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EL68D Wasteway Watershed Land-Cover Generation

Open-File Report 2007–1143

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Cover. Graphic showing location of EL68D Wasteway.

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By Sheila Ruhl, E. Lynn Usery, and Michael P. Finn

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Conversion Factors and Datum

Multiply	By	To obtain
	Length	
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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Abstract

Classification of land cover from Landsat Enhanced Thematic Mapper Plus (ETM+) for the EL68D Wasteway Watershed in the State of Washington is documented. The procedures for classification include use of two ETM+ scenes in a simultaneous unsupervised classification process supported by extensive field data collection using Global Positioning System receivers and digital photos. The procedure resulted in a detailed classification at the individual crop species level.

Introduction

The U.S. Geological Survey (USGS) recently completed land cover classification for the EL68D Wasteway Watershed in the State of Washington as a part of a larger project to model water quality in this and three other watersheds (Usery and others, 2004). The process used multiple image dates, extensive field visits with Global Positioning System (GPS) coordinates established, and a multiple process of classification including unsupervised classification and post processing. The result is a classified land-cover image that consists of a high fidelity classification scheme to the individual crop species level and allows differentiation between corn and wheat, for example. The purpose of this report is to document the procedures used in this classification approach and provide the final land-cover map.

Study Area and Data

The EL68D Wasteway in Adams County surrounds Othello, Washington, on the north, south, and east (fig.1). It drains into the Potholes Canal, which flows into the Scooteney Reservoir. The watershed was selected because it is a National Water Quality Assessment (NAWQA) test site for the USGS. The approximate center of the watershed is 119° 02' 13" W. and 46° 49' 11" N. The area of the EL68D Wasteway Watershed is approximately 37,719 hectares. The watershed is contained within moderately flat to gently rolling farmland with irrigated cropland in a total relief range of approximately 50 m. Some planted timber exists in the primarily agricultural

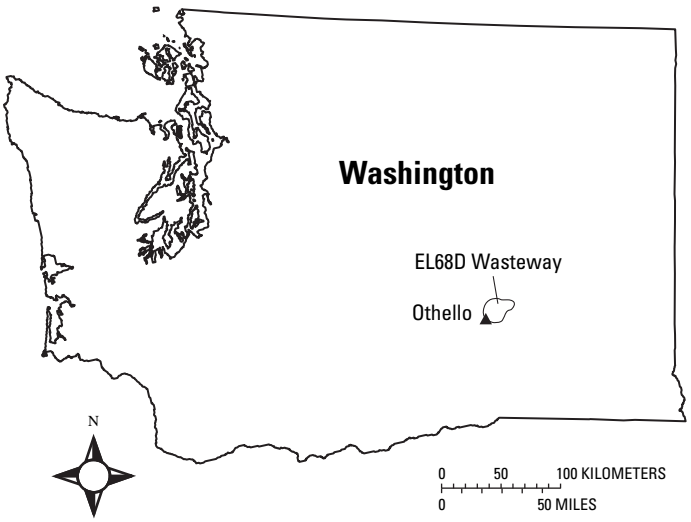


Figure 1. The Wasteway Watershed study area in Adams County, east of Othello, Washington.

watershed. Low-growing scrub and grassland are present on more rugged areas; the natural drainage areas tend to be more rugged.

In August 2001, crops grown within the EL68D Wasteway Watershed included wheat, alfalfa, potatoes, corn, onions, beans, spearmint, and peppermint. Other crops included carrots, asparagus, and smaller scattered plots of squash, tomato, eggplant, and some hay/pasture; a few apple and peach orchards also existed within the watershed. Much of the cropland has been lost to grass and weeds because of government agricultural subsidy programs. During the field visit, local residents indicated that beans, asparagus, and wheat are grown for the seed market. Corn is grown primarily for silage (animal consumption), except for a few smaller plots of sweet corn.

In an effort to produce a more accurate land cover dataset at 30-meter resolution for the EL68D Wasteway Watershed, 255 sites within and around the watershed were visited during the week of August 6-10, 2001. Vegetation and crops were described for each site and locations recorded in GPS coordinates in North American Datum 1983 (NAD 83). Available six band Enhanced Thematic Mapper Plus (ETM+) scenes from the Landsat 7 satellite were used to process and classify land cover. Two scenes, one acquired on July 12, 2001 (fig. 2) and the other acquired August 29, 2001, (fig. 3) were stacked

to create one 12-band image. Image data for the July scene were clustered using the ERDAS Imagine software (Leica Geosystems, 2007). Because of different maturity stages in plant growth and a vast range of spectral differences within many crop types, an unsupervised classification approach using 100 clusters was chosen as the clustering method, as opposed to a supervised classification approach. Each of 255 sites was visited within the digital raster data and spectrally profiled using the 12-band image and field source data. Spectral curves for crop types were then compared to delineate different crop characteristics within each cluster. The crop types were classified using the Spatial Modeler within the ERDAS Imagine software and classes were assigned to each cluster, therefore creating a new land-cover dataset with accurate crop and vegetation information at the time of the field visit. Land-cover classification is based on the Level II categories of the Land Use/Land Cover classification system documented by Anderson and others (1976).

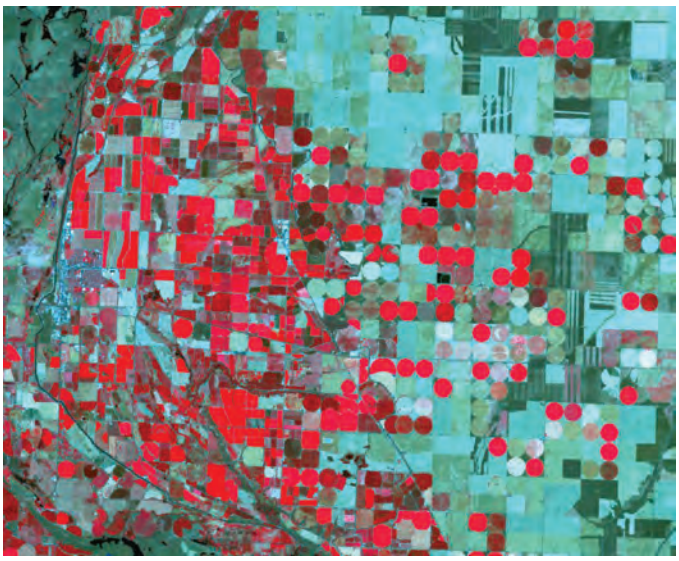


Figure 2. Enhanced Thematic Mapper Plus image subscene over EL68D Wastway Watershed, July 12, 2001. Bands 4, 3, and 2 are shown in red, green, and blue, respectively.

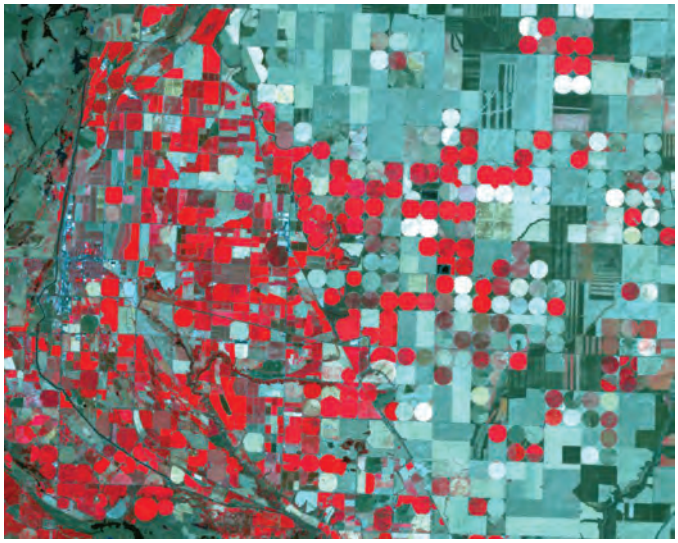


Figure 3. Enhanced Thematic Mapper Plus image subscene over EL68D Wastway Watershed, August 19, 2001. Bands 4, 3, and 2 are shown in red, green, and blue, respectively.

Field Data Collection

To aid in the classification process, a USGS researcher collected data for 255 sample sites. At each sample site, crop and other vegetation types were recorded to the species level, along with a description of the site. Coordinate locations were recorded for each site with a hand held GPS receiver, and digital photographs were taken of the various vegetation types and other features present. For example, at a cross roads sample site, photographs were taken of the four crops present in the corners. For sample sites along a road, photographs were taken of the vegetation on either side. Crop types along roadways were recorded on sketch maps with relative positions intact. A sample sketch map of the recordings for the GPS 167 data collection site is shown in figure 4. The complete table of points is included in the appendix at the back of this report and an archive of the photographs is available on the WWW at *http://mcmcweb.er.usgs.gov/carto_research/*.

Digital photographs were taken of several of the GPS locations, and used to help match the image spectral responses with the correct crop types. A sample of photographs showing peppermint and spearmint crops is shown in figure 5.

Classification Procedures

Classification was performed with the ERDAS Imagine software using the Iterative Self-Organizing Data Analysis Technique (ISODATA) (Tou and Gonzalez, 1974). The technique was applied to both ETM+ scenes for the watershed area. Spectral signatures were developed from each scene for each test site. Using the two scenes from different periods in the growing season, it is possible to differentiate individual species since the spectral response of individual species change differently. For example, figure 6 shows the spectral response curves for corn and wheat for each of the scenes. Note that, it would not be possible to separate these crops using the July 2001 image, but the August 2001 data provide sufficient spectral differences so the crops can be differentiated. Other species also were differentiable in the July scene and not in the August scene.

Once the spectral responses were determined from an initial unsupervised classification with ISODATA, they were matched to the field data to provide the class values for particular spectra for individual crops. The list of vegetation types that were classified is given is table 1 (at the back of this report). With the spectral signatures, a post processing

GPS 167:	46	46	53	Beans west of road
	119	06	45	Corn south of beans and west of road
				Small plots of mixed crops east

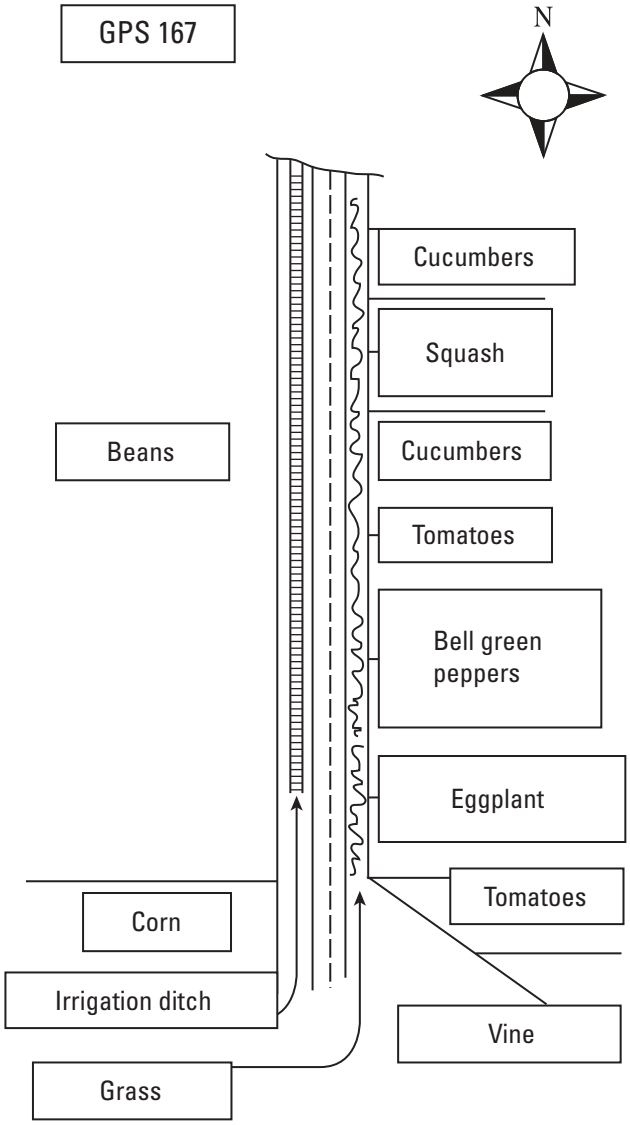


Figure 4. Sketch map of Global Positioning System 167 data collection site with crop types identified.

procedure was used to rectify the classification with the field-collected data which results in the final classification.

An example of how the GPS locations, field descriptions and photographs were used is shown in figure 7 (at the back of this report). Note the image band combinations showing the GPS locations with the corresponding photographs of the actual ground cover, in this case asparagus at GPS 123 and onions at GPS 13

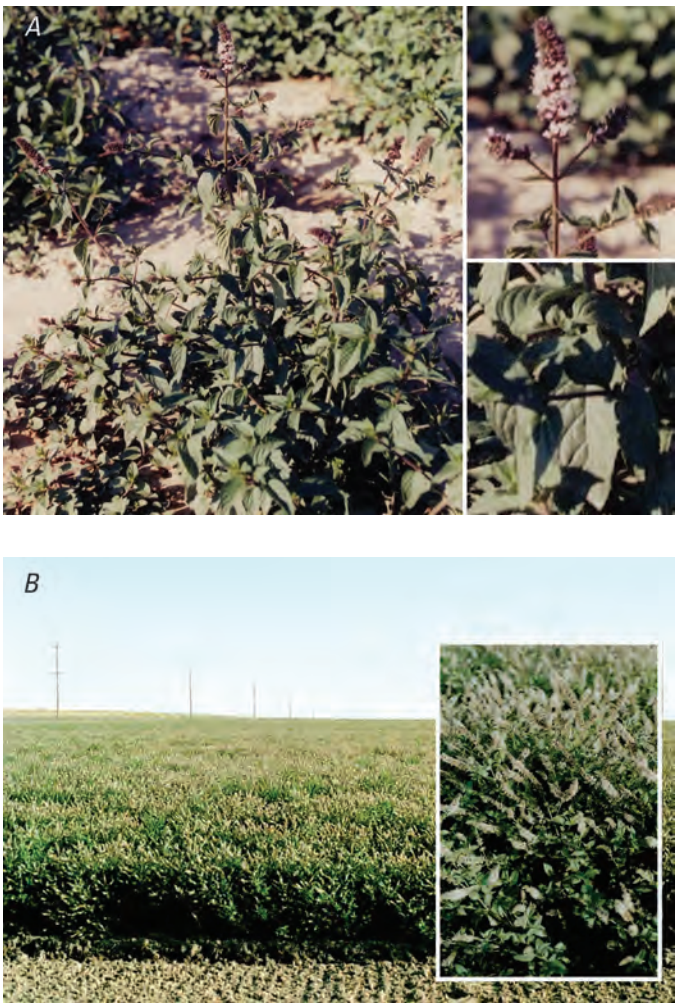


Figure 5. Fields of peppermint (*A*) and spearmint (*B*) in the EL68D Wasteway Watershed.

Results

The results provide a detailed classification of the land cover of the EL68D Wasteway Watershed. The final land-cover map includes all 255 locations with exact classification to match the field-collected data (fig. 8, at the back of this report). The map was created with each of the sample locations as a hot link based on the GPS coordinates. For each point, the link provides access to the field photos, the ETM+ image chip around the point, the spectral curves from both dates, and the final classification category assigned.

Conclusions

The land cover classification of EL68D Wasteway Watershed was required as an input to model water quality in the watershed. It resulted in development of rigorous procedures

for combining images from multiple dates with extensive field investigation to develop a detailed classification of individual crop species. The combination of on site field investigation, including field recording of descriptions, photographs, and GPS coordinates with multi-date ETM+ images provides a basis for discrimination of individual crop types.

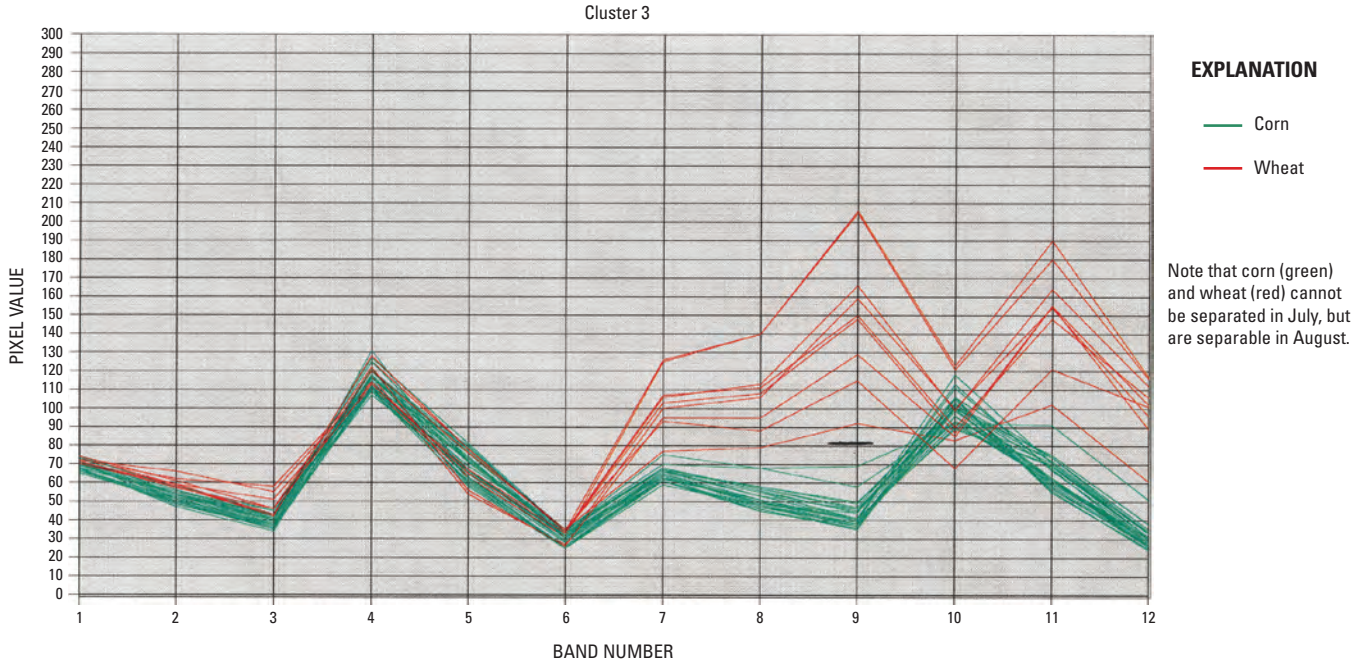


Figure 6. Spectral response curves from the July 2001, bands 1 through 6 and August 2001, bands 7 through 12, Enhanced Thematic Mapper Plus images.

References Cited

Anderson, J.R., Hardy, E.E., Roach, J.T., and Witmer, R.E., 1976, A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p.

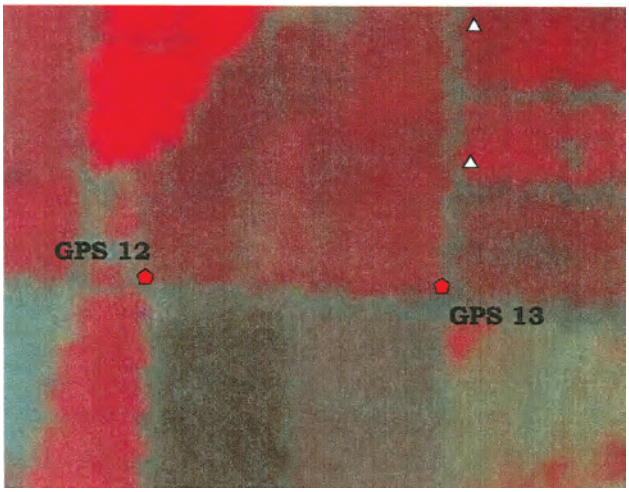
Leica Geosystems, 2007, ERDAS Imagine, *http://gi.leica-geosystems.com/LGISub1x33x0.aspx*, last accessed July 2007.

Tou, J.T., and Gonzalez, R.C., 1974, Pattern recognition principles: Addison-Wesley Publishing Co., Reading, Mass., 377 p.

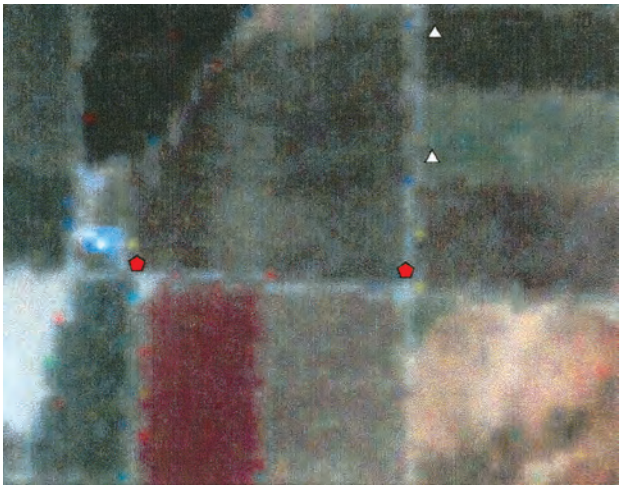
Usery, E.L., Finn, M.P., Scheidt, D.J., Ruhl, S., Beard, T., and Bearden, M., 2004, Geospatial data resampling and resolution effects on watershed modeling: A case study using the agricultural non-point source pollution model, Journal of Geographical Systems, vol. 6, no. 3, p. 286–309.

Table 1. Land cover classified for EL68D Wasteway Watershed.

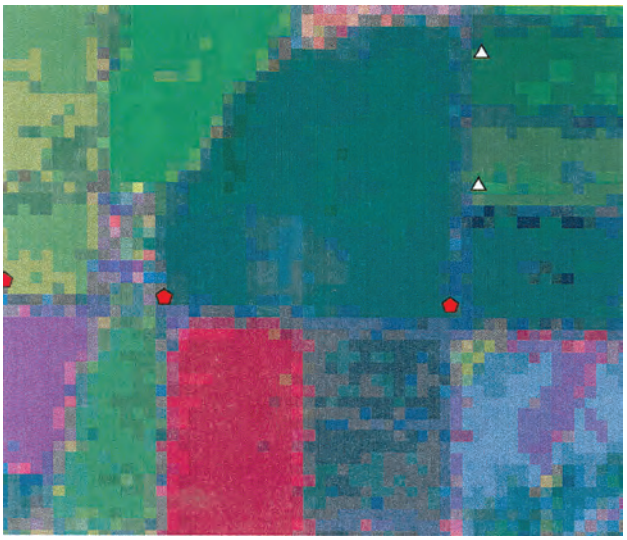
Class	Class code	Class	Class code
Urban			
Urban (unclassified)	10	Urban grasses (parks, cemeteries, golf courses)	17
Residential	11	Impervious surface (commercial)	18
Transportation/utilities	14		
Agriculture, including grasses/grains/irrigated crops			
Agriculture (unclassified)	20	Asparagus	209
Wheat	201	Hay/pasture	210
Soybeans	202	Crops (unclassified)	211
Beans	203	Mixed grass	212
Carrots	204	Corn	213
Onions	205	Cotton	214
Potatoes	206	Peanuts	215
Squash	207	Disturbed or harvested cropland	216
Tomatoes	208		
Orchards			
Unknown orchard	22	Nurseries	223
Peach	221	Feedlots/confined feeding	23
Apple	222		
Bare-cultivated/fallow crop			
Peppermint	217	Alfalfa	219
Spearmint	218	Farmsteads	242
Scrub			
Deciduous low desert scrub	33		
Timber			
Forest (unclassified)	40	Mixed deciduous and pine	43
Mature deciduous	41	Young planted pine	44
Mature planted pine	42		
Water			
Unclassified	50	Lakes/ponds	52
Canals/streams	51	Reservoirs	53
Wetlands			
Non-forested wetlands	60	Forested wetlands	61
Bare exposed			
Barren land	70	Bare transitional	76
Bare rock	74	Mixed barren land	77
Quarry/pit/mine	75		



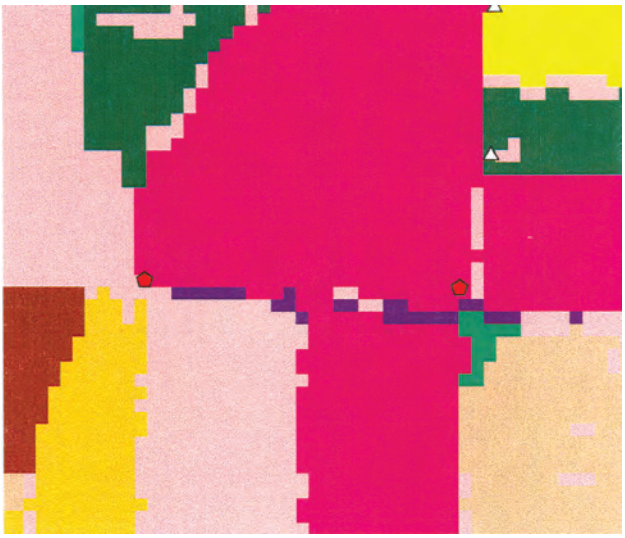
July 12, 2001 (6-band, 30-meter thematic mapping) visual bands (432 false color)



July 12, 2001 (6-band, 30-meter thematic mapping) visible bands (321 true color)



July 12, 2001 (Clustered) 100 clusters



Classified field source data (derivative of cluster data)

Global Positioning System 12 (asparagus)

Global Positioning System 13 (onions)

Figure 7. Global Positioning System locations and digital photographs used in the classification process.

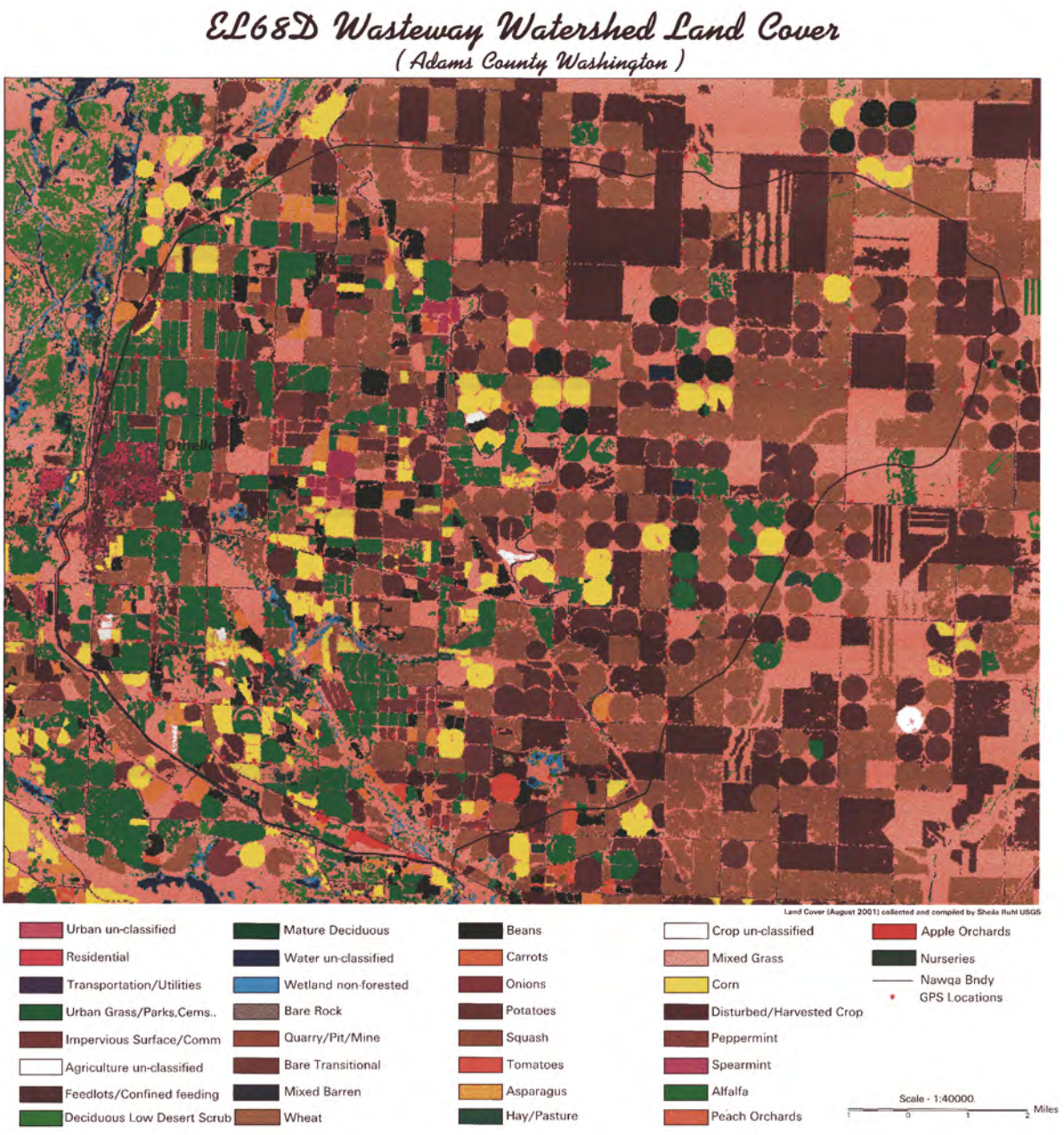


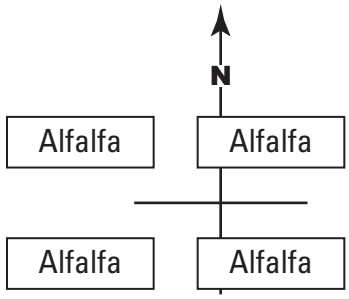
Figure 8. Final land-cover map for the EL68D Wasteway Watershed.

Appendix

GPS Locations For EI68D New Land Cover

Points Collected: 08-07-01

GPS 01:	46 51 11 119 07 36	Peaches east of field rd south Potatoes west of field rd south
GPS 02/3:	46 50 59 119 07 36	Onions east of field rd south Apples south of onions
GPS 04/5:	46 50 38 119 07 36	Apple Orchard west of field rd south Beans east of field rd south (beans have pink blooms)
GPS 06:	46 50 27 119 07 58	Alfalfa north and northwest of intersection Alfalfa south west of intersection Bare Cultivated south



GPS 07:	46 51 14 119 07 59	Cut Wheat west of Hwy 24
GPS 08:	46 52 11 119 07 43	Potatoes south and west of field rd
GPS 09:	46 52 10 119 07 03	Bare Cultivated (was onions) south of field rd Alfalfa North of field rd
GPS 10:	46 52 10 119 06 47	Onions north of rd (some weeds)
GPS 11:	46 52 09 119 06 18	(Young Timothy ?) Grass north of rd Bare Cultivated south of rd
GPS 12:	46 52 08 119 05 59	Asparagus (gone to seed) / Floral south of rd Onions north and east of GPS 12 and rd
GPS 13:	46 52 08 119 05 25	Onions north and south of rd

GPS 14:	46 52 18	Beans east of rd
	119 05 22	Onions west and southeast of GPS 14 and rd
GPS 15:	46 52 29	Corn east of field rd
	119 05 22	Onions west of field rd
GPS 16:	46 52 37	Beans east of rd
	119 05 21	Bare Cultivated west of rd
GPS 17:	46 52 43	Potatoes east of rd
	119 05 21	Bare Cultivated west of rd
GPS 18:	46 54 43	Wheat with Grass mix south of Providence Rd
	119 07 54	Scrub and feed lot north
		Bare Cultivated southwest of GPS 18 and Providence Rd
GPS 19:	46 54 43	Gravel Pit south of Providence Rd
	119 07 15	Natural Grass and Scrub around pit
GPS 20:	46 54 43	Natural Grass and Scrub south of Providence Rd and west
	119 06 44	of track x-ing
GPS 21:	46 54 43	Wheat south of Providence Rd, Grass (?) edge
	119 06 08	Corn north of Providence Rd
GPS 22:	46 54 42	Potatoes south of Providence Rd
	119 05 48	Corn north
GPS 23:	46 54 42	Wheat north and west of Providence Rd and GPS 23
	119 05 17	Cut Wheat north
		Cut Wheat south and east of GPS 23 and Providence Rd
		Grass south and west of GPS 23 and Providence Rd
GPS 24:	46 54 42	Wheat north of Providence Rd
	119 04 55	Cut Wheat north and west of Wheat
		Cut Wheat south
GPS 25:	46 54 42	Wheat south of Providence Rd
	119 04 23	Cut Wheat north
GPS 26:	46 54 41	Bare Cultivated north of Providence Rd
	119 03 43	Mixed Grasses so and w of GPS 26 and Providence Rd
		Cut Wheat south and east of GPS 26 and Providence Rd
GPS 27:	46 54 40	Cut Wheat north and south of Providence Rd
	119 02 03	Bare Cultivated north and east and south and east of
		GPS 27 and Providence Rd
		Bare Cultivated south and west and north and west of
		GPS 27 and Providence Rd

GPS 28:	46 54 40 119 01 03	Cut Wheat south of Providence Rd Bare Cultivated north
GPS 29:	46 54 40 118 59 21	Cut Wheat north of Providence Rd Potatoes south
GPS 30:	46 54 40 118 58 20	Bare Cultivated north of Providence Rd Mixed grass south Bare Cultivated so and e of GPS 30 and Providence Rd
GPS 31:	46 54 41 118 57 32	Mixed Grass and Scrub north and south of Providence Rd
GPS 32:	46 54 40 118 55 39	Grass north of Providence Rd Bare Cultivated south
GPS 33:	46 54 40 118 54 50	Potatoes north of Providence Rd, cut Grass around potatoes Bare Cultivated south Cut Wheat south and east of GPS 33 and Providence Rd Wheat north and east of GPS 33 and Providence Rd
GPS 34:	46 54 40 118 54 15	Beans (small striped (Pinto?) north of Providence Rd Cut Wheat south
GPS 35:	46 54 41 118 53 34	Corn (center pivot) south of Providence Rd, Grass on edges Potatoes north
GPS 36:	46 52 52 118 50 30	Cut Wheat north of Herman Rd Wheat (center pivot) south, Grass and Scrub on edges
GPS 37:	46 52 52 118 52 01	Mixed grass and Scrub north and south of Herman Rd Wheat (center pivot) south and west of GPS 37 and Herman Rd
GPS 38:	46 52 52 118 54 13	Corn south of Herman Rd Cut Wheat north
GPS 39:	46 52 53 118 54 49	Wheat south of Herman Rd
GPS 40:	46 52 56 119 00 29	Cut Wheat south of Herman Rd
GPS 41:	46 52 57 119 03 11	Alfalfa (center pivot) south Herman Rd, Grass on edges Cut Wheat north Corn west and south of GPS 41 and Herman Rd
GPS 42:	46 52 57 119 03 44	Beans north of Herman Rd Corn south

GPS 43:	46 52 57 119 04 16	Alfalfa south of Herman Rd Potatoes north
GPS 44:	46 53 04 119 08 22	Corn (center pivot) south of Herman Rd Grass strip north of Herman Rd, Alfalfa north of Grass strip
GPS 45:	46 52 12 119 08 12	Potatoes north of rd Cut Wheat south
GPS 46:	46 52 12 119 08 25	Alfalfa north of rd Cut Wheat south
GPS 47:	46 51 20 119 08 15	Cut Wheat north and south of Foley Rd
GPS 48:	46 51 19 119 09 18	Alfalfa north of rd Cut Wheat south
GPS 49:	46 50 26 119 10 07	Alfalfa south of Lee Rd Bare Cultivated north
GPS 50:	46 50 27 119 08 08	Alfalfa north and south of Lee Rd Potatoes south and west of Lee Rd
GPS 51:	46 50 26 119 06 31	Peppermint north and south of Lee Rd
GPS 52:	46 50 25 119 05 43	Potatoes north and south of Lee Rd
GPS 53:	46 50 23 119 04 34	Onions south of Lee Rd Alfalfa north
GPS 54:	46 50 22 119 03 48	Peppermint south of Lee Rd Alfalfa north
GPS 55:	46 49 38 119 07 52	Wheat north and west of GPS 55
GPS 56:	46 49 34 119 07 07	Alfalfa south of Cunningham Rd Weeds and Grass north
GPS 57:	46 49 34 119 06 24	Onions north of Cunningham Rd Beans south and west Corn south and east of Beans
GPS 58:	46 49 33 119 05 15	Spearmint north and south of Cunningham Rd

GPS 59:	46 49 31	Potatoes north of Cunningham Rd
	119 04 05	Corn east of Potatoes and north of Cunningham Rd
		Peppermint south of Cunningham Rd
		Asparagus (seed/floral) south of Peppermint
GPS 60:	46 49 30	Potatoes south of Cunningham Rd
	119 02 47	Peppermint north
GPS 61:	46 49 27	Potatoes (center pivot) so of Cunningham Rd, Grass edges
	119 00 30	Cut Wheat north
GPS 62:	46 49 27	Bare Cultivated so of Cunningham Rd, Grass edges
	118 59 59	Weeds and Scrub north
GPS 63:	46 49 24	Potatoes south of Cunningham Rd
	118 57 27	
GPS 64:	46 49 24	Cut and raked Alfalfa north of Cunningham Rd
	118 57 08	
GPS 65:	46 49 24	Wheat south of Cunningham Rd
	118 56 51	Cut and raked Alfalfa north
GPS 66:	46 49 23	Potatoes north of Cunningham Rd
	118 55 29	Alfalfa south
GPS 67:	46 49 22	Burnt field approx. ½ mile south of Cunningham Rd
	118 54 41	
GPS 68:	46 49 22	Cut Wheat (center pivot) south, (?) Grass edges
	118 53 47	Grass north
GPS 69:	46 49 21	Potatoes south of Cunningham Rd
	118 51 05	Grass north
GPS 70:	46 49 40	Cut Wheat east of Kulm Rd
	118 51 23	Grass west of Kulm Rd
GPS 71:	46 50 53	Potatoes east of Kulm Rd
	118 51 22	Wheat west
GPS 72:	46 51 07	Cut Wheat north of Foley Rd
	118 51 47	Wheat south of Foley Rd
GPS 73:	46 51 07	Grass north and south of Foley Rd
	118 53 00	Bare Cultivated north of Grass and north of rd
GPS 74:	46 51 08	Cut Wheat north and south of Foley Rd
	118 54 37	Strip of Grass North and East of GPS 74

GPS 75:	46 51 08 118 55 26	Cut Wheat (center pivot) north of Foley Rd, Scrub and Grass on edges Cut Wheat south
GPS 76:	46 51 09 118 55 59	Cut Wheat (center pivot) north of Foley Rd, Scrub edges Wheat south
GPS 77:	46 51 09 118 56 43	Corn (center pivot) south of Foley Rd, Grass edges Beans (center pivot) north, Grass edges
GPS 78:	46 51 09 118 57 11	Beans (center pivot) north of Foley Rd, Grass edges Corn south
GPS 79:	46 51 10 118 58 02	Potatoes (center pivot) south of Foley Rd Reservoir north
GPS 80:	46 51 10 118 58 34	Wheat north of Foley Rd Potatoes south
GPS 81:	46 51 12 119 00 32	Corn (center pivot) south of Foley Rd, Grass edges Beans (center Pivot) north, Grass edges
GPS 82:	46 51 12 119 0110	Potatoes north of Foley Rd Cut Wheat south
GPS 83:	46 51 13 119 02 25	Corn (center pivot) south of Foley Rd, Grass edges Potatoes (center pivot) north, Grass edges
GPS 84:	46 51 14 119 03 50	Cut Wheat north of Foley Rd Corn south of Foley Rd Wheat east of corn and south of Foley Rd

Points Collected: 08-08-01

GPS 85:	46 48 41 119 11 41	Scrub and Grass south of Hwy 26 Urban north Grass north and east of GPS 85 and north of Hwy 26 Cattails and Marsh Grass east of water and southeast of GPS 85
GPS 86:	46 48 41 119 07 47	Alfalfa south of Hwy 26 Grass, Scrub and rock and small stand of Poplar trees north Wheat no and e of GPS 86 and e of Scrub and Rock Alfalfa east of Wheat and north of Hwy 26

GPS 87:	46 48 41	Cut and raked Alfalfa south of Hwy 26
	119 09 03	Alfalfa north of Hwy 26, Corn north of Alfalfa
GPS 88:	46 48 39	Pasture and Grass north and south of Hwy 26
	119 07 36	Stand of Deciduous Trees in fe row north of Hwy 26
GPS 89:	46 48 29	Bare Cultivated south of Hwy 26
	119 06 30	Corn north
GPS 90:	46 48 21	Corn south of Hwy 26
	119 05 34	Potatoes east of Corn and south of Hwy 26
		Beans north of Hwy 26
		Alfalfa west of Beans and north of Hwy 26
GPS 91:	46 48 11	Grass south of Hwy 26
	119 04 21	Potatoes (center pivot) n of Hwy 26, raked Alfalfa edges
		Beans west of corn and north of Hwy 26
GPS 92:	46 48 07	Potatoes (center pivot) north of Hwy 26, corn in edges
	119 03 54	Potatoes south of Hwy 26
		Potatoes east of center pivot and north of Hwy 26
GPS 93:	46 48 00	Bare Cultivated south of Hwy 26, small square of Scrub
	119 03 12	in NE corner of Bare Cultivated
		Peppermint north of Hwy 26
		Grass and Scrub east of Peppermint and north of Hwy 26
		(some Peppermint mixed in Grass and Scrub)
GPS 94:	46 47 54	Onions south of Hwy 26
	119 02 27	Peppermint west of Onions and south of Hwy 26
		Beans north of Hwy 26
		Bare Cultivated north of Beans
		Alfalfa east of Beans and north of Hwy 26
GPS 95:	46 48 31	Wetland (triangle shape) south of Hwy 26 Grass
	119 06 45	all around Wetland
		Poplar Tree stand and Grass west of Wetland so of Hwy 26
		Wetland (triangle shape) north of Hwy 26
GPS 96:	46 47 41	(3) Non bearing deciduous tree stands north of Hwy 26
	118 59 36	and north and east of GPS 96
		Corn field (center pivot) north of tree stands north of Hwy 26
		Potato field south of Hwy 26
GPS 97:	46 47 39	Potatoes (center pivot) so of Hwy 26, Scrub/Grass edges
	118 56 11	Cut Wheat (center pivot) n of Hwy 26, Scrub/Grass edges
GPS 98:	46 47 38	Potatoes (center pivot) south of Hwy 26, Scrub/Grass edges
	118 54 40	Grass east of center pivot south of Hwy 26
		Burnt (center pivot) north of Hwy 26, Scrub/Grass edges

GPS 99:	46 47 38 118 53 46	Bare Cultivated south of Hwy 26 Grass north of Hwy 26 Cut Wheat north of Grass Grass north and east of Wheat Bare Cultivated north of Cut Wheat
GPS 100:	46 45 56 118 57 45	Bare Cultivated north and east of GPS 100 and Hatton Rd (2) Wheat (center pivot) north and west of GPS 100 and Hatton Rd, Grass edges Bare Cultivated south and east of GPS 100 and Hatton Rd Cut Wheat south and west of GPS 100 and Hatton Rd
GPS 101:	46 45 57 118 59 05	Asparagus north of Hatton Rd Grass/Scrub west of Asparagus n and s of Hatton Rd (runs north and south between canal and rr tracks)
GPS 102:	46 45 57 119 00 12	Onions north of Hatton Rd Potatoes west of Onions and north of Hatton Rd Bare Cultivated south
GPS 103:	46 45 59 119 02 01	Potatoes (center pivot) south of Hatton Rd, Grass edges Beans west of potatoes, (narrow strip of corn between Beans and Hatton Rd) Corn south of Beans Cut and raked Wheat (center pivot) north of Hatton Rd, Grass edges
GPS 104:	46 45 59 119 03 02	Peppermint north and south of Hatton Rd
GPS 105:	46 46 00 119 03 28	Peppermint north of Hatton Rd Onions west of Peppermint and north of Hatton Rd Beans south Alfalfa west of Beans and south of Hatton Rd
GPS 106:	46 46 00 119 04 46	Peppermint north of Hatton Rd Alfalfa east of Peppermint Onions east of Alfalfa Alfalfa south of Hatton Rd
GPS 107:	46 45 59 119 05 25	Grass and Scrub north of Hatton Rd Wetland (Marsh/Cattails along canal)
GPS 108:	46 46 02 119 06 37	Corn south of Hatton Rd Wetlands west of Corn north and south of Rd Mixed Hay/Grass north of Hatton Rd
GPS 109:	46 46 03 119 07 09	Nursery north of Hatton Rd Alfalfa south of Hatton Rd

GPS 110:	46 46 03	Wheat north of Hatton Rd
	119 07 43	Grass north and west of Wheat
		Corn south of Hatton Rd
GPS 111:	46 46 03	Potatoes south of Hatton Rd
	119 08 16	Corn west of Potatoes and south of Rd
		Rock and Scrub along canal north of Hatton Rd
		Grass north of Canal
GPS 112:	46 46 04	Asparagus south of Hatton Rd
	119 08 41	
GPS 113:	46 46 04	Rock and Scrub north and south of Hatton Rd
	119 09 07	Grass north and south of Rock and Scrub
GPS 114:	46 46 04	Rock and Grass north of Hatton Rd
	119 09 14	Rock and Scrub strip along rd south of Hatton Rd
		Alfalfa south of Rock and Scrub strip
GPS 115:	46 46 08	Feedlot west of Hatton Rd
	119 09 18	Grass east of Hatton Rd
GPS 116:	46 46 37	Beans east of Hatton Rd
	119 09 17	Alfalfa west of Hatton Rd
		Corn south of Alfalfa and west of Hatton Rd
GPS 117:	46 47 10	Peppermint east of rd (narrow grass strip along rd)
	119 09 16	Pasture west of rd
GPS 118:	46 46 57	Grass north of rd
	119 09 34	Alfalfa south of rd
GPS 119:	46 46 56	Corn north and east of GPS 119
	119 10 09	Beans south of rd
		(unidentified) irrigated field north and west of GPS 119
GPS 120:	46 46 56	Alfalfa south of rd
	119 08 56	L shape strip of Apple Trees north of rd
		Peppermint north of Apple Trees
GPS 121:	46 46 56	Small Apple Orchard north of rd
	119 08 47	Peppermint north of Apple Orchard
		Pasture/Grass south of rd
GPS 122:	46 46 56	Grass/Pasture south of rd
	119 08 32	Alfalfa north of rd
GPS 123:	46 47 45	Wheat north of rd, some grass mixed in
	119 04 21	Alfalfa west of Wheat and north of rd
		Airfield (paved) south of rd
		Cut Wheat south of Airfield

GPS 124:	46 47 49 119 06 47	Pasture mixed with Scrub north and south of rd
GPS 125:	46 47 49 119 07 51	Grass north of rd Cut and raked Alfalfa south
GPS 126:	46 47 49 119 09 30	Cut Wheat north of rd, Grass mixed in Alfalfa south
GPS 127:	46 47 48 119 10 11	Cut Wheat north of rd, Grass mixed in
GPS 128:	46 47 48 119 11 19	Scrub and Grass north of rd Alfalfa south of rd Small Garden on eastern edge of Alfalfa Scrub and Grass west of Alfalfa
GPS 129:	46 53 14 119 08 00	Alfalfa west of Hwy 17 Corn south of Alfalfa and west of Hwy 17 Beans east of Hwy 17 Corn north and east of Beans
GPS 130:	46 50 43 119 07 59	Alfalfa west of Hwy 17 Potatoes east of Hwy 17 Alfalfa south of Potatoes and east of Hwy 17
GPS 131:	46 49 34 119 08 44	Bare Cultivated south of Hwy Alfalfa north of Hwy Cut Wheat north and west of Alfalfa and GPS 131
GPS 132:	46 49 22 119 08 01	Cut Wheat west of Hwy 17 Peppermint east of Hwy 17 Grass and Weeds south of Peppermint and east of Hwy 17

(Construction excavation @ intersection of Hwy 26 and Hwy 17 Bare Soil just north of Hwy 26 west of intersection of Hwy 26 and Hwy 17)

GPS 133:	46 47 20 119 08 03	Alfalfa fields west of Hwy 17 Alfalfa east of Hwy 17 Grass east of Alfalfa and east of Hwy 17 Corn south of Alfalfa and east of Hwy 17
GPS 134:	46 46 33 119 08 03	Pasture west of Hwy 17 (strips of Marsh Grass and Cattails between Hwy 17 and Pasture west) Pasture east of Hwy 17 Alfalfa east of Pasture and east of Hwy 17

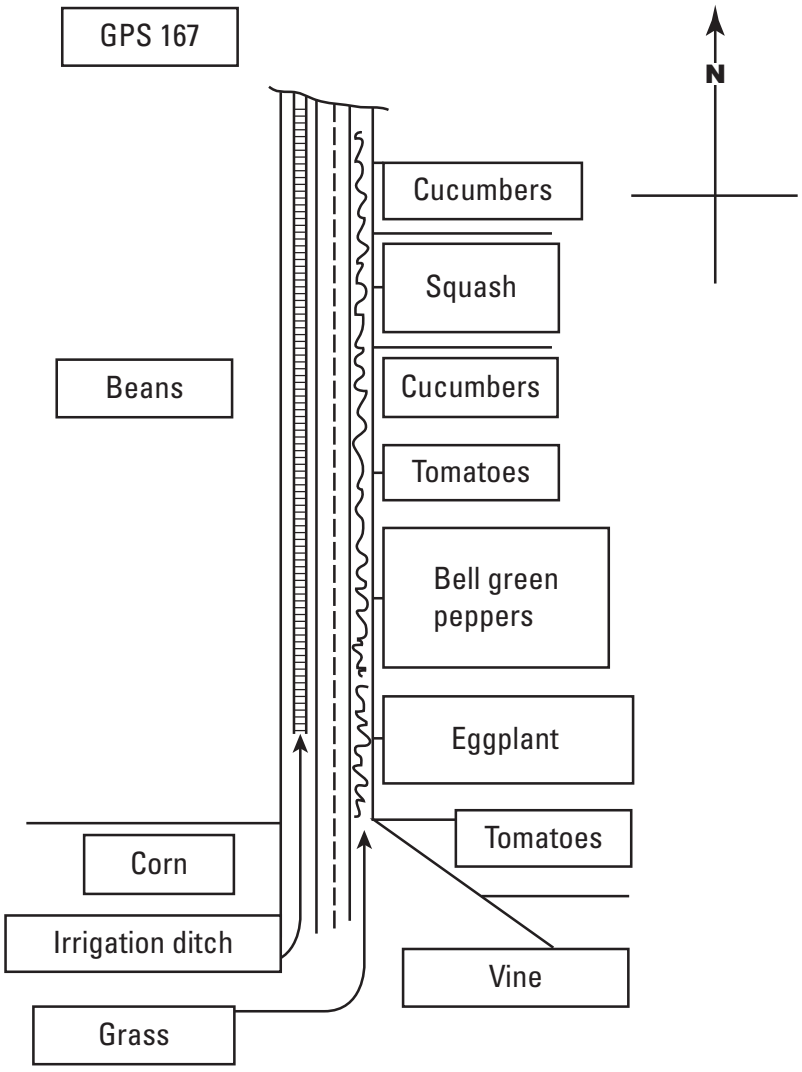
GPS 135:	46 45 12	Potato fields north and east of Hwy 17
	119 07 37	Corn fields north and west and north and east of Potatoes
		Potato (center pivot) south of Hwy 17, Grass edges
GPS 136:	46 44 37	Bare Cultivated south of Hwy 17
	119 06 03	Corn north of Hwy 17
GPS 137:	46 44 25	Apple Orchard south of Hwy 17
	119 05 22	Alfalfa north of Hwy 17
GPS 138:	46 44 07	Apple Orchard south of Hwy 17
	119 04 24	Cut and raked Grass/Hay north of Hwy 17
GPS 139:	46 43 48	Apple Orchard south of Hwy 17
	119 03 16	Grass and Scrub north
GPS 140:	46 43 36	Grass south of Hwy 17
	119 02 25	Corn south of Grass
		Grass and Scrub north
GPS 141:	46 44 13	Bare Cultivated north of Muse Rd
	119 00 41	Peppermint south of Muse Rd
		Corn west of Peppermint and south of Muse Rd
GPS 142:	46 44 14	Peppermint north of rd
	119 01 52	Cut Wheat south of rd
GPS 143:	46 44 14	Peppermint north of rd
	119 02 36	Grass south of rd
GPS 144:	46 44 19	Peach Orchard west of rd
	119 02 55	Peach Orchard (young) north of Peach Orchard
		Corn north of young Peach Orchard west of rd
		Peppermint mixed with Grass east of rd
		Peppermint north of Peppermint and Grass east of rd
GPS 145:	46 45 23	Corn (center pivot) east of rd, Cut Wheat edges
	119 02 52	Potatoes west of rd
GPS 146:	46 45 41	Corn east of rd
	119 02 51	Asparagus west of rd
GPS 147:	46 46 07	Peppermint west of rd
	119 02 53	Beans east of rd

Points Collected: 08-09-01

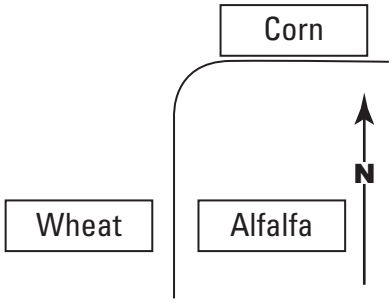
GPS 148:	46 50 09	Bare Cultivated east of canal and rd
	119 09 15	Alfalfa west of rd
		Potatoes north of Alfalfa and west of rd (not healthy)

GPS 149:	46 50 35	Alfalfa east of rd and east of canal
	119 09 15	Cut Wheat west of rd
		Alfalfa west of Cut Wheat
GPS 150:	46 51 27	Alfalfa east of rd (water body between Alfalfa and rd)
	119 09 14	Alfalfa west of rd
		Grass and Scrub north of Alfalfa and west of rd (next to sub division)
GPS 151:	46 52 08	Cut Wheat east of rd
	119 09 14	Alfalfa east and north of Cut Wheat
		Grass and Scrub west of rd
		Bare Cultivated west of Grass and Scrub and east of rr
		Track
GPS 152:	46 52 11	Corn north of rd
	119 09 33	Cut Wheat north and west of Corn
		Potatoes north of Corn
GPS 153:	46 51 19	Alfalfa north of rd
	119 09 46	Onions south of rd
GPS 154:	46 51 19	Alfalfa north and south of rd
	119 10 15	
GPS 155:	46 51 01	Scrub west of tracks and rd
	119 10 26	
GPS 156:	46 49 57	Alfalfa east of rd
	119 10 32	Urban Grass north of Alfalfa
		Bare Soil and Grass west
GPS 157:	46 48 20	Scrub and Rock west of rd
	119 11 17	Bare Soil and Rock east of canal
GPS 158:	46 48 10	Grass and Rock west of rd
	119 11 13	Rock and Scrub east of rd and east of canal
GPS 159:	46 48 52	Wheat (center pivot) west of rd, Grass edges
	119 09 17	Ball Diamond north of Wheat
		Alfalfa east of rd
GPS 160:	46 48 34	Alfalfa mixed with Grass west of rd
	119 09 17	Cut and raked Alfalfa east of rd
GPS 161:	46 48 23	Pasture (livestock grazing) west of rd
	119 09 17	(Strip of Rocks between rd and Pasture)
		Cut and Raked Alfalfa east
GPS 162:	46 47 42	Grass west of rd
	119 09 17	Pasture east of rd
		Adams Co Fairgrounds south of Pasture and east of rd

GPS 163:	46 47 17 119 09 17	Pasture west of rd Peppermint mixed with Grass east of rd
GPS 164:	46 46 44 119 09 17	Alfalfa west of rd Corn south of Alfalfa and west of rd Beans east of rd Alfalfa east of Beans and east of rd 2 Peppermint fields south of Alfalfa east of rd (Grass between mint fields)
GPS 165:	46 46 21 119 08 03	Pasture east and west of rd
GPS 166:	46 47 21 119 06 45	Grass west of rd Cut Alfalfa east of rd Alfalfa east of Cut Alfalfa east of rd Wheat south of Cut Alfalfa and Alfalfa east of rd
GPS 167:	46 46 53 119 06 45	Beans west of rd Corn south of Beans and west of rd Small plots of Mixed Crop east



GPS 168:	46 46 32	Pasture east of rd
	119 06 45	Hay north and east of Pasture
		Pasture west of rd
		Squash south of Pasture west of rd
GPS 169:	46 46 13	Pasture east of rd
	119 06 45	Feedlot and Barns west of rd
		Corn south of Feedlot
GPS 170:	46 46 02	Alfalfa south of rd
	119 06 55	Corn southeast of alfalfa
		Feedlot north of rd
GPS 171:	46 45 12	Alfalfa west of rd
	119 07 57	Corn east of rd
		Potatoes south of Corn and east of rd (some weeds)
GPS 172:	46 44 29	Onions east of rd
	119 08 37	Grass west of rd
GPS 173:	46 45 12	Potatoes northeast of rd
	119 07 36	Corn east of Potatoes
GPS 174:	46 45 10	Corn north of Yeisley Rd
	119 06 55	Strip of Grass south of Yeisley Rd
		Corn south of Grass strip
GPS 175:	46 45 09	Grass south of Yeisley Rd
	119 06 35	Cut Alfalfa north of Yeisley Rd
GPS 176:	46 45 09	Cut and raked Alfalfa south of Yeisley Rd
	119 05 35	Alfalfa east of Cut Alfalfa and east of north/south rd
		Cultivated (weedy) north of Yeisley Rd
GPS 177:	46 45 36	Alfalfa east of rd
	119 05 27	Ridge of Scrub northeast of Alfalfa
		Corn west of rd
		Wheat north of Corn and north and west of rd
GPS 178:	46 46 14	Alfalfa east of rd
	119 04 49	Peppermint west of rd
GPS 179:	46 46 46	Alfalfa east of rd
	119 05 04	Corn north of Alfalfa and north of rd
		Wheat west of rd

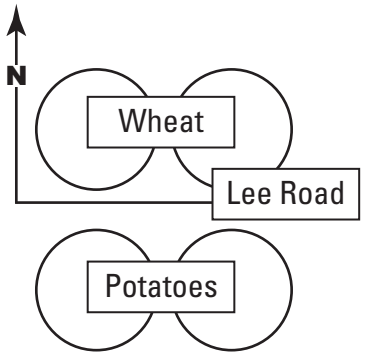


GPS 180:	46 46 43	Alfalfa west of rd
	119 04 10	Alfalfa east of rd
		Scrub ne of Alfalfa east running east and west along gulch
GPS 181:	46 45 49	Alfalfa east and west of rd
	119 04 34	
GPS 182:	46 45 36	Peppermint north of rd
	119 03 50	Cut Wheat (center pivot) south of rd, Scrub edges
		Peppermint east of Wheat and east of north/south rd
GPS 183:	46 45 07	Bare Cultivated south of rd
	119 03 23	Alfalfa north
GPS 184:	46 45 06	Potatoes south of rd
	119 02 31	Cut Wheat north
		Corn north of Cut Wheat
		Onions east of Corn and Cut Wheat
GPS 185:	46 44 26	Cut Wheat (center pivot) east of rd, Grass edges
	119 01 38	Asparagus west of rd, some weeds
		Peppermint south of Asparagus and west of rd
GPS 186:	46 44 52	Carrot fields (center pivot) east of rd, Bare Cultivated edges
	119 01 37	Potatoes (center pivot) west of rd
GPS 187:	46 45 42	Cut Wheat east of rd, (Bare Cultivated square in center)
	119 01 36	Potatoes (center pivot) west of rd
GPS 188:	46 45 47	Cut Wheat west of Fox Rd
	118 59 19	Grass and Scrub east of Fox Rd running north and south along rr track
GPS 189:	46 45 14	Bare Cultivated east and west of Fox Rd
	118 59 03	Corn south of Bare Cultivated and east of Fox Rd
GPS 190:	46 45 04	Beans south of Yeisley Rd
	118 59 18	Wheat east of Beans
		(?) Grass north of rd
		Bare Cultivated north of Grass
GPS 191:	46 45 04	Bare Cultivated north of Yeisley Rd
	118 59 43	Wheat south
GPS 192:	46 45 02	(?) Grass west of rd
	119 00 20	Bare Cultivated west of Grass
GPS 193:	46 44 33	Bare Cultivated west of rd
	119 00 21	Wheat east of rd and canal
		Alfalfa east of Wheat

GPS 194:	46 44 12	Cut Alfalfa south of Muse Rd
	118 59 57	Carrots north of Muse Rd
GPS 195:	46 40 10	Onions east of Lucy Rd
	119 00 20	Potatoes west of Lucy Rd
GPS 196:	46 46 35	Potatoes (center pivot) east and west of Lucy Rd
	119 00 20	
GPS 197:	46 47 11	Potatoes (center pivot) east of Lucy Rd
	119 00 20	New growth (?) west of Lucy Rd
GPS 198:	46 54 27	Bare Cultivated west of rd
	119 06 25	Wheat (center pivot) east of rd, Grass edges
GPS 199:	46 53 59	Wheat east of rd
	119 06 39	Spearmint fields west of rd
GPS 200:	46 53 37	Cut Wheat west of rd
	119 06 39	Asparagus east of rd
GPS 201:	46 53 22	Alfalfa west of rd
	119 06 39	Peppermint east of rd
GPS 202:	46 53 24	Asparagus east of rd
	119 05 21	
GPS 203:	46 54 17	Wheat east of rd, some Grass mix
	119 05 21	
GPS 204:	46 54 28	Potatoes west of rd
	119 05 25	Bare soil along canal east of rd
GPS 205:	46 53 42	Wheat (center pivot) west of rd, Grass edges
	119 02 48	Cut Wheat east of rd
GPS 206:	46 53 06	Cut Wheat west of rd
	119 02 48	Grass east of rd
GPS 207:	46 52 45	Cut Wheat east of rd
	119 02 48	(2) Alfalfa (center pivot) west of rd, Grass edges
GPS 208:	46 52 13	Cut Spearmint field west of rd
	119 02 49	Spearmint (young) east of rd, (not flowering)
GPS 209:	46 51 59	Spearmint (mature) fields west of rd
	119 02 49	Spearmint (young) east of rd, (not flowering)

GPS 210:	46 51 22 119 02 49	Peppermint west of rd Onions north of Peppermint and west of rd Grass and Scrub east of rd (2) Potato fields (center pivot) east of Grass and Scrub and east of rd
GPS 211:	46 51 26 119 00 16	Beans west of rd Potatoes east of rd
GPS 212:	46 51 53 119 00 15	Cut Wheat (center pivot) east and west of rd, Grass edges
GPS 213:	46 52 17 119 00 15	Bare Cultivated east of rd Cut Wheat (center pivot) west of rd, Grass edges Bare Cultivated northwest of GPS 213 and Cut Wheat
GPS 214:	46 53 28 119 00 14	Bare Cultivated east of rd Cut Wheat west of rd Bare Cultivated north of Cut Wheat and west of rd Bare Cultivated north and west of Cut Wheat
GPS 215:	46 54 35 118 57 41	Bare Cultivated west of rd Scrub and Grass east of rd
GPS 216:	46 53 32 118 57 42	Bare Cultivated east and west of Irby Rd Grass and Scrub north and east of GPS 216 and east of rd
GPS 217:	46 53 08 118 57 42	Bare Cultivated west of Irby Rd Cut Wheat (center pivot) east of rd, Grass edges Cut Wheat (center pivot) south of Herman Rd and east and west of Irby Rd, Grass edges
GPS 218:	46 52 19 118 57 44	Beans (Pinto?) (center pivot) west of rd, Grass edges (Pelgro Pesticide on Beans) Potatoes (center pivot) east of rd Bare Cultivated southeast of GPS 218 and Potatoes Corn (center pivot) south of Potatoes and east of Irby Rd, Grass edges Potatoes (center pivot) west of Corn and west of Irby Rd, Grass edges
GPS 219:	46 51 26 118 57 44	Reservoir west of Irby Rd, Grass around Reservoir Beans (center pivot) east of Irby Rd, Grass edges
GPS 220:	46 50 56 118 57 45	Potatoes (center pivot) west of rd, Grass edges Cut Wheat south of Potatoes and west of Irby Rd Corn (center pivot) east of rd, Grass edges Cut Wheat (center pivot) south of Corn and east of Irby Rd

GPS 221:	46 50 17 118 57 24	(2) Potato (center pivot) south of Lee Rd, (2) Cut Wheat (center pivot) north of Rd, Grass edges



GPS 222:	46 51 21 118 53 54	Bare Cultivated east of Johnson Rd Cut Wheat (center pivot) west of rd, Grass edges
GPS 223:	46 52 11 118 54 54	Cut Wheat (center pivot) east and west of Johnson Rd, Grass edges
GPS 224:	46 52 38 118 53 53	Corn (center pivot) west of Johnson Rd, Grass edges Cut Wheat (center pivot) east of Johnson Rd
GPS 225:	46 53 41 118 53 53	Grass, some Scrub mixed east of Johnson Rd Cut Wheat (center pivot) north of Grass and east of rd Cut Wheat west of Johnson Rd Bare Cultivated west of Cut Wheat and west of Johnson Rd
GPS 226:	46 54 26 118 53 53	Corn (center pivot) east of Johnson Rd Cut Wheat west of Johnson Rd
GPS 227:	46 51 46 118 51 22	Potatoes (center pivot) east of Kulm Rd, Grass edges Cut Wheat (center pivot) west of Rd, Grass edges Bare Cultivated north of Potatoes and Cut Wheat and east and west of Kulm Rd
GPS 228:	46 51 11 118 51 22	Cut Wheat (center pivot) west of Kulm Rd, Grass edges Grass east of Kulm Rd
GPS 229:	46 49 33 119 05 16	Spearmint north and south of Cunningham Rd
GPS 230:	46 49 06 119 08 17	Bess Hampton Memorial Gardens Cemetery (Pine and Cedar within Cemetery)
GPS 231:	46 49 47	Lions Club Park, Othello, Wa.

Points Collected: 08-10-01

GPS 232:	46 51 05	Alfalfa fields west of rd
	119 06 42	Onion fields east of rd
GPS 233:	46 50 52	Alfalfa west of rd
	119 06 42	Potatoes east of rd

Peppermint (center pivot) south of Potatoes and east of rd, Grass edges

GPS 234:	46 50 14	Cut Wheat west of rd
	119 06 43	Peppermint east of rd
GPS 235:	46 49 50	Grass west of rd
	119 06 43	Asparagus east of rd
		Onions south of Asparagus and east of rd
GPS 236:	46 49 26	Alfalfa west of rd
	119 06 44	Bare Cultivated south of Alfalfa and west of rd
		Beans east of rd
		Alfalfa south of Beans and east of rd
GPS 237:	46 48 11	(2) Corn (center pivot) west of rd, Grass edges
	119 05 27	Potatoes (center pivot) east of road, Grass edges
		Alfalfa south of Potatoes and east of rd
GPS 238:	46 47 42	Squash (over mature) west of rd, Grass mixed
	119 05 27	Corn south and west of Squash and west of rd

Alfalfa east of rd

GPS 239:	46 47 01	Alfalfa east of rd
	119 02 53	Corn south of Alfalfa and east of rd
		Cut Wheat west of Corn and west of rd
GPS 240:	46 47 26	Cut and raked Alfalfa east of rd
	119 02 53	(2) Wheat fields east of Alfalfa, Grass between Cut Alfalfa and Wheat
		Corn east of Wheat
		Grass west of rd
GPS 241:	46 48 10	Potatoes east of rd
	119 02 53	Beans north of Potatoes and east of rd
		Peppermint west of rd, Scrub mixed in west of rd
		Beans east of Corn and east of rd
GPS 242:	46 48 38	Peppermint east and west of rd
	119 02 52	Corn north of Peppermint and north of rd
		Potatoes south of Peppermint and east of rd
GPS 243:	46 49 28	Potatoes east of rd
	119 02 53	Alfalfa west of rd

GPS 244:	46 49 20	Potatoes (center pivot) west of rd, Grass edges
	119 00 19	Bare Cultivated (center pivot) east of rd, Grass edges
GPS 245:	46 48 14	Cut Wheat east of rd
	119 00 20	Corn (center pivot) west of rd
		Potatoes north of Corn and west of rd
GPS 246:	46 50 33	Beans east of rd
	119 00 17	Bare Cultivated west of rd
		Corn fields (center pivot) north of Beans and Bare Cultivated and east and west of rd
GPS 247:	46 50 05	Potatoes (center pivot) east and west of Irby Rd,
	118 57 45	Grass edges
		Bare Cultivated south of Potatoes and west of Irby Rd
		Cut Alfalfa south of Potatoes and east of Irby Rd
		(Some new growth in Cut Alfalfa field)
GPS 248:	46 49 12	Potatoes (center pivot) east and west of Irby Rd,
	118 57 46	Grass edges
		(Potatoes west of rd had been harvested as of 08-10-01)
		Corn (center pivot) south of harvested Potato field
GPS 249:	46 48 20	Cut Wheat west of rd
	118 57 46	Cut Alfalfa (center pivot) east of rd, Scrub edges
GPS 250:	46 47 28	Potatoes (center pivot) west of rd, Bare Cultivated edges
	118 57 46	Grass and Scrub east of rd
GPS 251:	46 47 01	Bare Cultivated west of rd
	118 57 46	Potatoes (center pivot) east of rd
		Cut Wheat south of Potatoes and east of rd
		Bare Cultivated south of Wheat and east of rd
GPS 252:	46 46 05	Cut Wheat (center pivot) west of rd, Grass edges
	118 57 46	Bare Cultivated east of rd
GPS 253:	46 49 33	Cut Wheat (center pivot) west of rd, Grass edges
	118 53 56	Grass east of rd
GPS 254:	46 51 01	Grass east of rd
	118 53 55	Cut Wheat (center pivot) west of rd, Grass edges
GPS 255:	46 52 38	Cut Wheat (center pivot) east of rd, Grass edges
	118 53 54	Corn (center pivot) west of rd, Grass edges

Notes:

According to local residents in and around the El68D Wasteway Watershed, Beans, Asparagus, and Wheat were grown for seed.

Corn was grown mostly for silage or animal consumption except for some smaller individual plots of sweet corn.

Potatoes, Wheat, Alfalfa, Spearmint, and Peppermint were all at different stages of maturity during field visit.

Also according to local residents there wasn't any Barley growing in EL68D Wasteway Watershed.

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