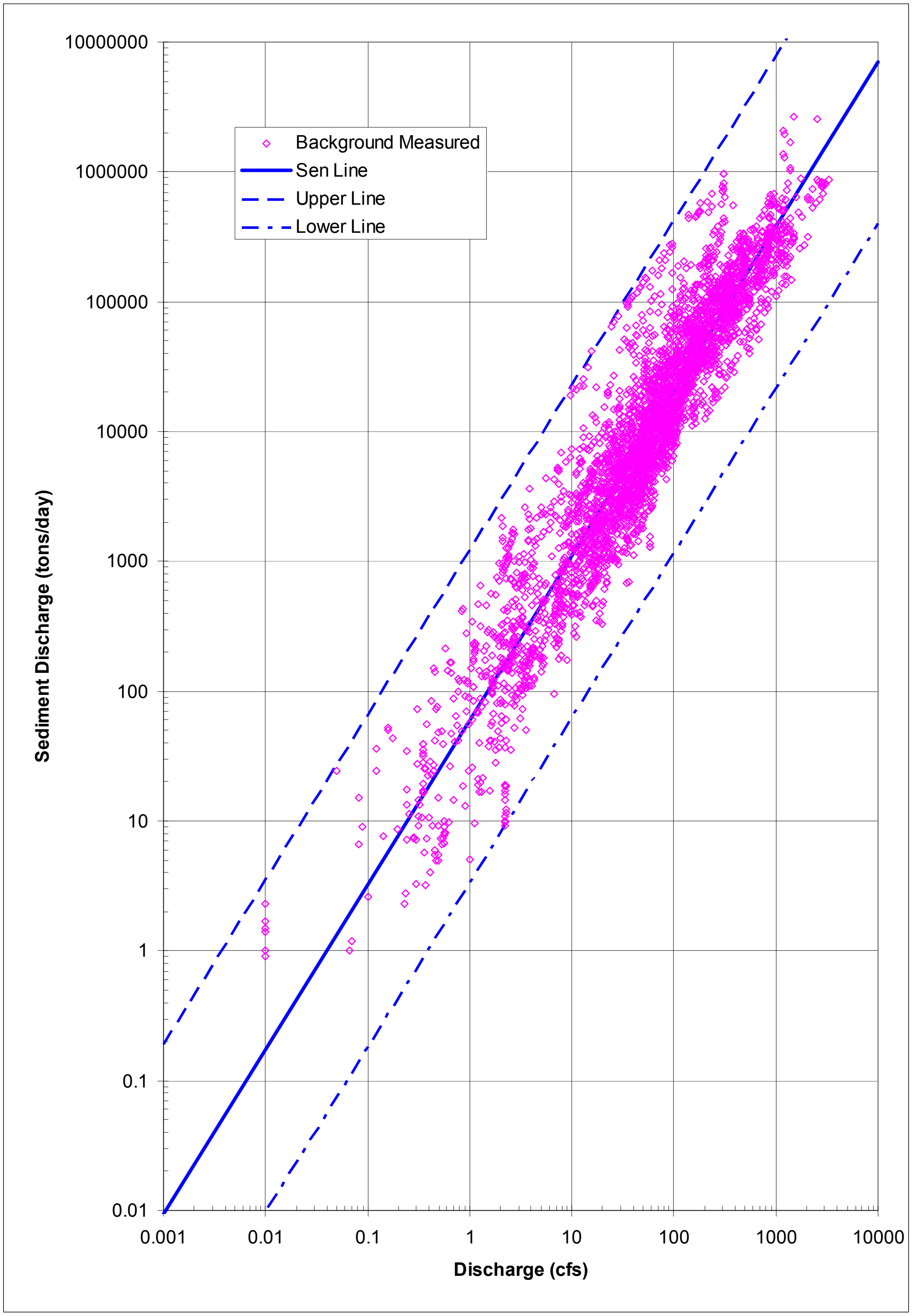

Figure 2.3. Background measured sediment and water discharge.

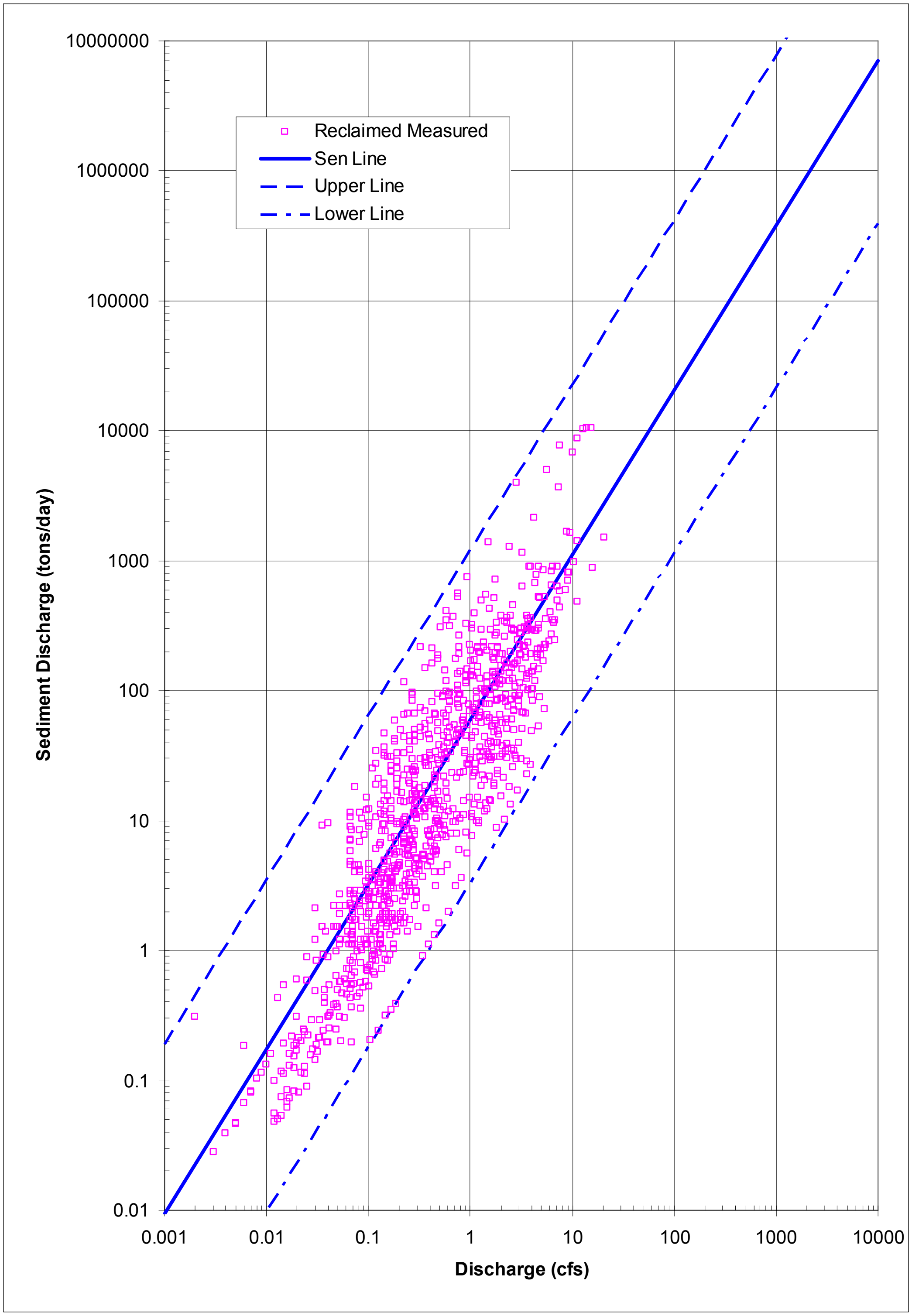

Figure 2.4. Reclaimed measured sediment and water discharge.

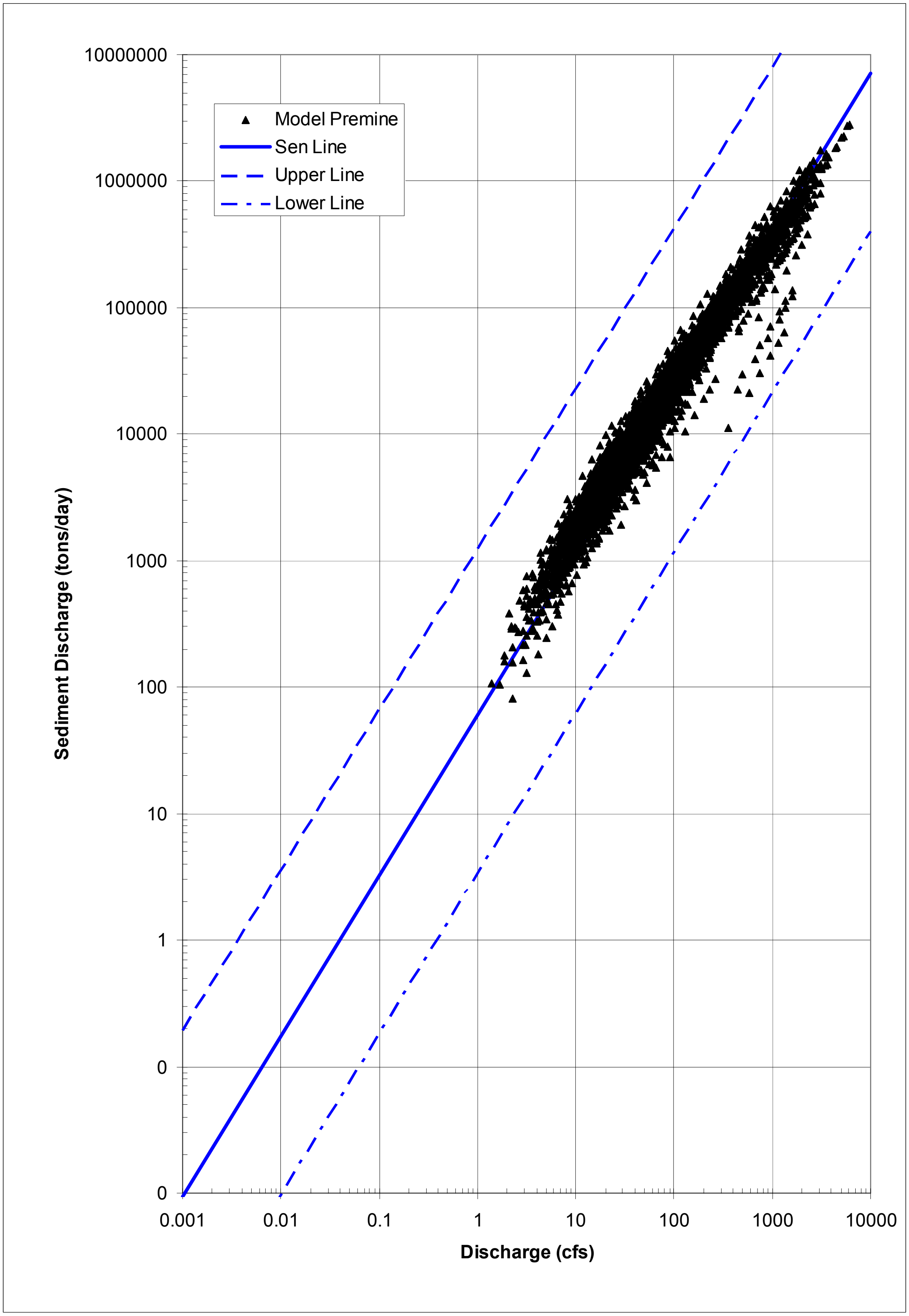

Figure 2.5. Modeled premine sediment and water discharge for J21.

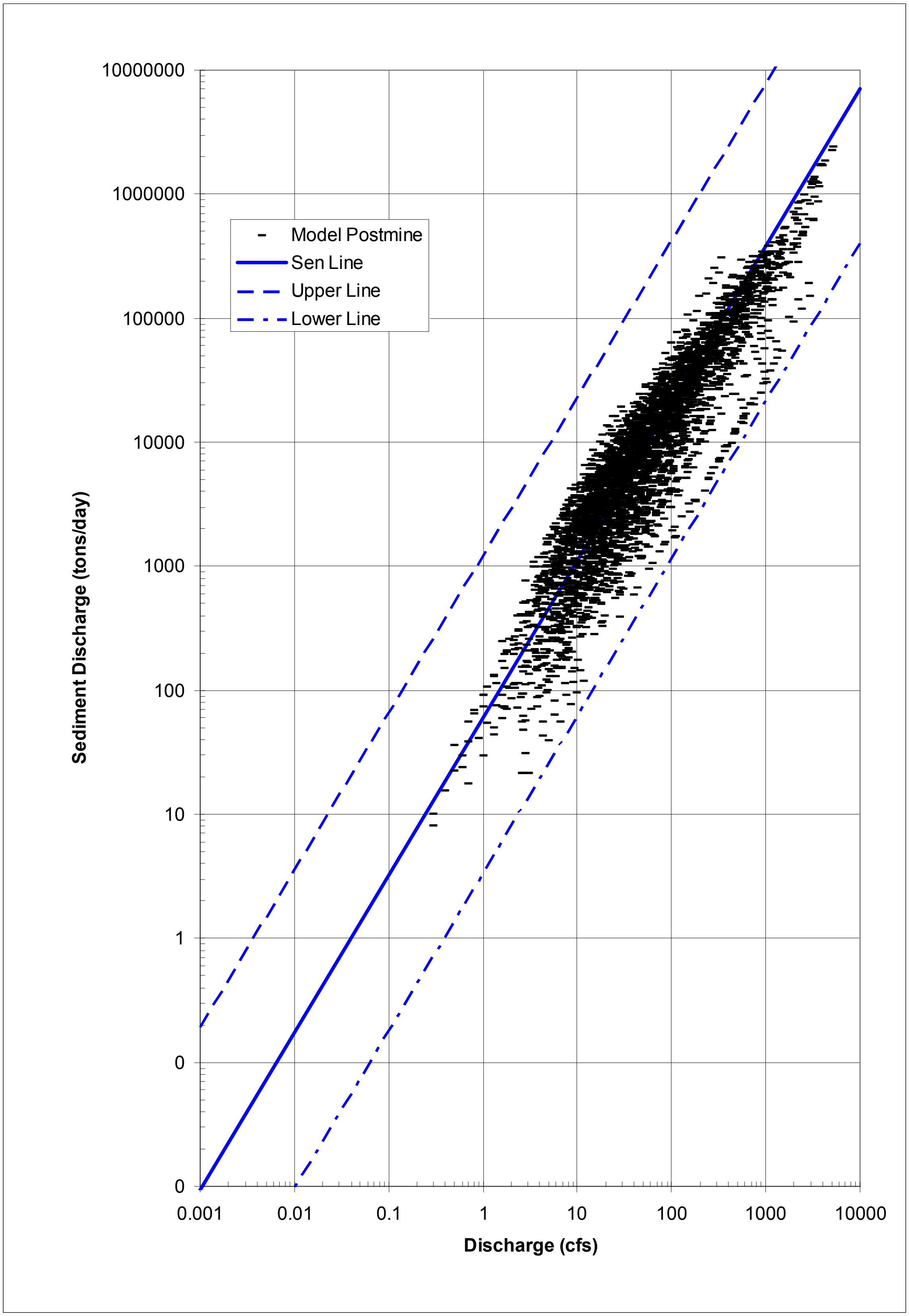

Figure 2.6. Modeled postmine sediment and water discharge for J21.

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EXHIBIT 1
Postmine Topography

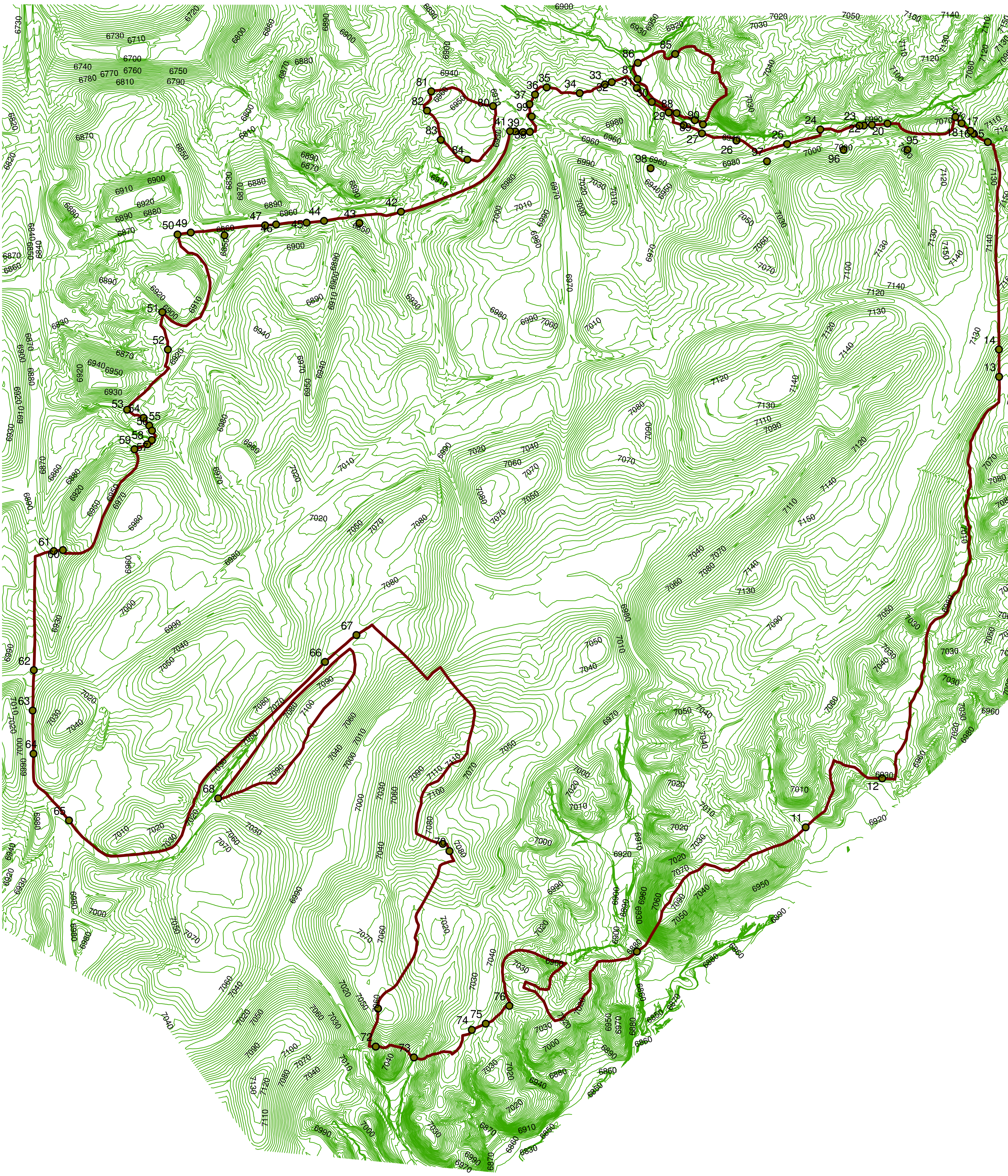


Exhibit 1. Postmine Topography
(5 foot contour)

0 1,000 2,000 4,000 6,000 Feet

N

Legend

- End Points
- Modeling Area Post

EXHIBIT 2
Premine Topography

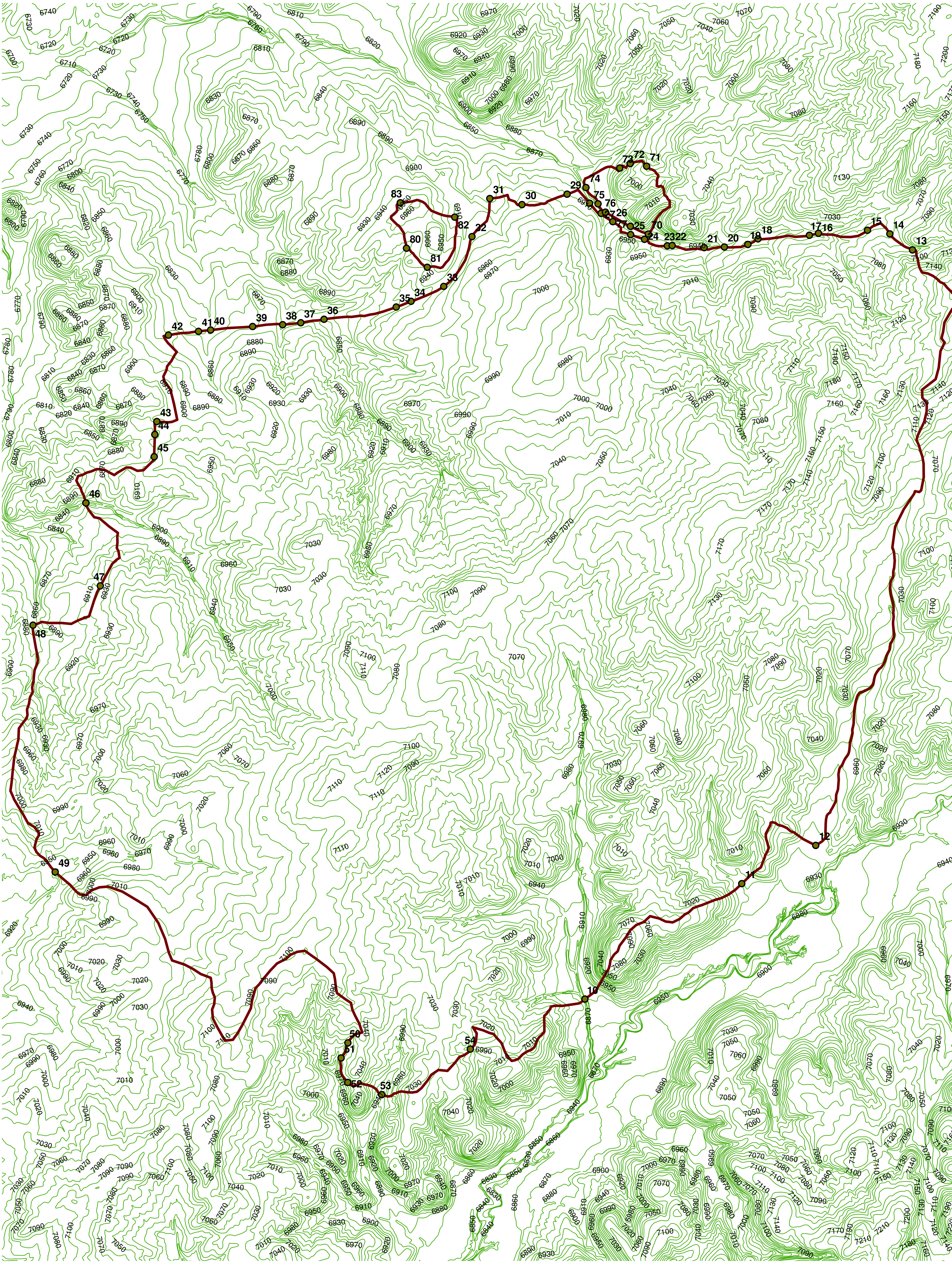


Exhibit 2. Premine Topography
(10 foot contour)

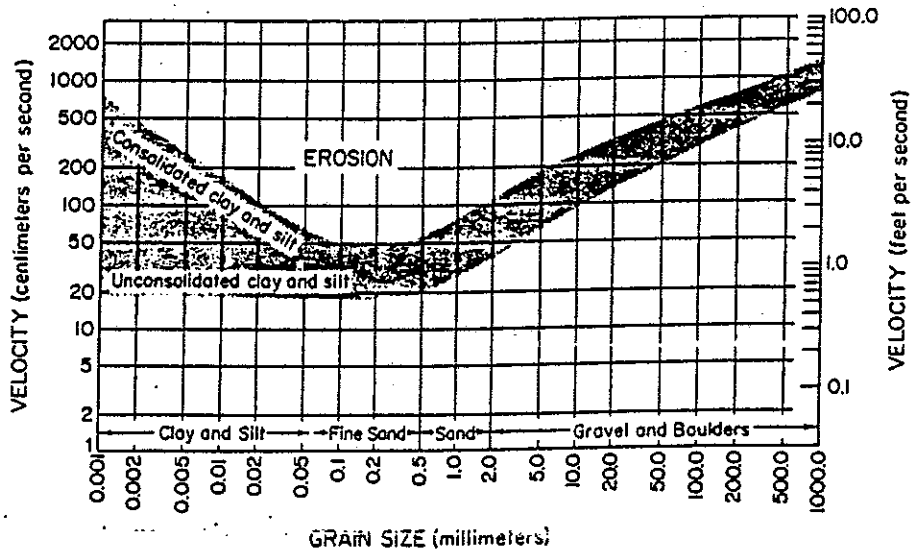
0 1,000 2,000 4,000 6,000 Feet

N

Legend

- End Points
- Modeling Area Pre

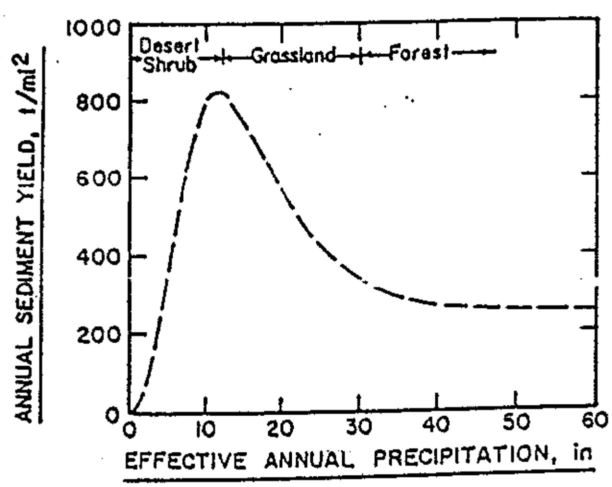
Figure 4.1



Hjulstrom's diagram, showing critical velocity for movement of quartz grains on a plane bed at a water depth of one meter, as modified by Sundborg (1956). The shaded area indicates the scatter of experimental data. There are very few reliable data in the clay and silt region.

(from Blatt, Middleton and Murray, 1972)

Figure 4.2



Variation of sediment yield with climate in the United States (from Langbein and Schumm, 1958).

Section 4. Phase II Bond Release Supporting Information

Suspended Solids Outside of the Permit Area

Introduction

Beginning in the early 1980's, PWCC collected numerous measurements of suspended solids (Total Suspended Solids – TSS) in runoff events at sites established on the main washes and at small watersheds located on both reclaimed and un-mined areas within the leasehold. TSS values collected in runoff from runoff plots and small flumes contributed to the development of a surface water model (EASI) used to predict runoff and sediment loads from both un-mined and reclaimed mined lands at the Kayenta Mine. The following sections summarize the development of the EASI model and reference recent EASI modeling reports for reclaimed parcels adjacent to or within the Phase II parcels subject to this Phase II application (J-16, J-19, and J-21). Comparisons of measured and predicted sediment discharges and TSS concentrations collected at main channel monitoring sites, small un-mined watersheds, and in small reclaimed parcels located within the Black Mesa and Kayenta Mines are also summarized. Based on the following discussions, PWCC is confident that runoff from these parcels will not contribute additional suspended solids to stream flow outside the permit area.

EASI Model Development

PWCC initiated a Small Watershed Study (SWS) monitoring program on Black Mesa in 1985, and continued monitoring through 1992. Details regarding study objectives and monitoring associated with the study are provided in Attachment 4 in Chapter 16, Hydrologic Monitoring Program in the AZ-0001F Permit application package. Several small watersheds located within reclaimed and undisturbed areas were instrumented with supercritical flow flumes and continuous flow recorders for collecting runoff, sediment (TSS) and water quality data. Rainfall data were collected using Belfort automated tipping bucket rain gauges located at the centroids of each watershed and direct reading rain gauges set up at various locations within each watershed. Total overland runoff and sediment yield data for individual storm events were collected from hill slopes in each watershed using runoff plots. Small flumes were also installed downstream of the plots and were instrumented with continuous stage recorders and automated samplers in order to measure runoff rates and TSS concentrations during runoff events. In addition, runoff rates and TSS concentrations were collected at sites located in the main channels (e.g., Moenkopi Wash) over many years as part of historic monitoring commitments contained in the Hydrologic Monitoring program during the 1980s into the mid-1990s. The data results were utilized to calibrate the physically based runoff and sediment yield model named EASI (Erosion And Sediment Impacts - Zevenbergen et al., 1990; WET, 1990). EASI has been used to support Termination of Jurisdiction (TOJ) applications for mined areas reclaimed under the initial program rules (30 CFR Part 715) and bond release applications for mined areas reclaimed under the permanent program rules (30 CFR Part 816). The modeling results were used to support the first TOJ application submitted for the Kayenta Complex in March 1994 for the N-1/N-2 and J-27 interim program reclaimed areas (PWCC, 1994). The 1994 TOJ application included the final report for the modeling project completed in August of 1993 (RCE, 1993).

The model was calibrated and verified using a two-step process and site-specific data collected as part of the Small Watershed Study. The EASI model was first calibrated and validated using total runoff volumes and sediment yields measured in the runoff plots along with rainfall data, followed by simulation of actual runoff hydrographs and corresponding sediment concentrations collected from the flumes considering measured storm durations and intensities. Soils and vegetative cover data measured in each plot and at select points in each watershed were also used in the model development process. Parameters that influence the model's predictions of runoff and sediment were calculated from observed data or estimated through model testing. Other theoretical parameters such as rainfall interception storage and Manning's "n" were estimated based on previous experience in the application of EASI at other surface mines in the Colorado Plateau region (WET, 1990).

<u>EASI Model Sensitivity Analysis.</u> The 1993 report provides a discussion of the influence of several key input parameters on its ability to duplicate measured hillslope and channel responses. Runoff and sediment yields (TSS) predicted by EASI are controlled by the short-duration, high-intensity rainfall events common to the area. The model tends to underpredict runoff and sediment yield response for small rainfall events (< 0.1 inches), especially on hillslopes where antecedent moisture, looseness of surface soils, wind and temperature can vary appreciably. For larger events, the small watershed study runoff plot and flume data were in good agreement with EASI model predictions based on the calibration and validation process utilized for optimizing model inputs.

The sensitivity of the EASI model to several input parameters was performed after completing the calibration and validation work. The analysis evaluated calibrated values for soil hydraulic conductivity, total ground cover, and both overland flow (hillslope) and channel flow detachment coefficients (erosion) by varying the input parameter values by percentages. Model response to these variations was evaluated on a unit runoff (inches) and sediment yield (tons/acre) basis at both hillslope and watershed scales. The analysis indicates runoff is not appreciably affected by cover at either a hillslope or watershed scale. For larger events, rainfall intensities are far higher than infiltration rates.

However, sediment yield from pre-mining and reclaimed hillslopes is highly sensitive to total ground cover and less sensitive to infiltration (hydraulic conductivity) and erosion (detachment coefficients). On a watershed scale, the differences between pre-mine and reclaimed sediment yield are less pronounced because channel sediment transport processes dominate at the watershed outlet.

Many of the required EASI model input parameters used for modeling runoff and sediment yield from watersheds at the Kayenta Mine were developed during the calibration and validation process because direct measurements were difficult to obtain and not readily available. However, percent ground cover values for modeling un-mined and reclaimed areas are based on field measurements of vegetative ground cover, litter, and rock. These values are readily measured directly in the field and are required for demonstrating successful establishment of vegetation growth in the reclaimed parcels subject to this Phase II bond release application. Because predictions of sediment yields (including TSS concentrations) using EASI are sensitive to values of total ground cover, and are readily available, it follows that measurements of total ground cover in reclaimed areas may be used to indicate whether reclaimed areas are generating sediment yields, expressed as tons/acre on a unit basis or as individual TSS concentrations (mg/L), that may result in appreciable contributions of suspended solids to streamflow outside the permit area.

Table 4.1 presents average total ground cover used in previous EASI models to predict sediment yields in numerous reclaimed areas throughout the leasehold and provides a general description of the reclaimed areas modeled, drainage area, and average total ground cover used for modeling purposes. The values range from 38.2 percent to 65.6 percent. Of note, the EASI models that were developed for all reclaimed areas listed predicted average annual sediment yields less than or equal to pre=mining conditions. Importantly, the processes that dominate the sediment yield predictions involve sediment transport in channels, not erosion from hill slopes. Measurements of total ground cover in the reclaimed parcels subject to this application are 45.8 percent (J16), 45.1 percent (J19), and 55.3 percent (J21). Accordingly, absent application of the EASI model to these parcels, the average total ground cover values indicate average annual sediment yields from these areas will be less than or equal to conditions that were present prior to mining these parcels.

Table 4.1. Total Ground Cover Values for Reclaimed Conditions Used in Previous EASI Sediment Models

Reclaimed Area Modeled	Model Date (Month-Year)	Drainage Area (acres}	Total Ground Cover[1] (percent}
N1/N2	Aug-93	2732.5	41.2
J27	Aug-93	178.9	43.9

N7/N8	Jul-01	946.0	53.9
N14	Jul-08	1580.6	46.5
J21-D/J21-E	Aug-08	68.9	65.6
J16-E/J16-F	Aug-08	148.5	61.0
N6-C/N6-D/N6-F	Aug-08	280.9	38.2
J7-CD/J7-E/J7-F	Aug-08	99.8	48.5
J21-A	Apr-09	111.2	52.7
N6-G	Apr-09	37.9	55.6
J7-K/J7-M	Jun-09	37.3	55.2
N5-D/N5-E	Aug-09	28.3	48.9
J1/N6 and N6 East Central	Sep-09	1533.3	46.2
J21	Sep-10	2832.0	59.4
J7-A/J7-B1/J7-G/J7-H/ J7-I/J7-J/J7-R/J7-R1	Feb-11	440.0	55.2
J19	Sep-11	943.4	55.8
J3	Nov-12	95.5	39.9
J7	Nov-12	1194.7	48.7
Total Drainage Area Modeled =		13289.7	
[1] Total Ground Cover = Vegetation Ground Cover + Litter + Rock			

Following the 1994 TOJ application submittal, sixteen additional EASI models were developed for reclaimed parcels located within the Kayenta and Black Mesa Mines, including reclaimed watersheds upstream of temporary sediment ponds that were permitted as outfalls in the Kayenta Complex NPDES Permit No. NN-0022179. As of 2016, a total of 13,289.7 acres of reclaimed areas had been modeled using EASI. The combined total of topsoiled and seeded areas at both mines at the end of 2016 was 15,584 acres, of which approximately 85 percent were modeled using EASI. The following sections discuss EASI models that have been developed proximate to the J16, J19, and J21 reclaimed parcels subject to this application.

<u>J16 EASI Sediment Yield Model</u>. Attachment 4.1 contains an EASI model report entitled "Surface Water Modeling of the Reclaimed Ponds J16-E and J16-F Watershed Area at Kayenta Mine" (Ayres, 2008) for two ponds (J16-E and J16-F) that drain reclaimed areas situated adjacent to or lie within the J-16 TOJ parcels. The results indicate no difference in average annual runoff (0.42 inches) generated from reclaimed hill slopes and low-order channels established above both ponds compared to pre-mining conditions. Reclamation methods including BMPs (e.g., vegetative cover) utilized in the J-16 TOJ parcel were like those evaluated in the J16-E and J16-F EASI model. In addition, physical properties of the reclaimed watersheds above both ponds, including drainage density, channel lengths and gradients, and hillslope lengths and gradients were lower than pre-mining conditions characterized by highly dissected topography.

J19 EASI Sediment Yield Model. Attachment 4.2 contains the EASI model entitled "Surface Water Modeling of Reclaimed Parcels at the J19 Coal Resource Area, Kayenta Mine" (Ayres, 2011). The model results indicate post-mine (reclaimed parcels) average annual sediment yields are about 29 percent less than pre-mine levels. Hill slope and sub-watershed erosion rates, which are significant for sustaining the postmining land use, are 9 percent higher for the reclaimed landscape, yet are comparable to pre-mine levels and are less than 1.0 ton/acre/year. The reduction of sediment yield is due to comparable hill slope erosion combined with channel erosion control measures for the post-mine landscape.

J21 EASI Sediment Yield Model. The EASI model report entitled "Surface Water Modeling of Reclaimed Parcels at the J21 Coal Resource Area, Kayenta Mine" (Ayres, 2010) is included in Attachment 4.3. The results for the J-21 reclaimed parcel show average annual sediment yield (2.99 tons/acre/year) and erosion (0.56 tons/acre/year) values lower than the those predicted for pre-mining conditions. The lower values are largely due to more effective hydrologic cover and lower drainage density, channel lengths and slopes in the J-21 reclaimed parcel compared to pre-mining conditions.

Total Suspended Solids

Soils replaced within the J-16, J-19, and J-21 reclaimed parcels and naturally occurring soils in surrounding undisturbed areas within the leasehold overall and in the arid/semiarid Southwest typically lack cohesion. Un-mined stream channels within and adjacent to the Kayenta Mine and PWCC leasehold consist of steep sided, deeply incised arroyos with loosely consolidated channel banks and fine-grained sand bed channels. Figure 4.1 from Blatt, Middleton, and Murray (1972) shows these types of soils (unconsolidated clays, silts and fine-grained sands) are easiest to keep in suspension. The gray band shown in Figure 4.1 represents the flow velocity ranges necessary to keep particle types and sizes in suspension. Above the gray band are the velocities necessary to erode or entrain soil particles, whereas velocities below the gray band would be insufficient to transport the particles and deposition would occur. The bandwidths for the clay and silt particle sizes are quite wide because considerably higher velocities are necessary to erode consolidated and cohesive clays and silts. For the unconsolidated non-cohesive silts, clays and fine-grained sands found on the leasehold, velocities of less than 2 feet/second will erode and keep the particles in suspension. Typical flow velocities measured historically in the stream channels on the leasehold including Dinnebito Wash (sites CG34 and SW34) and the main channels along Yucca Flat Wash, Coal Mine Wash, and Moenkopi Wash where monitoring sites SW155, SW25, and SW26 are located, respectively, range from 8 to 12 feet/second.

In the semiarid Southwest, much of the precipitation is effective in terms of producing runoff. A majority of the rainfall occurs in short duration, very high intensity storms that rapidly overcome soil infiltration and generate larger amounts of runoff. Total annual rainfall on the PWCC leasehold ranges from 6 to 12 inches. Figure 4.2, from Langbein and Schumm (1958), shows the relationship of annual sediment yield to effective annual precipitation and cover in the U.S. Note the highest annual sediment yields occur where there is a combination of approximately 12 inches of effective precipitation and desert/shrub type cover. Both factors are consistent for the leasehold and for the undisturbed areas adjacent to the J-16, J-19, and J-21 reclaimed parcels. Because of the soil and rainfall characteristics and the vegetative cover for this geomorphic region, stream flows on the leasehold more closely approximate debris flows than they do stream flows.

Suspended Solids Outside of the Permit Area

Section 2.0, Comparisons with Measured Sediment Transport in each of the three EASI model reports provided in Attachments 4.1 (Ayres, 2008), 4.2 (Ayres, 2011) and 4.3 (Ayres, 2010) contain a discussion of measured sediment discharge and total suspended sediment (TSS) concentrations along with EASI-model derived sediment discharge and TSS concentrations. Measured values were collected over many years at main channel stream monitoring sites and at Small Watershed Study (SWS) flumes. Each EASI model report compares predicted values for sediment discharge and TSS concentrations for reclaimed area modeled with measured values based on data plots (see Figures 2.1 and 2.2 in each model report). Overlap of model predictions for both pre- and post-mine conditions with measured data strongly indicate EASI model predictions are representative and reasonable. In addition, the plots indicate sediment loads and concentrations are dependent on the channel sediment transport capacity for small un-mined and reclaimed channels as well as larger channels draining larger basins. Channel sources of sediment in the semi-arid environment of the leasehold are virtually unlimited. Accordingly, channel transport capacity and channel-derived sediment limits and governs sediment discharge and TSS concentrations from the small tributaries and large sand-bed channels (e.g., Moenkopi Wash).

Section 2.2 of each EASI model report (Attachments 4.1, 4.2, and 4.3) also discusses statistical analysis of the sediment discharge and sediment concentration plots provided in Figures 2.1 and 2.2. The analysis involved applying non-parametric statistics to determine if channels in reclaimed areas have similar sediment transport characteristics as background (un-mined) channels. The analysis showed data collected at un-mined SWS flumes can be combined with the main channel monitoring site data, and that sediment is being conveyed at or near capacity. In addition, reclaimed channel sediment discharge and TSS concentrations show the same characteristics of the data collected at un-mined SWS flumes and main channel monitoring sites even though the flow ranges are lower. The data plots and statistical analysis indicate that channel flows within and adjacent to the leasehold achieve the sediment transport capacity of the channel regardless whether they are located within reclaimed areas or in in small and large basins that drain background watersheds not impacted by surface coal mining activities. Accordingly, runoff from any of the reclaimed parcels located within the J-16, J-19, and J-21 parcels subject to this Phase II bond release application are not contributing additional suspended solids (TSS) to streamflow outside the permit area.

Alluvial Valley Floors

Chapter 17, Protection of the Hydrologic Balance in the AZ-0001F permit application package (PAP) provides a summary of early investigations of the existence of alluvial valley floors (AVFs) within or adjacent to the leasehold. The findings clearly indicate there are no AVFs within or adjacent to the leasehold.

Surface and Subsurface Water Pollution

The regulations set forth under 30 CFR Parts 780 and 816 require operators to minimize impacts to the prevailing hydrologic balance. PWCC conducted mining and reclamation activities at the J-16, J-19, and J-21 reclaimed parcels subject to this Phase II bond release application in accordance with plans and procedures approved by the Office of Surface Mining Reclamation and Enforcement (OSMRE) as provided in the PAP for Surface Mining Permit AZ-0001F, many of which were developed in order to ensure impacts to the hydrologic balance in the vicinity were minimized. The changes to ground water (subsurface) are largely based on long term monitoring of ground water in monitoring wells completed in the Wepo Formation and adjacent alluvial deposits along Moenkopi Wash, Dinnebito Wash and Reed Valley Wash. Changes to surface water (surface) are based on long term monitoring of runoff at stream sites located on Moenkopi Wash, Dinnebito Wash, and Reed Valley Wash. Changes in water chemistry discussed above cover decades of monitoring in many cases, and are within magnitudes and ranges representative of naturally occurring or background values. In summary, no pollution of surface or subsurface sources of water has been found within or adjacent to the subject reclaimed J-16, J-19, and J-21 parcels shown on Map 1.1.

References Cited

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