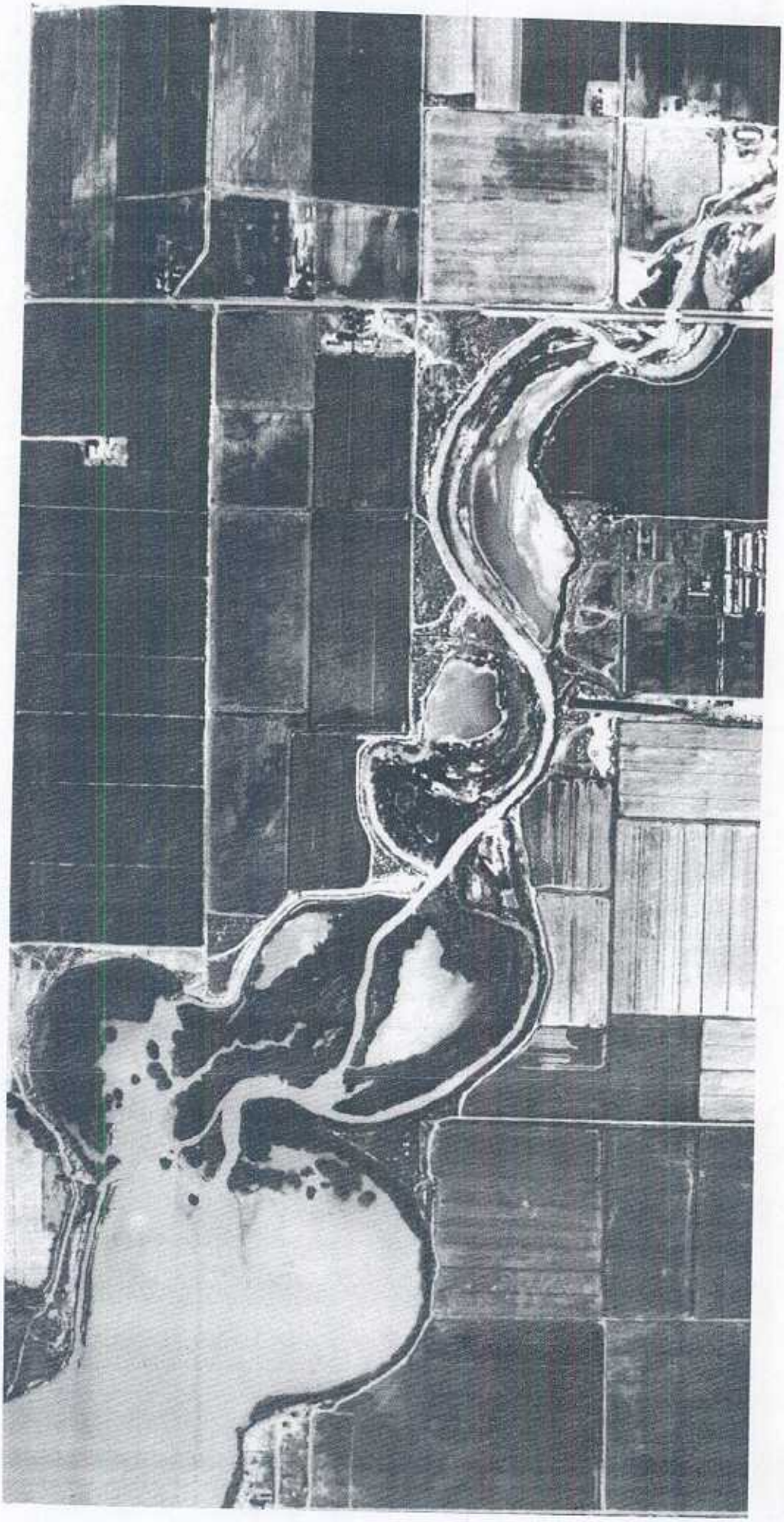

Water-Related Land Use Inventories

Utah

Sevier River Basin

UTAH
NATURAL RESOURCES
Water Resources

Inventory
SP lu/use/state/cnty500 & name

WATER-RELATED
LAND USE INVENTORY REPORT
of the
SEVIER RIVER BASIN

Aerial Photography and Field Mapping
Conducted 1981 thru 1985

Prepared by

Utah Department of Natural Resources
Division of Water Resources

October 1992

ACKNOWLEDGEMENTS

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D. Larry Anderson

D. Larry Anderson, Director

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SUMMARY

The Water-Related Land Use Inventory Report of the Sevier River Basin is another in a series of land use reports prepared by the Division of Water Resources. In compiling these reports, the division has developed a program to determine water supply and water use throughout the state. The hydrologic and climatic data required to make these determinations has generally been available from other state or federal resources agencies, but up-to-date land use data has not always been available from outside sources. The land use inventory program of the division was set up to provide data needed in the preparation of water budgets, hydrologic inventory reports, and other state water planning needs.

The water-related land use data for the Sevier River Basin was collected in three separate studies corresponding to the upper, middle, and lower portions of the basin. The division contracted with the University of Utah Center for Remote Sensing and Cartography (CRSC) in 1981 to provide land use data for the upper Sevier River area, and again in 1984 for the same services on the middle portion of the Sevier River. The division contracted with Olympus Aerial Surveys Inc. in 1985 to provide the 35mm photography on the San Pitch River drainage and the lower Sevier River basin to complete the land use data requirements for input to the Sevier River Hydrologic Inventory. The methodology used by the CRSC is summarized in this report and given in detail in the CRSC Reports 81-6 and 84-5, Supplements I and II to this report.

The water-related land use data for the Sevier River Basin is displayed in the report by study/subarea (see Figures 5 through 17) and tabulated by study/subarea and county in Tables i and ii of this summary and are repeated in the main body of the report as Tables 2 and 3, respectively.

Table i. Summary of Land Cover (in acres) by Study/Subarea for the Sevier River Basin.

Code	Cover	Mammoth (5-6-1)	Panguitch (5-6-2)	East Fork (5-5-1)	Otter Creek (5-5-2)	Piute (5-6-3)	Marysvale (5-4-1)	Richfield (5-4-2)
		Study/Subareas						
IA1a	Orchard	0	0	0	0	0	0	2
IA1e	Berries	0	0	0	0	0	0	0
IA2a	Grain	0	558	817	403	218	304	5,576
IA2a1	Corn	0	0	5	0	472	0	2,674
IA2b1	Potatoes	0	0	17	0	3	0	0
IA2b2	Onions	0	0	0	0	0	0	0
IA2b3	Beans	0	0	0	0	0	0	0
IA2b4	Tomatoes	0	0	0	0	0	0	0
IA2c	Other Row Crops	0	0	0	0	0	0	0
IA3a	Alfalfa	123	3,375	3,028	3,302	4,379	1,479	14,975
IA3b	Grass/Hay	0	0	0	0	0	0	0
IA3d	Pasture	665	3,916	875	980	1,212	1,074	6,998
IA3e	Turf	0	0	0	0	0	0	0
IA4a	Idle Plowed	0	0	56	0	0	18	407
IA4b	Idle Overgrown	0	0	0	0	27	329	4,406
IIA1a	Pasture (Subject to spring flooding)	911	2,923	368	2,160	1,556	766	3,197
IIA1b	Grass/Hay (Subject to spring flooding)	221	498	1,382	2,940	0	0	0
Surface Irrigated Cropland Subtotal		1,919	11,269	6,547	9,784	7,866	3,970	38,235
IIA2a	Sub-Irrigated Pasture	102	1,906	531	673	1,752	1,090	3,025
IIA2b	Sub-Irrigated Grass/Hay	0	0	0	0	0	0	0
Sub-Irrigated Cropland Subtotal		102	1,906	531	673	1,752	1,090	3,025
Total Irrigated Croplands		2,021	13,175	7,078	10,458	9,617	5,060	41,261
IIC	Wet Flats (Cattails/bullrush, etc.)	0	0	0	0	0	52	519
IIE	Riparian Areas	202	687	491	308	423	1,068	574
IIF	Open Water	600	1,241	457	2,915	1,927	228	597
IIF4a	Temporarily Flooded	0	27	94	268	359	463	1,133
IIF4b	Sewage Lagoon	3	0	4	0	0	0	3
Wet/Open Water Areas Subtotal		805	1,954	1,045	3,492	2,709	1,811	2,825
VB	Residential	1,184	1,235	204	304	701	452	6,723
VB4	Public Open Space (Parks, golf courses)	0	0	12	18	0	4	0
VC	Commercial/Industrial	0	34	0	0	0	0	0
Built-up Land Areas Subtotal		1,184	1,269	216	322	701	456	6,723
Land Use/Land Cover Totals		4,011	16,398	8,339	14,271	13,027	7,326	50,809

Table i. Continued.

Code	Cover	San Pitch (5-1)	Gunnison (5-3)	Scipiolintic (5-2-1)	Fillmore (5-7)	Delta (5-2-2)	Sevier Lake (5-8)	Total
		Study/Subareas						
IA1a	Orchard	0	0	0	0	28	0	30
IA1e	Berries	0	0	0	0	0	0	0
IA2a	Grain	8,107	5,903	2,874	13,374	21,866		60,000
IA2a1	Corn	641	2,871	532	3,050	5,609	0	15,853
IA2b1	Potatoes	0	0	5	1,526	0	0	1,551
IA2b2	Onions	3	0	0	13	13	0	29
IA3a	Alfalfa	25,820	17,037	10,802	20,120	27,649	0	132,087
IA3b	Grass/Hay	4,117	0	0	404	353	0	4,874
IA3d	Pasture	21,598	6,303	1,801	6,099	5,565	0	57,085
IA4a	Idle Plowed	682	133	917	4,495	3,590	0	10,297
IA4b	Idle Overgrown	2,971	10,379	11,640	2,276	4,838	0	36,865
IIA1a	Pasture (Subject to spring flooding)	10,712	3,862	0	0	0	0	26,453
IIA1b	Grass/Hay (Subject to spring flooding)	0	0	0	0	0	0	5,040
Surface Irrigated Cropland Subtotal		74,648	46,487	28,571	51,358	69,511	0	350,166
IIA2a	Sub-Irrigated Pasture	9,087	6,454	6,232	71	0	0	30,922
IIA2b	Sub-Irrigated Grass/Hay	0	0	0	0	0	0	0
Sub-irrigated Cropland Subtotal		9,087	6,454	6,232	71	0	0	30,922
Total Irrigated Croplands		83,735	52,941	34,803	51,429	69,511	0	381,088
IIC	Wet Flats (Cattails/bullrush, etc.)	588	3,383	1,904	0	0	n/a[a]	6,447
IIE	Riparian Areas	444	730	399	25	4,093	0	9,444
IIF	Open Water	2,583	6,638	1,541	307	6,372	120,422[b]	25,406[c]
IIF4a	Temporarily Flooded	458	1,045	1,242	0	2,919	0	8,006
IIF4b	Sewage Lagoon	119	0	0	29	164	0	321
Wet/Open Water Areas Subtotal		4,192	11,796	5,087	361	13,548	120,422[b]	49,624[c]
VB	Residential	7,396	3,546	1,299	2,298	4,159	0	29,500
VB4	Public Open Space (Parks, golf courses)	308	0	0	20	122	0	483
VC	Commercial/Industrial	581	0	27	148	362	n/a	1,152
Residential/Industrial Subtotal		8,285	3,546	1,326	2,466	4,642	n/a	31,135
Land Use/Land Cover Totals		96,211	68,283	41,216	54,256	87,700	120,422[d]	461,847

[a,b,c,d]Figures for Sevier Lake are not included in the totals. See footnotes on page opposite Figure 17 for explanation.

Table ii. Summary of Land Cover (in acres) by County for the Sevier River Basin.

Code	Cover	Iron	Piute	Garfield	Kane	Sevier	Sanpete	Millard	Juab	Total
			Counties							
IA1a	Orchard	0	0	0	0	2	0	28	0	30
IA2a	Grain	0	915	1,207	0	7,563	12,202	36,722	1,391	60,000
IA2a1	Corn	0	477	0	0	4,601	1,584	9,107	84	15,853
IA2b1	Potatoes	0	10	9	0	0	0	1,532	0	1,551
IA2b2	Onions	0	0	0	0	0	3	27	0	29
IA3a	Alfalfa	0	8,434	6,250	0	24,077	34,755	53,128	5,444	132,087
IA3b	Grass/Hay	0	0	0	0	0	4,117	757	0	4,874
IA3d	Pasture	0	3,031	4,833	31	10,381	25,343	12,526	940	57,085
IA4a	Idle Plowed	0	74	0	0	443	779	8,063	939	10,297
IA4b	Idle Overgrown	0	356	0	0	8,796	8,960	11,338	7,416	36,865
IIA1a	Pasture (Subject to spring flood)	233	2,735	3,677	115	0	13,323	0	0	26,453
IIA1b	Grass/Hay (Subject to spring flood)	0	2,909	1,444	0	687	0	0	0	5,040
Surface Irrigated Cropland Subtotal		233	18,940	17,421	146	62,921	101,065	133,227	16,213	350,166
IIA2a	Sub-Irrigated Pasture	18	3,288	2,211	52	5,089	13,962	825	5,477	30,922
IIA2b	Sub-Irrigated Grass/Hay	0	0	0	0	0	0	0	0	0
Sub-Irrigated Cropland Subtotal		18	3,288	2,211	52	5,089	13,962	825	5,478	30,922
Total Irrigated Croplands		251	22,228	19,633	198	68,009	115,027	134,052	21,691	381,088
IIC	Wet Flats (Cattails/bullrush, etc)	0	52	0	0	630	3,860	0	1,904	6,447
IIE	Riparian Areas	0	1,785	1,328	0	1,193	621	4,368	149	9,444
IIF	Open Water	46	4,566	1,744	502	1,813	5,816	6,802*	4,118	25,406*
IIF4a	Temporarily Flooded	27	1,064	120	0	1,734	901	3,320	841	8,006
IIF4b	Sewage Lagoon	0	0	4	3	3	119	192	0	321
Wet/Open Water Areas Subtotal		72	7,467	3,195	505	5,372	11,318	14,682	7,012	49,624
VB	Residential	221	1,273	1,572	753	9,272	8,655	7,030	726	29,500
VB4	Open Spaces (Parks, golf courses)	0	22	12	0	0	308	142	0	483
VC	Commercial/Industrial	0	0	34	0	0	581	537	0	1,152
Built-Up Land Areas Subtotal		221	1,294	1,618	753	9,272	9,544	7,708	726	31,135
Land Use/Land Cover Totals		545	30,989	24,445	1,456	82,653	135,888	156,442	29,428	461,847

*This total does not include the surface area of Sevier Lake because it is so highly variable from season to season and year to year. For a further explanation, see the footnote for the table opposite the Sevier Lake Study Area figure on page 28.

The division inventoried 461,847 acres of land in the Sevier River Basin. This included land in Juab, Millard, Sanpete, Sevier, Piute, Kane, Iron and Garfield counties. This represents about seven percent of the entire Sevier River Basin (approximately 6.7 million acres). Of the 461,847 acres inventoried, 350,166 were surface irrigated cropland; 30,922 were grasses, hays, and pastureland which receive subsurface irrigation; 49,624 were phreatophytes and other wet/open water areas; and 31,135 were residential/industrial areas. In addition, approximately 36,865 acres were classified as idle agricultural land. In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agricultural lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown in non-irrigated category reflect only the number of acres mapped, not the total number of acres that may be in that category in the basin.

This report also discusses the Division of Water Resources' previous and present methodology of collecting and processing water-related land use data. It discusses the various land use classification codes used in past studies and what is now considered the Standard Land Use Codes, which the division adopted in 1988 for all land use/land cover studies.

The information should be valuable to a variety of users, including county and city planners, state and federal agencies, and private land owners. The division will use the data to update water budget reports, operate basin hydrologic models, and in state planning reports.

INTRODUCTION

The Division of Water Resources has been charged by the Utah State Legislature with the responsibility of developing a State Water Plan. This plan would coordinate and give direction to the activities of state and federal agencies concerned with Utah's water resources. To accomplish this objective, an assessment of the land use and available water resources is being made on a continuing basis. As a basis for planning and further development, the state has been divided into 11 natural drainage basins or study units as shown in Figure 1. The Southeast Colorado River Basin (originally designated basin No. 9) has been divided into the Southeast Colorado River Basin (retaining designation No. 9) and the Lower Colorado River Basin, which is now basin No. 10.

While land use inventories contain information on land use in the state, hydrologic inventories contain climate, hydrologic, and general information on the water resources within specific drainages. Each hydrologic inventory contains a water budget for a specific drainage area of the state. The water budgets provide an accounting of water inflow, outflow, yield, storage, evaporation, transpiration and uses in the study area. Hydrologic Inventories currently published by the division are listed in Appendix A.

A major consideration in preparing these water budgets is the quantity of water depleted through evaporation and transpiration. Estimates of these depletions are obtained by preparing water budgets from data gathered in the water-related land use inventories. This data includes the kinds and extent of irrigated crops, as well as similar information on phreatophytes, wet/open water areas, and residential/industrial areas.

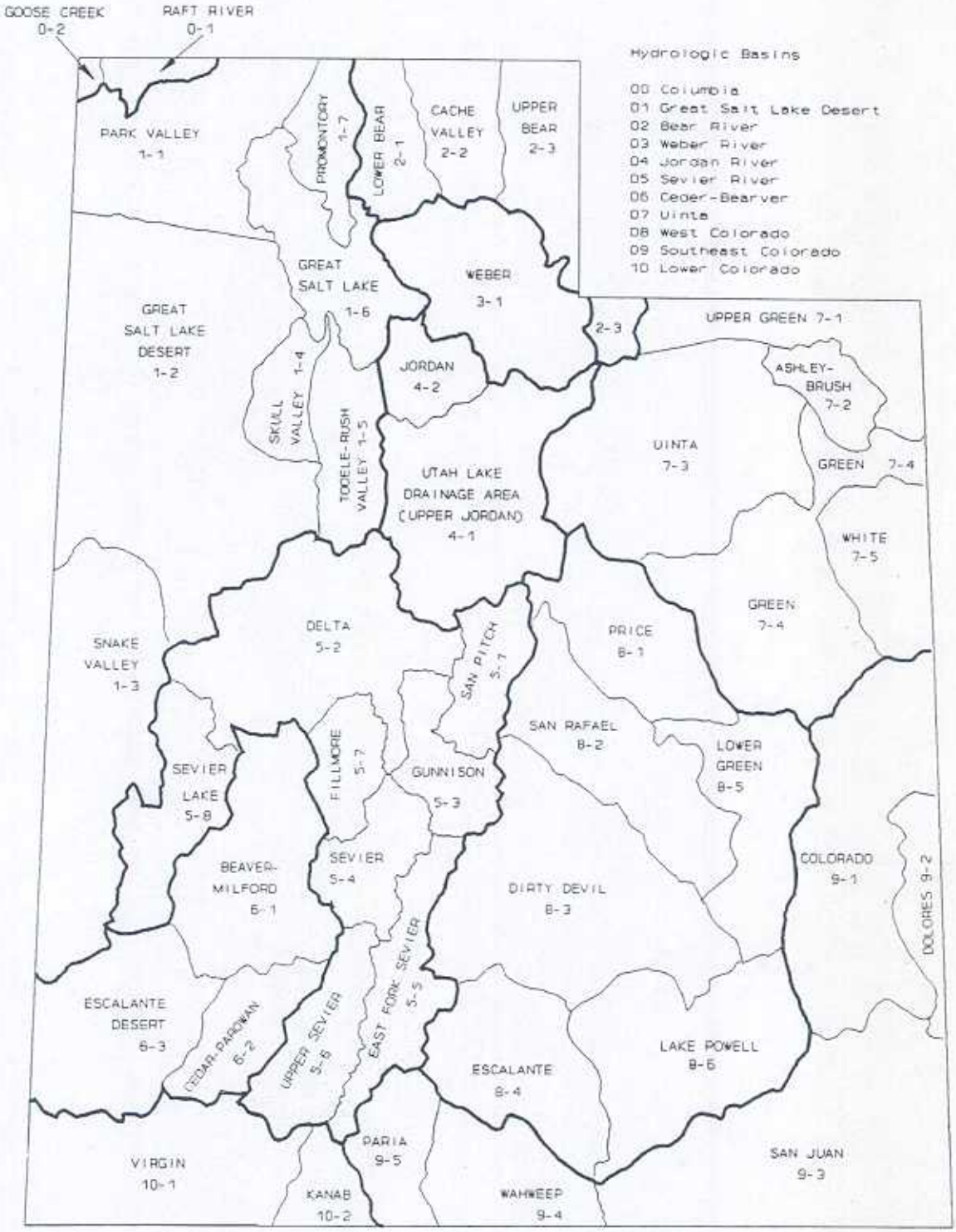

Figure 1. Hydrologic Basins and Study Areas in the State of Utah with the Sevier River Basin highlighted.

Since 1966, the division has conducted these water-related land use and hydrologic inventories and other state water planning activities. These inventories are of particular importance as they relate to water use under the Upper Colorado River Compact of 1948 and the Amended Bear River Compact of 1980.

This land use report should assist in promoting the coordinated and orderly conservation, development, use, and management of water and land resources in the Sevier River Basin. It can also be a guide to local sponsors and other agencies in planning and implementing both current and long-term projects and programs.

SEVIER RIVER BASIN WATER-RELATED LAND USE INVENTORY

The Sevier River Basin Water-Related Land Use Inventory consists of the Sevier River drainage and the tributaries to the Sevier River, including the San Pitch River, Otter Creek, and the East Fork Sevier River. For use in this report, the Sevier River Basin has been divided into eight study areas, some of which have been further divided into subareas, for a total of 13 subdivisions, as shown in Figure 2. The Wasatch Plateau generally forms the northern boundary, along with the Sheeprock and Tintic Mountains. The east boundary is generally formed by the Wasatch Plateau, Fish Lake Mountains, Parker Range and the Aquarius Plateau. The Pink Cliffs and Markagunt Plateau form the southern boundary. They are part of the drainage divide between the Great Basin of the Basin and Range Province and the Colorado River drainage of the Colorado Plateau Province. It is the northward drainage from these cliffs that gives initial life to the Sevier River system. The western boundary of the Sevier River Basin is formed by the Wah Wah Mountains and the House Range but, in general, is less identifiable because it traverses vast desert areas with scattered basin ranges and unclear surface drainage. Figure 3 shows the study/subareas of the Sevier River Basin overlaid by a template showing the 7 ½ minute USGS quadrangle maps that cover the basin.

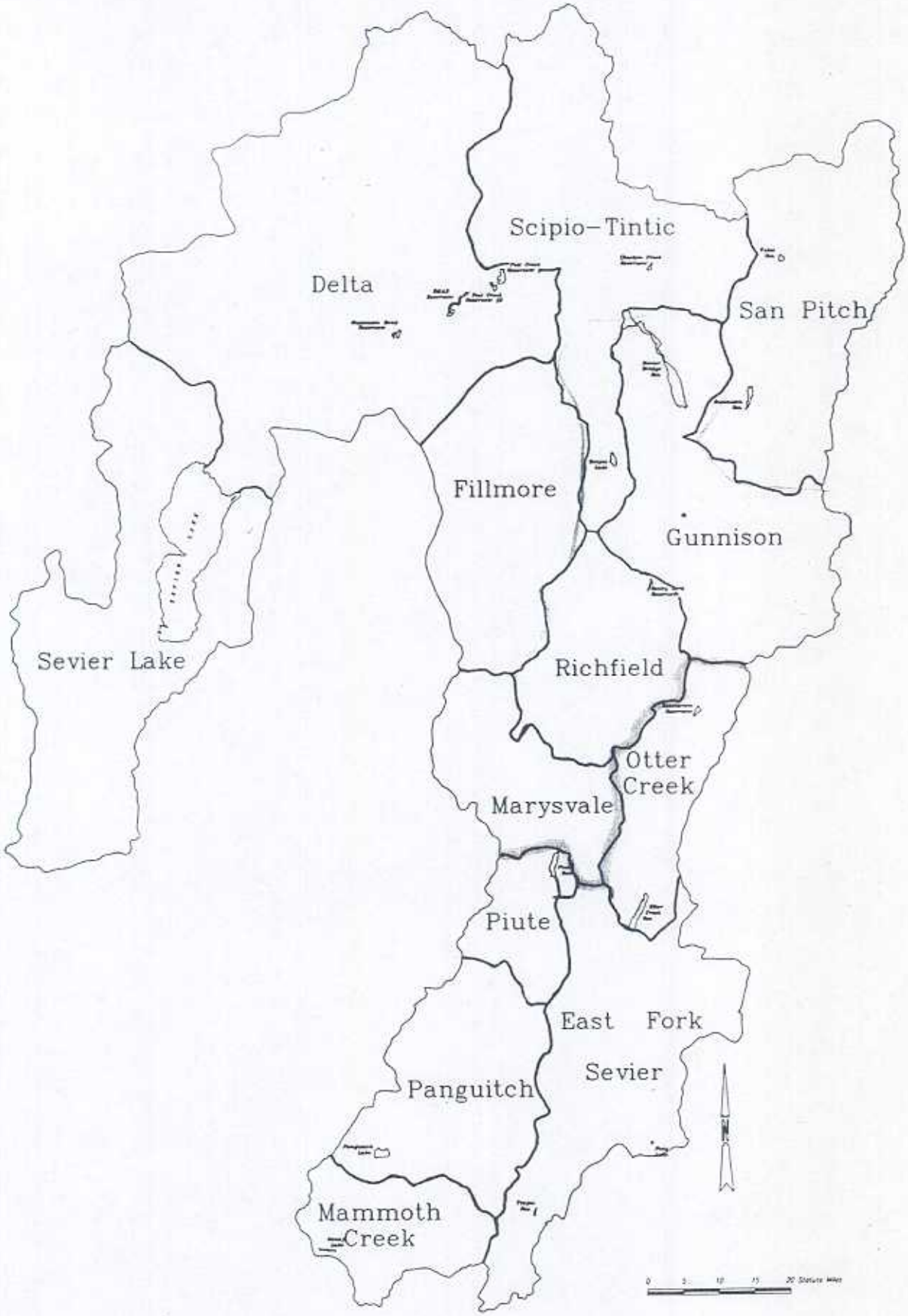

Figure 2. Hydrologic Study Areas and Subareas of the Sevier River Basin.

USGS 7½ minute quadrangles covering the Sevier River Basin as shown in Figure 3.

1. Boulter Peak
2. Indian Springs
3. Erickson Knoll
4. Dutch Peak
5. Sabie Mountain
6. Tintic Junction
7. Eureka
8. Keg Pass
9. Keg Mountain Ranch
10. Erickson Wash SW
11. Desert Mnt. Pass
12. Cherry Creek
13. Maple Peak
14. McIntyre
15. Tintic Mountain
16. Indianola
17. C Canyon
18. Topaz Mtn. E
19. Picture Rock Hills
20. The Hogback
21. Crater Bench Res.
22. Desert Mountain Res.
23. Lynndyl NW
24. Tanner Creek Narrows
25. Jericho
26. Furner Ridge
27. Sugar Loaf
28. Fountain Green N.
29. Big Hollow
30. Fairview
31. Fairview Lakes
32. Sand Pass SE
33. Topaz Mtn. SW
34. Lady Laird Peak
35. Drum Mtns. Well
36. Fumarole Butte
37. Baker Hot Springs
38. Rain Lake
39. Lynndyl West
40. Lynndyl East
41. Champion Peak
42. Sage Valley
43. Juab
44. Levan
45. Fountain Green S
46. Moroni
47. Mt. Pleasant
48. Huntington Res.
49. Swasey Peak
50. Whirlwind Valley NW
51. Little Drum Pass
52. Smelter Knolls W.
53. Smelter Knolls E.
54. Sutherland
55. Delta NE
56. Strong
57. Oak City North
58. Fool Creek Peak
59. Mills
60. Skinner Peaks
61. Chriss Canyon
62. Wales
63. Chester
64. Spring City
65. South Tent Mtn.
66. Marjum Pass
67. Whirlwind Valley SW
68. Red Knolls
69. Clay Knoll
70. Crafts Lake
71. Hinckley
72. Delta
73. Harding
74. Oak City South
75. Williams Peak
76. Scipio North
77. Hells Kitchen Can. SW
78. Hells Kitchen Can. SE
79. Manti
80. Ephriam
81. Danish Knoll
82. Notch Peak
83. Miller Cove
84. Long Ridge Res.
85. Long Ridge
86. Rocky Knoll
87. Pot Mountain
88. Sunstone Knoll
89. Pavant Butte North
90. McCormick
91. Duggins Creek
92. Scipio Pass
93. Scipio South
94. Hayes Canyon
95. Gunnison
96. Sterling
97. Black Mountain
98. Ferron Reservoir
99. Hell-N-Maria Kitchen
100. Skull Rock
101. Long Ridge SW
102. Long Ridge SE
103. Red Pass
104. Pavant Butte So.
105. The Sink
106. Holden
107. Coffee Peak
108. Scipio Lake
109. Redmond Canyon
110. Redmond
111. Mayfield
112. Woods Lake
113. Heliotrope Mtn.
114. King Top
115. The Barn
116. Burnout Canyon
117. Needle Point
118. Sevier Lake NE
119. Candland Spring
120. Tabernacle Hill
121. Meadow
122. Fillmore
123. Mt. Cathrine
124. Beehive Peak
125. Aurora
126. Salina
127. Steves Mountain
128. Water Hollow Ridge
129. Accord Lakes
130. Crystal Peak
131. Warm Point
132. Red Tops
133. Sevier Lake SW
134. Headlight Mtn.
135. Cat Canyon
136. Six Mile Point
137. Kanosh
138. Sunset Peak
139. White Pine Peak
140. Richfield
141. Sigurd
142. Rex Reservoir
143. Gooseberry Creek
144. Yoga Creek
145. Old Woman Plateau
146. Grassy Cove
147. Fifteen Mile Pt.
148. Brown Knoll
149. Iron Mine Pass
150. Red Rock Knoll
151. Red Ridge
152. Joseph Peak
153. Elsinore
154. Annabella
155. Water Creek Canyon
156. Boobe Hole Res.
157. Mt. Terrill
158. Helgard Mountain
159. Wah Wah Summit
160. Wah Wah Cove
161. Frisco Peak
162. High Rock
163. Cove Fort
164. Trail Mountain
165. Marysvale Canyon
166. Antelope Range
167. Monroe Peak
168. Koosharem
169. Burrville
170. Fish Lake
171. Sewing Machine Pass
172. Wallace Peak
173. Frisco
174. Pole Mountain
175. Mount Belknap
176. Mount Brigham
177. Marysvale
178. Marysvale Peak
179. Greenwich
180. Abes Knoll
181. Lamerdorf Peak
182. Frisco SW
183. White Mountain
184. Delano Peak
185. Piute Reservoir
186. Mahustan Peak
187. Parker Knoll
188. Circleville Mtn.
189. Circleville
190. Junction
191. Phonolite Hill
192. Angle
193. Flossie Knoll
194. Burnt Peak
195. Fremont Pass
196. Bull Rush
197. Mount Dutton
198. Deep Creek
199. Antimony
200. Pollywog Lake
201. Little Creek Pk.
202. Panguitch NW
203. Blind Spring Mtn
204. Adams Head
205. Cow Creek
206. Grass Lakes
207. Barker Reservoir
208. Red Creek Res.
209. Five Mile Ridge
210. Panguitch
211. Casto Canyon
212. Flake Mountain West
213. Flake Mountain East
214. Sweetwater Creek
215. Brian Head
216. Panguitch Lake
217. Haycock Moutain
218. Hatch
219. Wilson Peak
220. Bryce Canyon
221. Navajo Lake
222. Henrie Knolls
223. Asay Bench
224. George Mountain
225. Tropic Reservoir
226. Bryce Point
227. Strawyberry Pt.
228. Long Valley Jct.
229. Podunk Creek

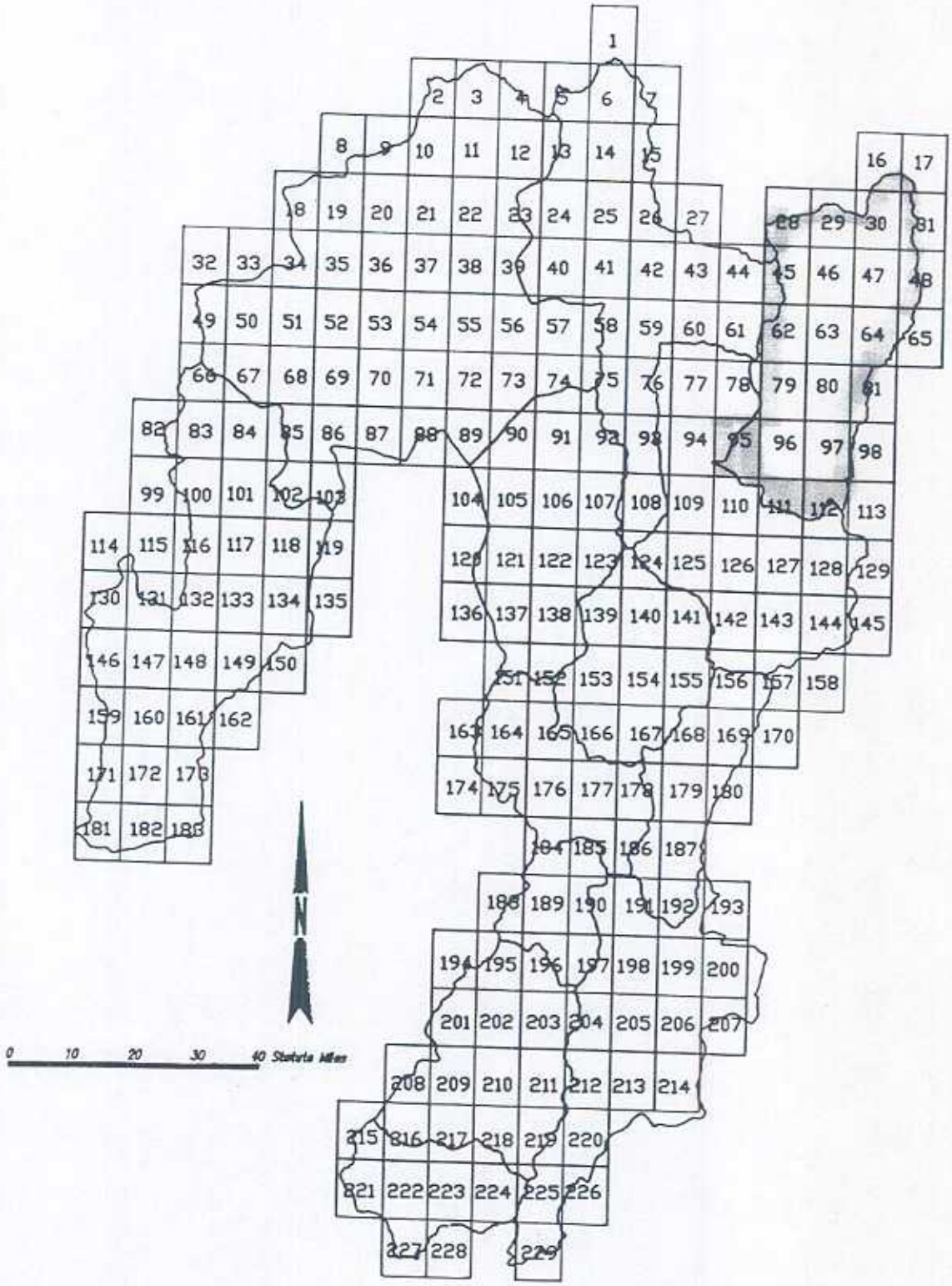

Figure 3. Sevier River Basin with the hydrologic study/subarea boundaries overlaid by a template showing the 7½ minute USGS quadrangle maps covering the basin.

OPERATIONS USED IN LAND USE DATA ACQUISITION

Sevier River Basin Land Use Data

The water-related land use data for the Sevier River Basin was obtained in three separate studies corresponding to the upper, middle, and lower portions of the basin. The division contracted with the University of Utah Center for Remote Sensing and Cartography (CRSC) in 1981 to provide land use data for the upper Sevier River area, and again in 1984 for the same services on the middle portion of the Sevier River. The division contracted with Olympus Aerial Surveys Inc. in 1985 to provide the 35mm photography on the San Pitch River drainage and the lower Sevier River basin to complete the land use data requirements for input to the Sevier River Hydrologic Inventory.

Using color infrared photography and Landsat multi-spectral scanner digital data, the CRSC constructed transparent overlays for USGS 7 ½ minute topographic quads depicting land cover characteristics for the upper river basin. Using orthophoto quads and aerial photographs, in addition to color infrared photos, the CRSC also made transparent overlays for USGS quads showing land cover in the middle portion of the basin. That data and the methodology used by the CRSC may be found in CRSC Reports 81-6 and 84-5, Supplements I and II to this report.

Aerial Photography

Aerial photography of the lower Sevier River Basin and San Pitch River drainage was obtained for the division from July 8 to August 15, 1985. The division contracted with Olympus Aerial Surveys Inc., Salt Lake City,

Utah, who photographed the study area using a Cessna 210 aircraft specially modified for aerial photography. A Zeiss RMK intervalometer system timed the frequency of the photos using a Nikon F-3 35mm camera mounted in the photo well of the plane. All slides were taken on 35mm Kodachrome film and processed by Kodak labs. Slides were identified according to flight line number, cross-referenced on a special location map, and delivered to the division between July 12 and September 13. The actual flight date was written on each slide frame by the division. Approximately 1,100 slides were delivered to the division covering the water-related land use in the study unit. These slides may be viewed at the Utah Division of Water Resources, Planning Section, 1636 W. North Temple, Salt Lake City, Utah. Copies of the slides may also be obtained from the division.

Field Mapping and Checking

Transferring data from 35mm slides to the field maps commenced on July 12 and continued until mid-September 1985. Slide cataloging, filing and mapping were done concurrently. Field checking/mapping commenced on July 15 and continued until the third week of September 1985. This process involved staff from the division and two people from the B.Y.U. Civil Engineering Department. Data and maps from the CRSC studies on the upper and middle Sevier River were also checked at this time. Some changes and corrections were made to the CRSC data. These changes were mainly shifting lands along the Sevier River from a wetland to an irrigated pasture category. this was only done where field checking identified canals or other means of irrigating these lands. The data tabulated in figures 4 - 17 reflect these corrections or changes.

Digitizing and Processing

The data resulting from digitizing the field maps was processed through the Utah State Automated Geographic Reference Center (AGRC) facilities during the fall and winter of 1985-86 and is maintained both there and at the Division of Water Resources. Maps or other detailed data can be obtained from the AGRC at the Office of Planning and Budget, State Office Building, Salt Lake City, Utah.

A draft map of the cropland cover types was printed for each 7 ½ minute quadrangle map for the purpose of checking the data. Each map was laid over the corresponding field map on a light table, and the cropland types and boundaries were double-checked for accuracy. Any corrections or additions were marked in red on the draft map for future updating. The corrected maps were updated and stored on the AGRC system.

Division policy is to publish its land use data in these types of reports; detailed maps, however, will not be included. With the establishment of the Automated Geographic Reference Center (AGRC) for the state of Utah, the division policy is to supply the land use data to them for further distribution. Detailed maps can be obtained directly from AGRC.

Table 1 is the list of cover types and codes used in the 1986 water-related land use inventory of the Sevier River Basin. Because the land use data for the Sevier was gathered before the 1988 Standard Cover Types List was adopted, the 1986 list differs somewhat from the standardized list. To compare the two lists, refer to Table 5 in the section on land use catagories.

Table 1. List of cover types and codes used by the division in the 1986 water-related land use inventory for the Sevier River Basin.

Code	Cover Type	Comments/Explanations
I	Cropland	
IA	Irrigated Cropland	(Rotation Crops)
IA1	Horticulture & Specialty Crops	
IA1a	Fruit	
IA1a1	Cherry	(Orchards)
IA1a2	Apple	
IA1a3	Peach	
IA1a4	Pear	
IA1a5	Apricot	
IA1a6	Other	
IA1b	Nuts	
IA1b1	Walnut	(Groves)
IA1b2	Pecan	
IA1b3	Other	
IA1c	Vineyard	
IA1d	Bush Fruit	(Grapes)
IA1e	Berries	
IA1f	Other Horticulture	(Nurseries)
IA2	Row and Close Grown Crops	
IA2a	Grain	
IA2a1	Corn	
IA2a2	Sorghum	
IA2a3	Wheat	
IA2a4	Barley	
IA2a5	Oats	
IA2b	Vegetables	
IA2b1	Potatoes	
IA2b2	Onions	
IA2b3	Beans	
IA2b4	Tomatoes	
IA2b5	Other Vegetables	(Melons, Squash, Etc.)
IA3	Forage Crops	
IA3a	Alfalfa	
IA3b	Grass Hay	
IA3c	Other Hay	
IA3d	Pasture	
IA3e	Turf	(Turf Farms)
IA4	Other Irrigated Land	
IA4a	Idle-Plowed	(Plowed or disked that year.)
IA4b	Idle-Overgrown	(Overgrown more than 1 season.)
IB	Non-Irrigated Cropland	(Rotation Crops)
IB1	Row and Close-Grown Crops	
IB1a	Grain, Beans, Seeds	
IB1a1	Wheat	
IB1a2	Other Grains	(Barley, Etc.)
IB1a3	Dry Beans	
IB1a4	Grains	

Table 1. Continued.

Code	Cover Type	Comments/Explanations
IB2	Hayland Crops	
IB2a	Alfalfa	
IB2b	Pasture	
IB3	Other	
IB3a	Idle-Plowed	(Plowed, Stubble, Mulch)
IB3b	Idle-Overgrown	(Overgrown more than 1 season.)
II	Grassy/Phreatophytes/Open Water Areas	
IIA	Grassy Aspect	
IIA1	Salt Water Grasses	
IIA1a	Irrigated S.W. Grasses	
IIA1a1	Irrigated S.W. Pasture	(Subject to spring flooding.)
IIA1b2	Irrigated S.W. Hayland	(Subject to spring flooding.)
IIA1b3	S.W. Grasses Non Agri.	(Subject to spring flooding.)
IIA2	Fresh Water Grasses	
IIA2a	Irrigated Fresh Water Grasses	
IIA2a1	Irrigated Fresh Water Pasture	
IIA2a2	Irrigated Fresh Water Hayland	
IIA2b	Non Irrigated Fresh Water Grasses	
IIA2b1	Wet Pasture/Non-Irrigated	(Receives Subsurface Water)
IIA2b2	Wet Hayland/Non-Irrigated	(Receives Subsurface Water)
IIA2b3	Wet Grasses/Non-Irrigated	(Receives Subsurface Water)
IIB	Cattail/Bullrush Aspect	
IIC	Wet Flats	(Mud flats W/Little Vegetation)
IID	Shrub Aspect	(Salt Brush, Sagebrush)
IIE	Riparian Wetlands	
IIE1	Riparian-Forested	(Cottonwoods, Birch)
IIE2	Riparian-Shrub	(Willows)
IIF	Open Water	
IIF1	Streams	
IIF2	Reservoirs	(Man-Made)
IIF3	Ponds & Lakes	
IIF4	Other	
IIF4a	Temporary Flooded	
IIF4b	Sewage Lagoon	
IIF4c	Evaporation Pond	
III	Rangeland and Forestland	
IIIA	Alpine Plant Communities	
IIIB	Conifer	
IIIB1	Douglas Fir - White Fir	
IIIB2	Ponderosa Pine	
IIIB3	Fir - Spruce	
IIIB4	Lodgepole Pine	
IIIB5	Pinion Pine - Juniper	
IIIB6	Other	
IIIC	Deciduous	
IIIC1	Aspen	
IIIC2	Mountain Brush	(Oak Brush, Maples, Chaparral)
IIIC3	Other	

Table 1. Continued.

Code	Cover Type	Comments/Explanations
IIID	Rangeland-Grass	
IIID1	Dry Pastures - Improved	(Chained and reseeded)
IIID2	Native Grasses	
IIID3	Other	(Forbs)
IIIE	Shrub Aspect	
IIIE1	Northern Desert Shrubs	
IIIE1a	Sagebrush	
IIIE1b	Other	(Shadscale, Greasewood, Etc.)
IIIE2	Southern Desert Shrubs	
IIIE2a	Creosote Bush	
IIIE2b	Other	(Forbs, Annual Grasses)
IIIE3	Salt Desert Shrubs	
IIIE3a	Shadscale	
IIIE3b	Greasewood	
IIIE3c	Saltbrush	
IIIE3d	Desert Molley	
IIIE3e	Other	(Halogeton)
IV	Barren Lands	
IVA	Bare Soil/Sand	
IVB	Rock Outcrops	
IVC	Excavated Lands	(Quarries, Gravel Pits, Etc.)
IVD	Other	
V	Built-Up Land	
VA	Farmsteads	
VB	Residential	
VB1	Buildings/Homes	(Res. Medium Lot)
VB2	Buildings/Homes	(Res. Trailer Court)
VB3	Building/Homes	(Res. Large Lot)
VB4	Public Open Space	(Golf Courses, Parks)
VB6a	Summer Homes	
VC	Commercial/Industrial	
VC1	Buildings/Parking	
VC2	Salt Evap. Ponds	
VC3	Disturbed Land	(Unfinished Subdivisions)
VC4	Other	
VD	Transportation, Communications	
VE	Utilities	

Figure 4 shows the general location of the water-related land use areas that have been mapped in the Sevier River Basin. Opposite Figure 4 are the land cover categories and the number of acres of land in each category for the basin. Figures 5-17 show the water-related land use in each hydrologic study/subarea of the Sevier River Basin. Again, opposite each figure are the land cover categories and the number of acres of land in each category for that study/subarea.

Land Cover Summary for the Sevier River Basin.[a] Reference Figure 4.

Code	Land Cover	Acres
IA1a	Fruit Orchards	30
IA2a	Grain	60,000
IA2a1	Corn & Sorghum	15,797
IA2b1	Potatoes	1,551
IA2b2	Onions	29
IA3a	Alfalfa	132,087
IA3b	Grass/Hay	4,874
IA3d	Pasture	57,085
IA4a	Fallow	10,241
IA4b	Idle	36,921
IIA1a	Pasture (Subject to spr. flood)	26,453
IIA1b	Grass/Hay (Subject to spr. flood)	5,040
IIA2a	Sub-Irrigated Pasture	30,922
IB	Non-Irrigated Cropland[b]	27,646[b]
IB1a	Non-Irr. Grain/Beans/Seeds[b]	17,075[b]
IB2a	Non-Irrigated Alfalfa[b]	872[b]
IB2b	Non-Irrigated Pasture[b]	9,551[b]
IB3a	Non-Irrigated Fallow[b]	4,022[b]
IIC	Wet Flats	6,446
IIE	Riparian Areas	9,444
IIF	Open Water	25,406
IIF	Open Water (Sevier Lake)[c]	120,422[c]
IIF4a	Temporarily Flooded	8,006
IIF4b	Sewage Lagoon	320
VA1	Bldgs/Homes (Rural)	5
VB	Residential	28,116
VB1	Bldgs/Homes (Hi-density)[d]	1,378
VB4	Open Spaces (Parks, golf courses)	483
VC	Commercial/Industrial	1,152
	Total	520,952[e]

[a] Combined data from all three studies.

[b] In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the basin.

[c] Surface area of Sevier Lake as digitized from 1:24,000 topographic maps. This area varies from year to year depending upon precipitation and agricultural needs upstream.

[d] Listed as summer homes before the 1988 Standard Cover Types and Codes was adopted.

[e] This total does not include the surface area of Sevier Lake.

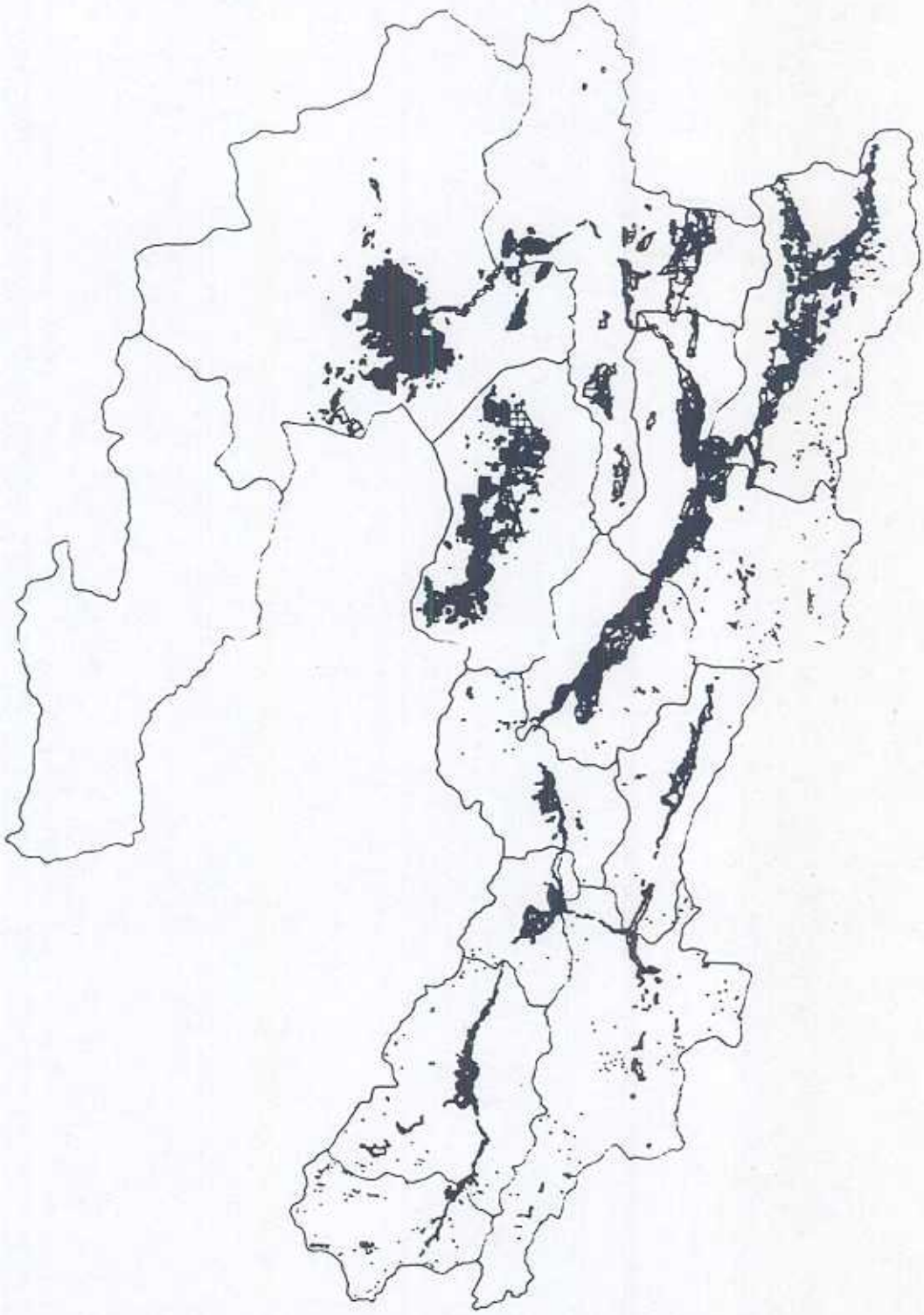

Figure 4. Water-related land use areas mapped in the Sevier River Basin.

Land Cover Summary for the Mammoth Creek Subarea[a] (5-6-1). Reference Figure 5.

Code	Land Cover	Acres	Counties Garfield	Iron	Kane
IA3a	Alfalfa	122.7	122.7	0	0
IA3d	Pasture	664.9	634.0	0	30.9
IIA1a	Pasture (Subject to)	910.9	795.7	0	115.2
IIA1b	Grass/Hay (spr. flood)	220.9	220.9	0	0
IIA2a	Sub-irrigated Pasture	101.5	31.7	18.0	51.8
IIE	Riparian Areas	202.2	202.2	0	0
IIF	Open Water	599.9	60.1	38.1	501.7
IIF4b	Sewage Lagoon	3.2	0	0	3.2
VB	Residential	86.6	86.6	0	0
VB1[b]	Bldgs/Homes(Hi-density)	1,097.9	123.8	221.4	752.7
	Total	4,010.7	2,277.7	277.5	1,455.5

[a] Data from the University of Utah Center for Remote Sensing and Cartography (CRSC) Report 81-6, 1981.

[b] Listed as summer homes before the 1988 Standard Cover Types and Codes was adopted.

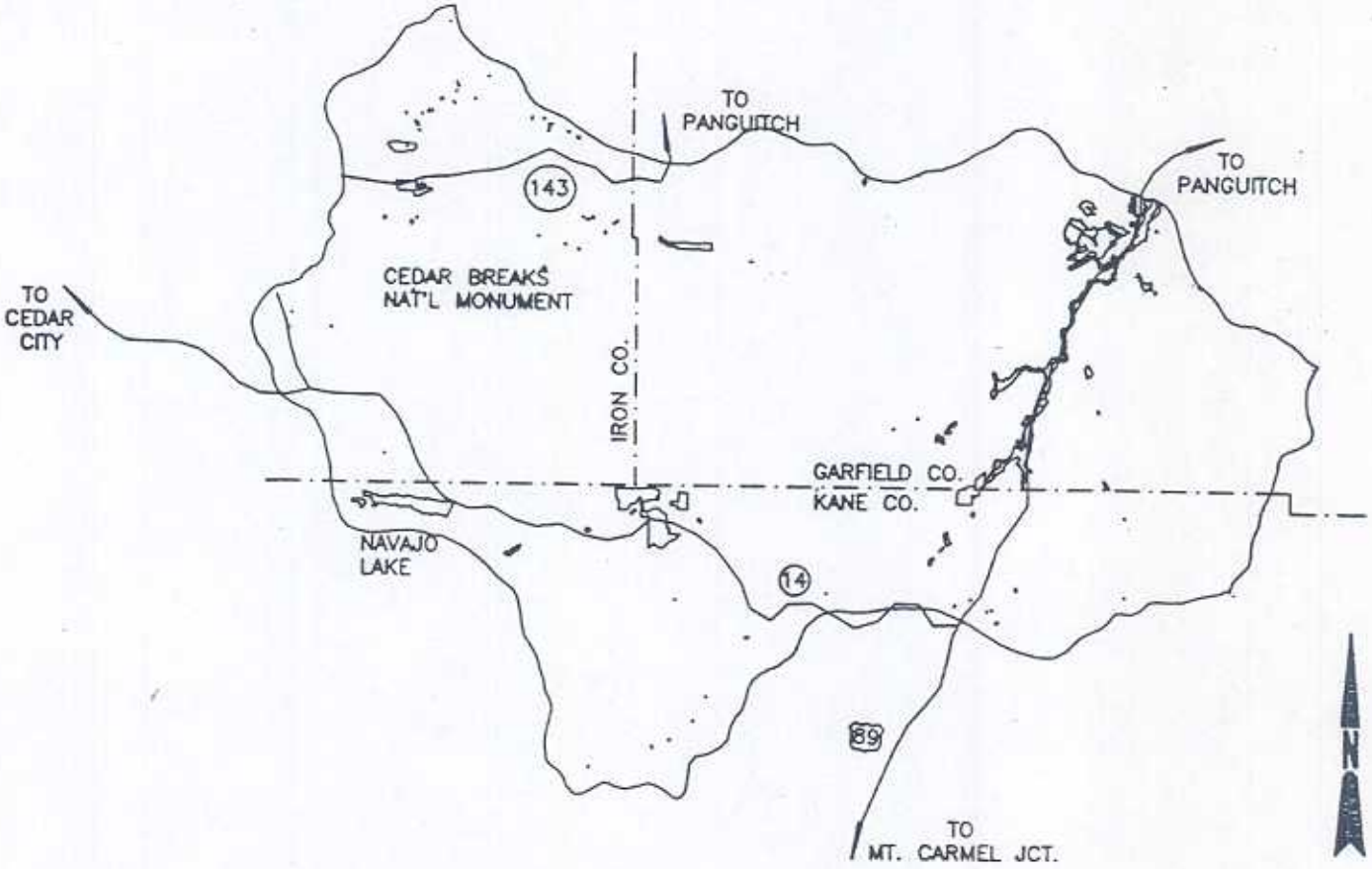

Figure 5. Water-related land use areas in the Mammoth Subarea (5-6-1).

Land Cover Summary for the Panguitch Subarea[a] (5-6-2). Reference Figure 6.

Code	Land Cover	Acres	Counties	
			Garfield	Iron
IA2a	Grain	558.4	558.4	0
IA3a	Alfalfa	3,374.8	3,374.8	0
IA3d	Pasture	3,915.6	3,915.6	0
IIA1a	Pasture (Subject to)	2,922.7	2,689.6	233.1
IIA1b	Grass/Hay (spring flooding)	497.6	497.6	0
IIA2a	Sub-irrigated Pasture	1,906.0	1,906.0	0
IIE	Riparian Areas	686.6	686.6	0
IIF	Open Water	1,241.0	1,233.3	7.7
IIF4a	Temporarily Flooded	26.5	0	26.5
VB	Residential	954.5	954.5	0
VB1[b]	Residential (Hi-density)[b]	280.1[b]	280.1	0
VC	Commercial/Industrial	34.0	34.0	0
	Total	16,397.8	16,130.5	267.3

[a] Data from the CRSC Report 81-6, 1981.

[b] Listed as summer homes before the 1988 Standard Cover Types and Codes was adopted.

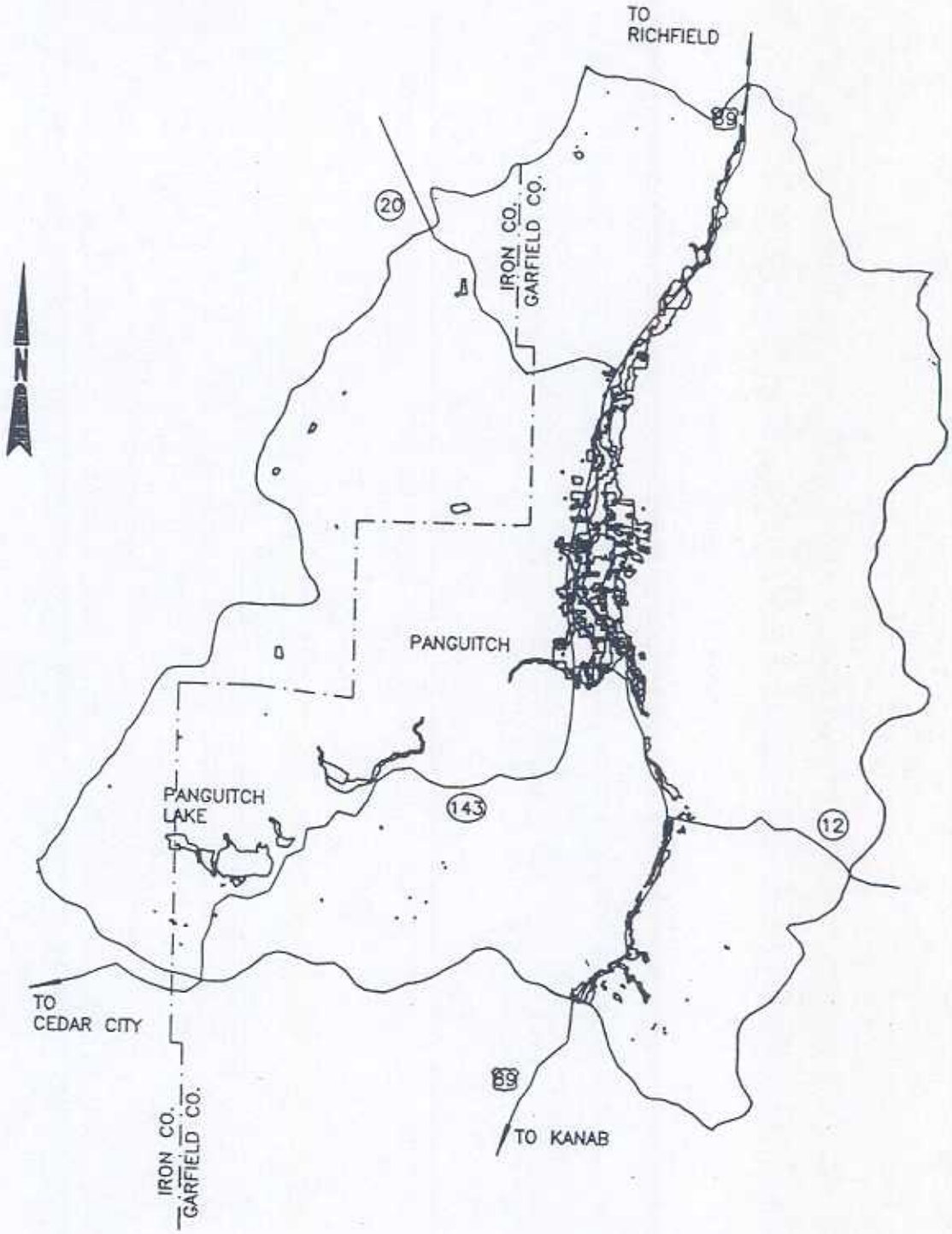

Figure 6. Water-related land use areas in the Panguitch Subarea (5-6-2).

Land Cover Summary for the East Fork Subarea[a]
(5-5-1). Reference Figure 7.

Code	Land Cover	Acres	Counties	
			Garfield	Piute
IA2a	Grain	817.0	648.6	168.4
IA2a1	Corn	5.2	0	5.2
IA2b1	Potatoes	16.8	9.3	7.5
IA3a	Alfalfa	3,028.0	2,532.9	495.1
IA3d	Pasture	874.5	262.2	612.3
IA4b	Idle	55.8	0	55.8
IIA1a	Pasture (Subject to spr. flood)	367.6	191.9	175.7
IIA1b	Grass/Hay(Subject to spr. flood)	1,382.3	725.9	656.4
IIA2a	Sub-irrigated Pasture	530.7	273.6	257.1
IB2b[b]	Non-Irrigated Pasture[b]	11.9[b]	11.9	0
IIE	Riparian Areas	490.6	399.3	91.3
IIF	Open Water	457.3	447.3	10.0
IIF4a	Temporarily Flooded	93.5	93.5	0
IIF4b	Sewage Lagoon	3.9	3.9	0
VB	Residential	204.1	124.2	79.9
VB4	Open Space (Parks, golf courses)	12.0	11.9	0.1
	Total	8,351.2	5,736.4	2,614.8

[a]Data from the CRSC Report 81-6, 1981.

[b]In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the subarea.

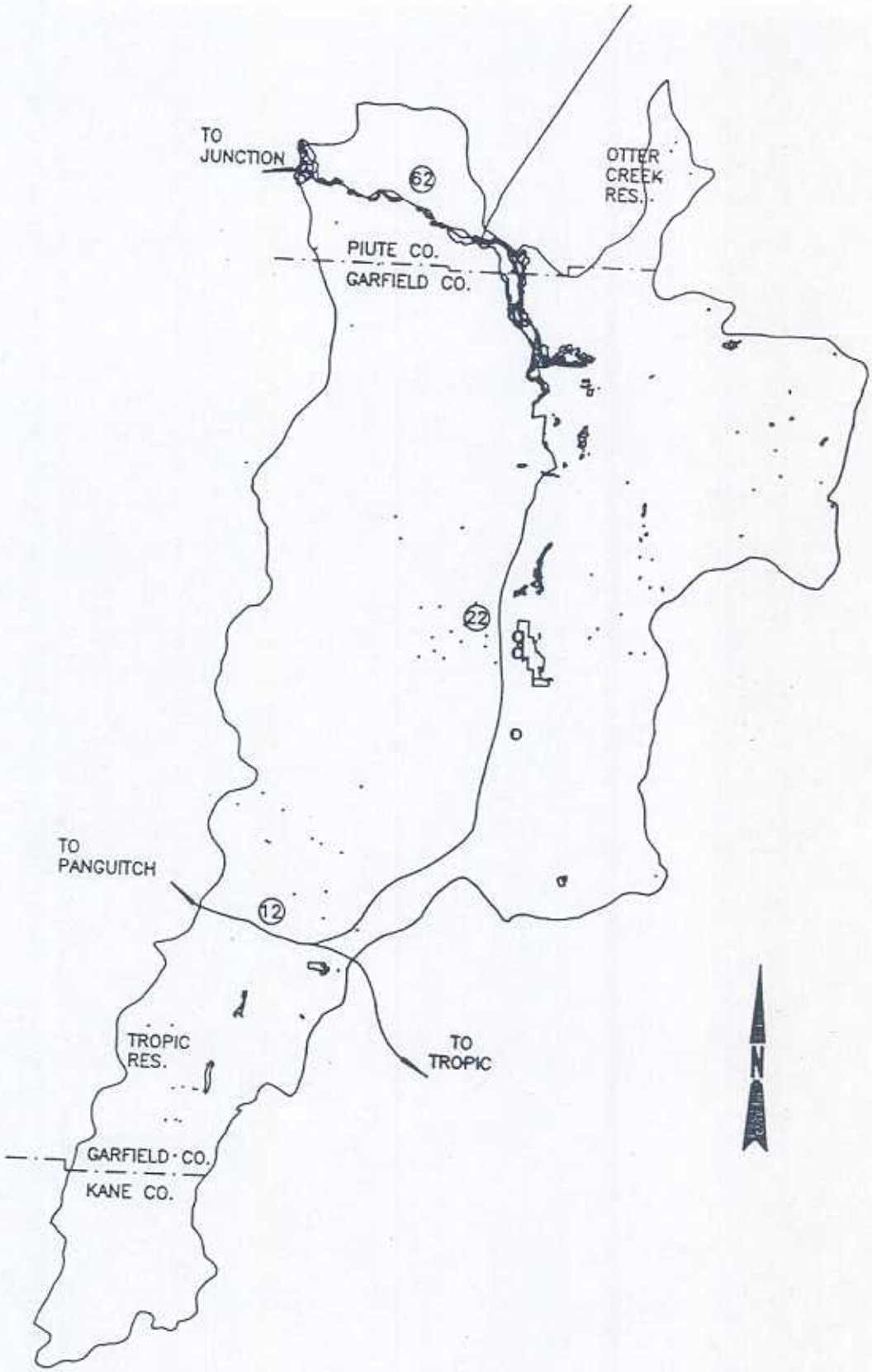

Figure 7. Water-related land use areas in the East Fork Sevier Subarea (5-5-1).

Land Cover Summary for the Otter Creek Subarea[a]
(5-5-2). Reference Figure 8.

Code	Land Cover	Acres	Counties	
			Piute	Sevier
IA2a	Grain	403.0	224.5	178.5
IA3a	Alfalfa	3,301.7	2,385.3	916.4
IA3d	Pasture	980.3	159.2	821.1
IIA1a	Pasture (Subject to spr. flood)	2,159.9	471.1	1,688.8
IIA1b	Grass/Hay (Subject to spr. flood)	2,939.5	2,252.1	687.4
IIA2a	Sub-Irrigated Pasture	673.1	188.4	484.7
IB2b[b]	Non-Irrigated Pasture[b]	252.5[b]	0	252.5
IIE	Riparian Areas	308.4	308.4	0
IIF	Open Water	2,915.0	2,534.8	380.2
IIF4a	Temporarily Flooded	268.4	268.4	0
VB	Residential	303.8	42.2	261.6
VB4	Open Spaces (Parks, golf courses)	18.2	18.2	0
	Total	14,523.8	8,852.6	5,671.2

[a]Data from the CRSC Report 81-6, 1981.

[b]In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the subarea.

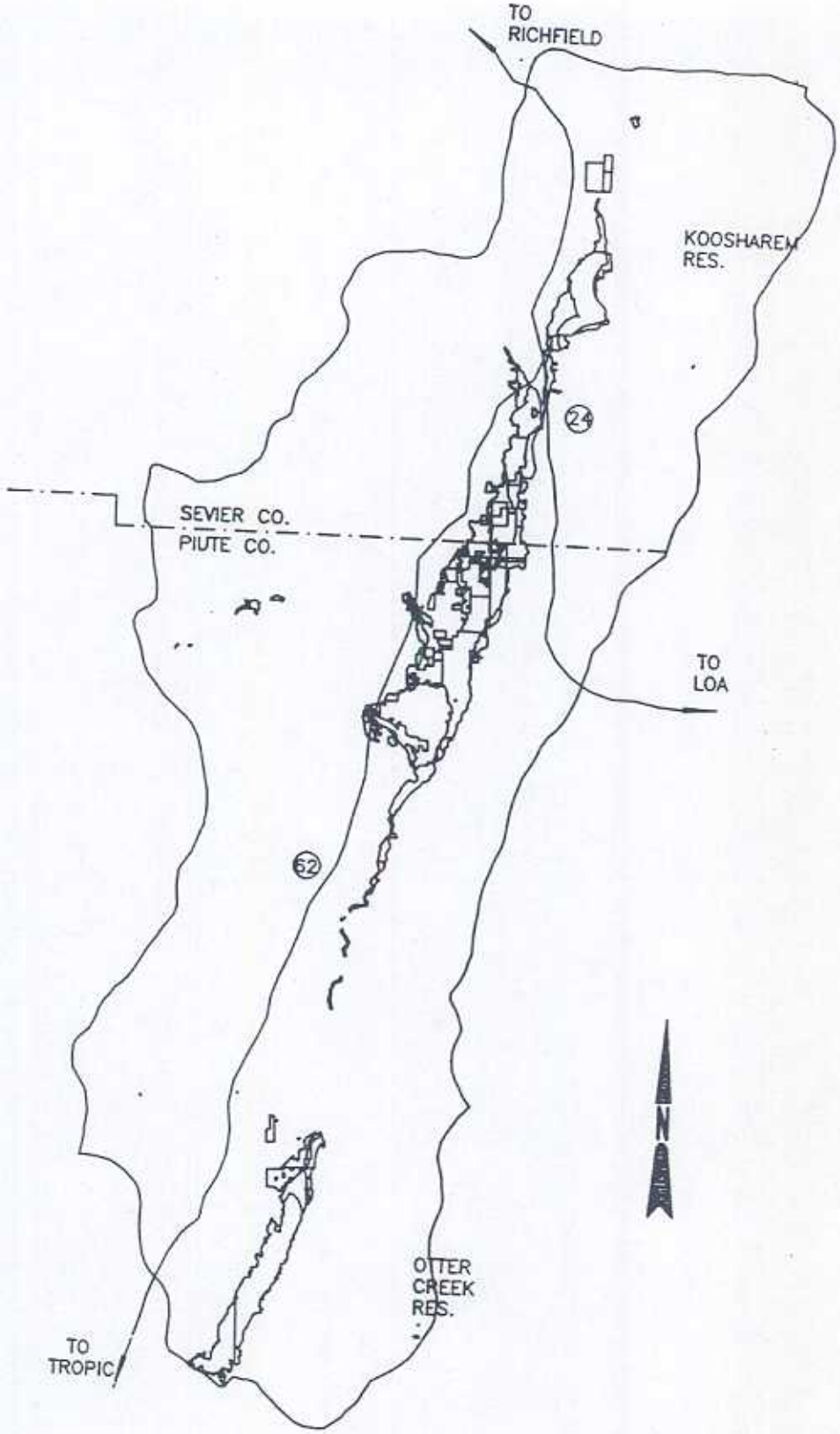

Figure 8. Water-related land use areas in the Otter Creek Subarea (5-5-2).

Land Cover Summary for the Piute Subarea[a]
(5-6-3). Reference Figure 9.

Code	Land Cover	Acres	Counties	
			Garfield	Piute
IA2a	Grain	217.9	0	217.9
IA2a1	Corn	471.7	0	471.7
IA2b1	Potatoes	2.8	0	2.8
IA3a	Alfalfa	4,378.6	219.8	4,158.8
IA3d	Pasture	1,211.7	21.3	1,190.4
IA4b	Idle	27.2	0	27.2
IIA1a	Pasture (Subject to spr. flood)	1,555.7	0	1,555.7
IIA2a	Sub-irrigated Pasture	1,751.7	0	1,751.7
IIE	Riparian Areas	423.1	40.1	383.0
IIF	Open Water	1,927.0	2.8	1,924.2
IIF4a	Temporarily Flooded	358.8	26.1	332.7
VB	Residential	700.9	2.6	698.3
	Total	13,027.1	312.7	12,714.4

[a]Data from the CRSC Report 81-6, 1981.

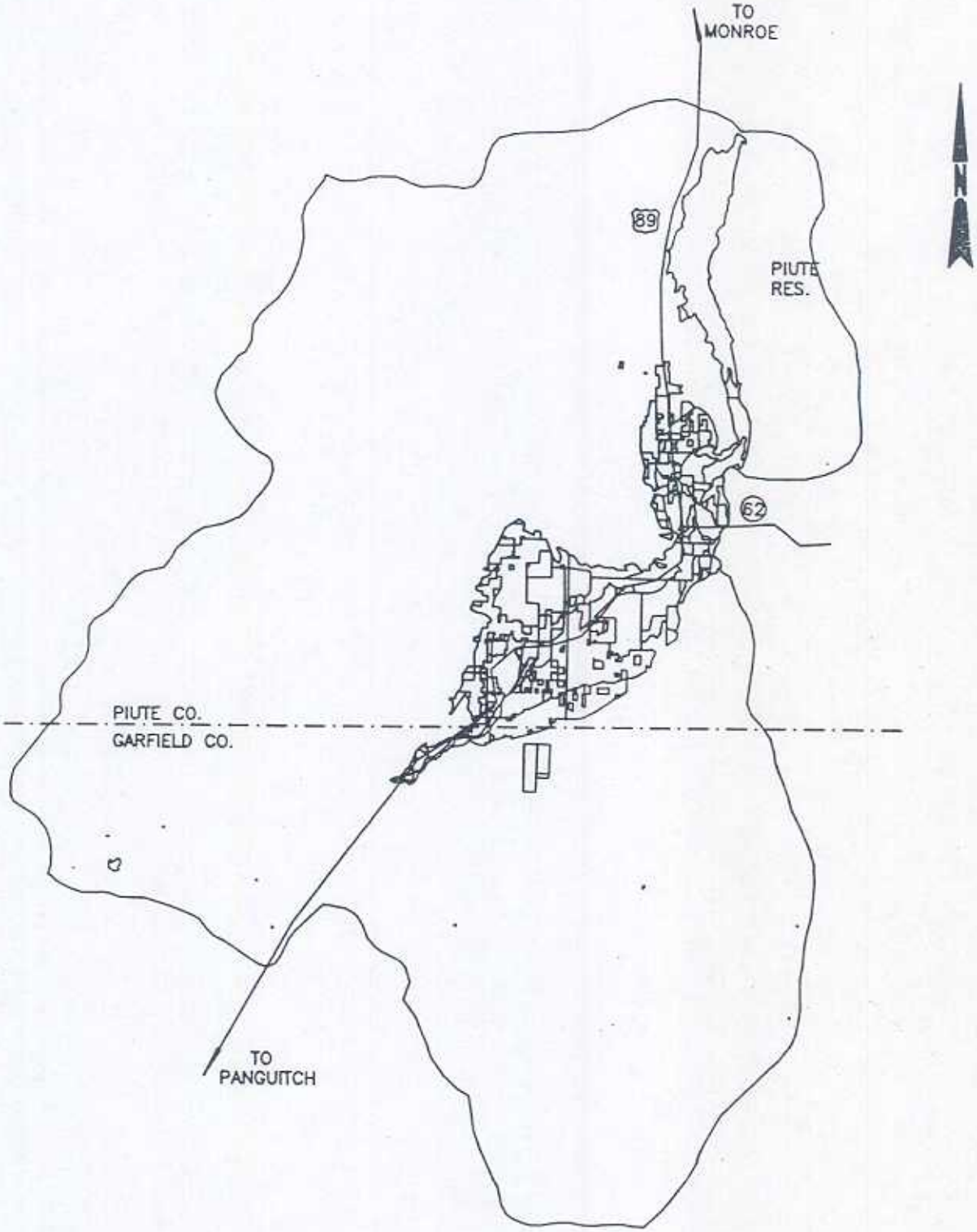

Figure 9. Water-related land use areas in the Piute Subarea (5-6-3).

Land Cover Summary for the Marysvale Subarea[a]
(5-4-1). Reference Figure 10.

Code	Land Cover	Acres	Counties	
			Piute	Sevier
IA2a	Grain	304.0	304.0	0
IA3a	Alfalfa	1,478.8	1,394.6	84.2
IA3d	Pasture	1,074.2	1,069.4	4.8
IA4a	Fallow	17.8	17.8	0
IA4b	Idle	329.1	329.1	0
IIA1a	Pasture (Subject to spr. flood)	765.7	532.0	233.7
IIA2a	Sub-irrigated Pasture	1,090.3	1,090.3	0
IB2b[b]	Non-Irrigated Pastsure[b]	10.6[b]	10.6	0
IIC	Wet Flats	52.4	52.4	0
IIE	Riparian Areas	1,068.0	1,002.6	65.4
IIF	Open Water	227.6	96.6	131.0
IIF4a	Temporarily Flooded	462.8	462.8	0
VB	Residential	452.1	452.1	0
VB4	Open Space (Parks, golf courses)	3.5	3.5	0
	Total	7,336.9	6,817.8	519.1

[a]Data from the University of Utah Center for Remote Sensing and Cartography (CRSC) Report 84-5, 1984.

[b]In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the subarea.

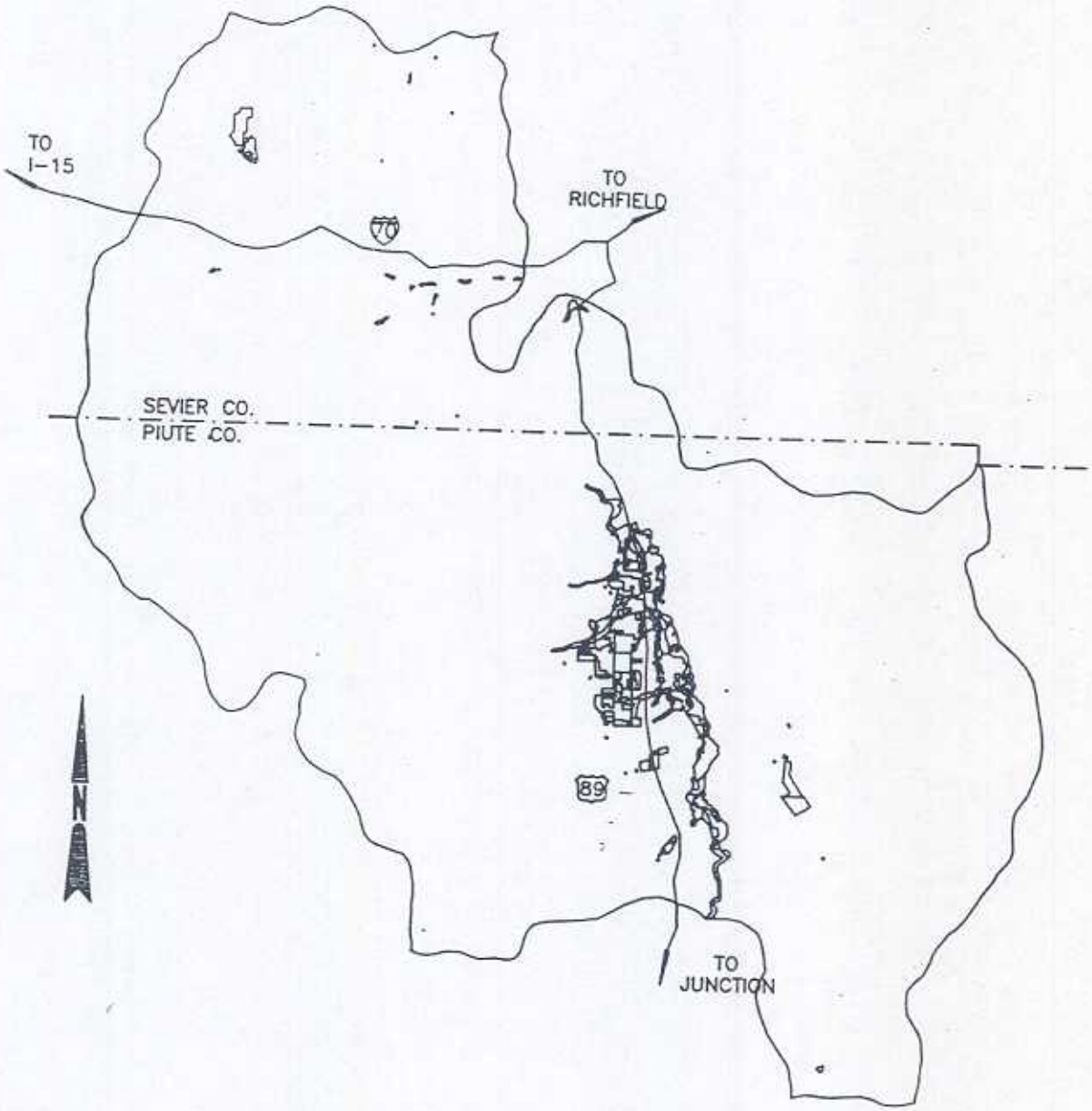

Figure 10. Water-related land use areas in the Marysvale Subarea (5-4-1).

Land Cover Summary for the Richfield Subarea[a]
(5-4-2). Reference Figure 11.

Code	Land Cover	Acres	Counties: Sevier	
IA1a	Fruit/Orchards	2.3	2.3	All water-related land use in this subarea is located within Sevier County.
IA2a	Grain	5,576.3	5,576.3	
IA2a1	Corn	2,673.8	2,673.8	
IA3a	Alfalfa	14,974.6	14,974.6	
IA3d	Pasture	6,997.6	6,997.6	
IA4a	Fallow	407.2	407.2	
IA4b	Idle	4,406.4	4,406.4	
IIA1a	Pasture (Subject to spr. flood)	3,197.2	3,197.2	
IIA2a	Sub-irrigated Pasture	3,025.1	3,025.1	
IB[b]	Non-Irrigated Cropland[b]	206.5[b]	206.5	
IIC	Wet Flats	518.8	518.8	
IIE	Riparian Areas	574.2	574.2	
IIF	Open Water	596.5	596.5	
IIF4a	Temporarily Flooded	1,132.9	1,132.9	
IIF4b	Sewage Lagoon	2.8	2.8	
VB	Residential	6,722.8	6,722.8	
	Total	51,015.0	51,015.0	

[a] Data from the CRSC Report 84-5, 1984.

[b] In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the subarea.

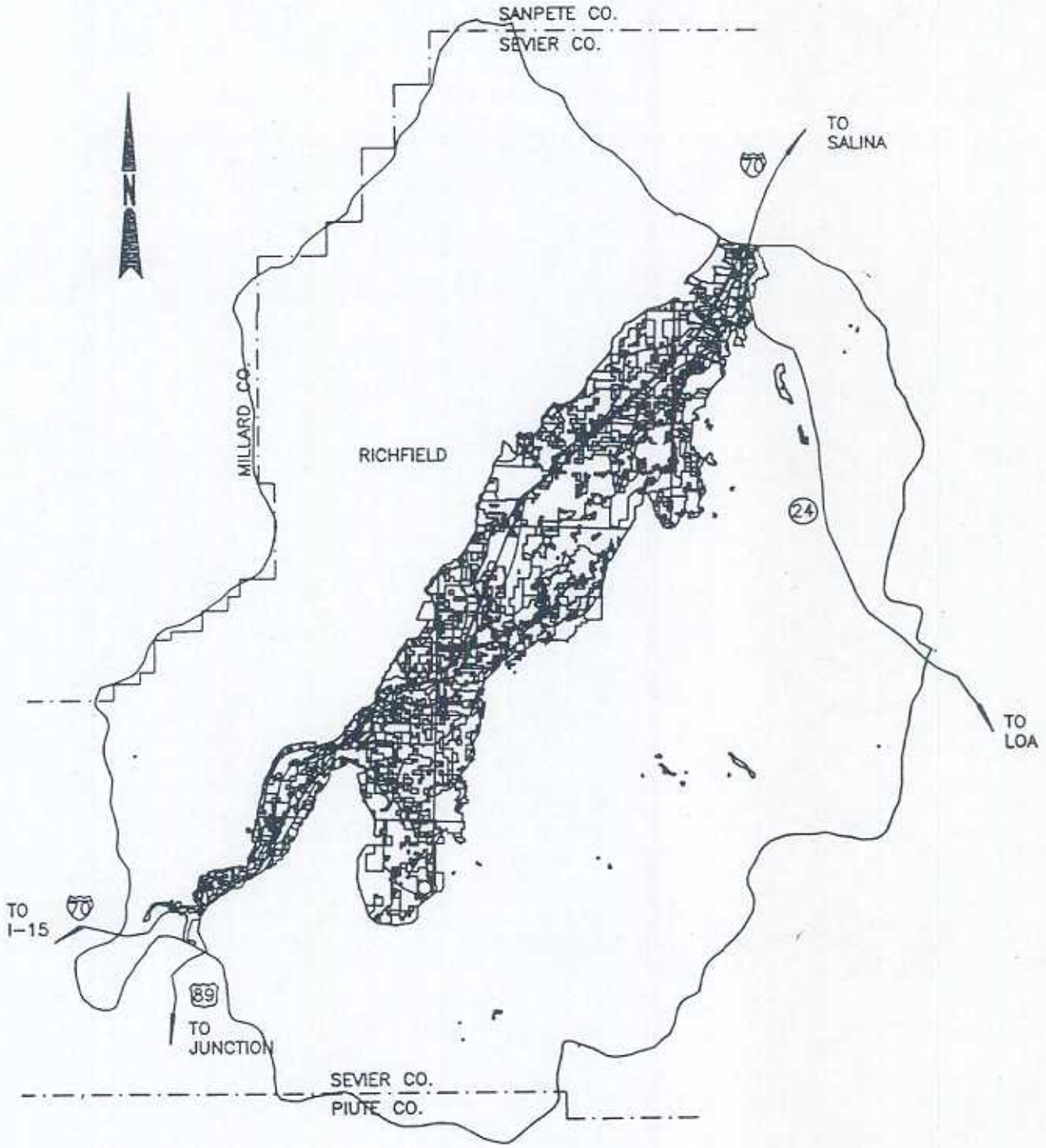

Figure 11. Water-related land use areas in the Richfield Subarea (5-4-2).

Land Cover Summary for the San Pitch Study Area[a]
(5-1). Reference Figure 12.

Code	Land Cover	Acres	Counties: Sanpete	
IA2a	Grain	8,107.4	8,107.4	All water-related land use in this study area is located within Sanpete County.
IA2a1	Corn	640.6	640.6	
IA2b2	Onions	2.5	2.5	
IA3a	Alfalfa	25,819.6	25,819.6	
IA3b	Grass/Hay	4,117.1	4,117.1	
IA3d	Pasture	21,597.5	21,597.5	
IA4a	Fallow	681.6	681.6	
IA4b	Idle	2,970.6	2,970.6	
IIA1a	Pasture (Subject to spr. flood)	10,711.5	10,711.5	
IIA2a	Sub-irrigated Pasture	9,086.7	9,086.7	
IB[b]	Non-Irrigated Cropland[b]	2,779.9[b]	2,779.9	
IB1a[b]	Non-Irrigated Grains/Beans/Seeds[b]	291.0[b]	291.0	
IB2a[b]	Non-Irrigated Alfalfa[b]	140.7[b]	140.7	
IB2b[b]	Non-Irrigated Pasture[b]	1,267.8[b]	1,267.8	
IB3a[b]	Non-Irrigated Fallow[b]	117.5[b]	117.5	
IIC	Wet Flats	588.4	588.4	
IIE	Riparian Areas	444.0	444.0	
IIF	Open Water	2,582.7	2,582.7	
IIF4a	Temporarily Flooded	457.9	457.9	
IIF4b	Sewage Lagoon	118.6	118.6	
VB	Residential	7,395.5	7,395.5	
VB4	Open Space (Park, golf courses)	308.0	308.0	
VC	Commercial/Industrial	581.0	581.0	
	Total	100,808.1	100,808.1	

[a] Data from the division in its 1985 land use survey of the lower Sevier River Basin.

[b] In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the study area.

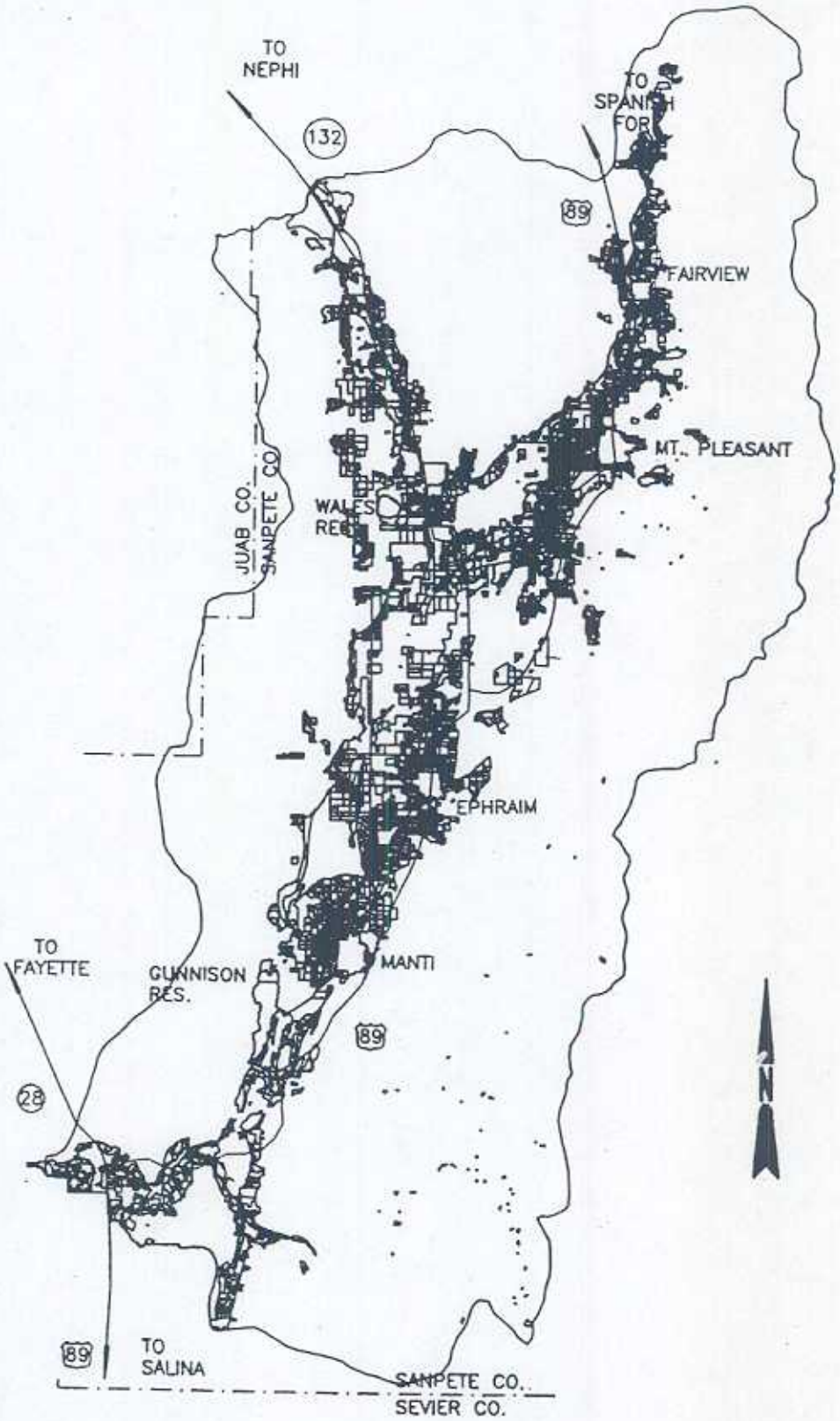

Figure 12. Water-related land use areas in the San Pitch Study Area (5-1).

Land Cover Summary for the Gunnison Study Area[a]
(5-3). Reference Figure 13.

Code	Land Cover	Acres	Juab	Counties Sanpete	Sevier
IA2a	Grain	5,902.7	0	4,094.1	1,808.6
IA2a1	Corn	2,870.6	0	943.3	1,927.3
IA3a	Alfalfa	17,037.1	0	8,935.5	8,101.6
IA3d	Pasture	6,302.7	0	3,745.0	2,557.7
IA4a	Fallow	133.0	0	97.6	35.4
IA4b	Idle	10,378.6	0	5,989.2	4,389.4
IIA1a	Pasture (Sub.spr.flood)	3,862.0	0	2,611.6	1,250.4
IIA2a	Sub-Irrigated Pasture	6,454.2	0	4,875.4	1,578.8
IB[b]	Non-Irrigated Cropland[b]	3,080.8[b]	905.4	2,175.4	0
IIC	Wet Flats	3,382.8	0	3,272.0	110.8
IIE	Riparian Areas	730.4	0	177.4	553.0
IIF	Open Water	6,637.9	2,699.0	3,233.5	705.4
IIF4a	Temporarily Flooded	1,044.6	0	443.5	601.1
VB	Residential	3,546.4	0	1,259.1	2,287.3
	Total	71,363.8	3,604.4	41,852.6	25,906.8

[a]Data from the CRSC Report 84-5, 1984.

[b]In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the study area.

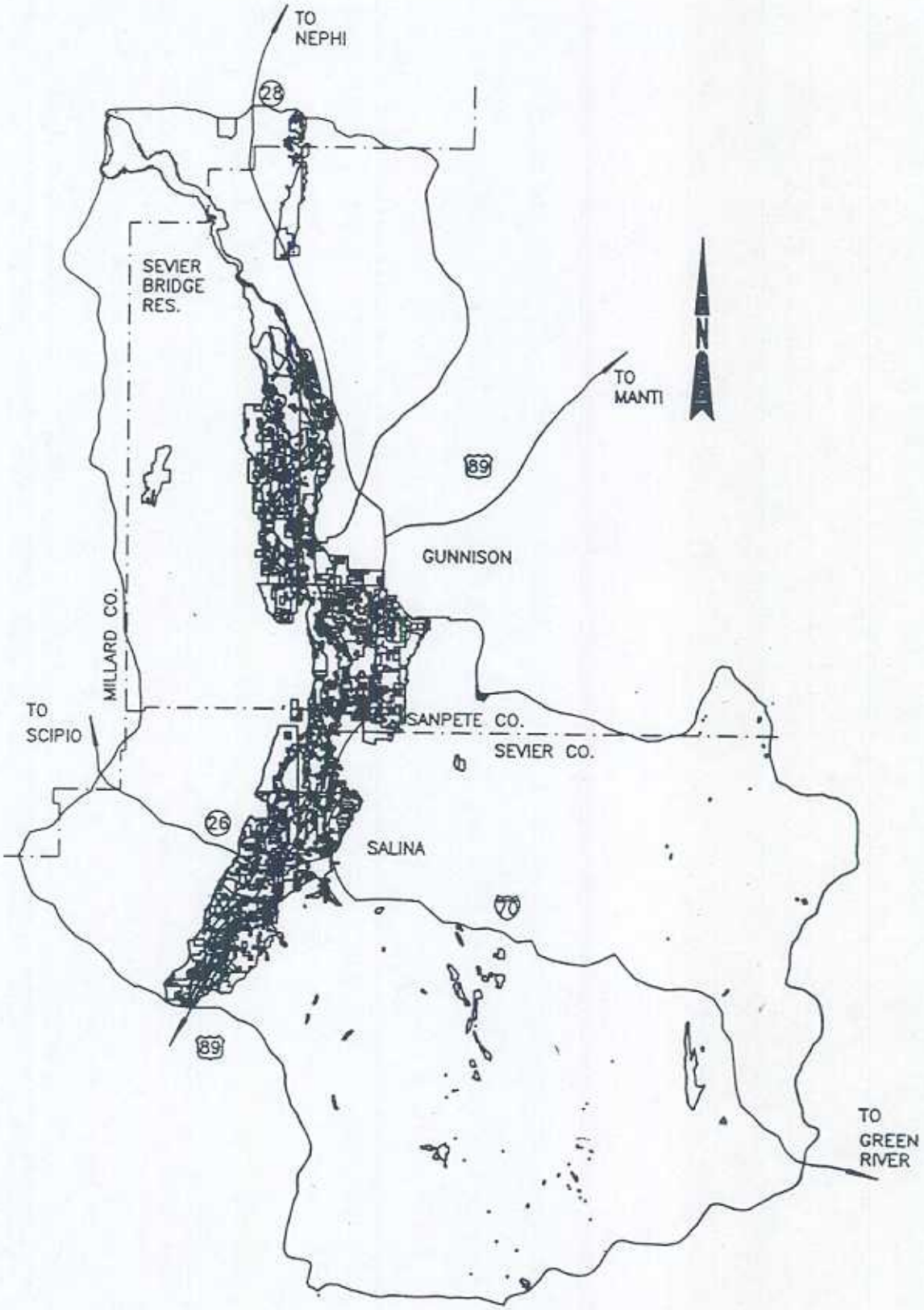

Figure 13. Water-related land use areas in the Gunnison Study Area (5-3).

Land Cover Summary for the Scipio-Tintic Subarea[a] (5-2-1). Reference Figure 14.

Code	Land Cover	Acres	Counties	
			Juab	Millard
IA2a	Grain	2,873.9	1,349.5	1,524.4
IA2a1	Corn	532.2	83.8	448.4
IA2b1	Potatoes	5.2	0	5.2
IA3a	Alfalfa	10,802.0	5,389.8	5,412.2
IA3d	Pasture	1,801.1	940.2	860.9
IA4a	Fallow	917.1	686.8	230.3
IA4b	Idle	11,639.8	6,998.4	4,641.4
IIA2a	Sub-Irrigated Pasture	6,231.4	5,477.7	754.0
IB[b]	Non-Irrigated Cropland[b]	21,578.7[b]	17,433.7	4,145.0
IB2b[b]	Non-Irrigated Pasture[b]	374.4[b]	185.2	189.2
IIC	Wet Flats	1,904.2	1,904.2	0
IIE	Riparian Areas	399.0	148.8	250.2
IIF	Open Water	1,541.4	618.4	923.0
IIF4a	Temporarily Flooded	1,242.2	841.0	401.2
VB	Residential	1,299.2	720.5	578.7
VC	Commercial/Industrial	27.2	0	27.2
	Total	63,169.0	42,777.7	20,391.3

[a]Data from the division in its 1985 land use survey of the lower Sevier River Basin.

[b]In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the subarea.

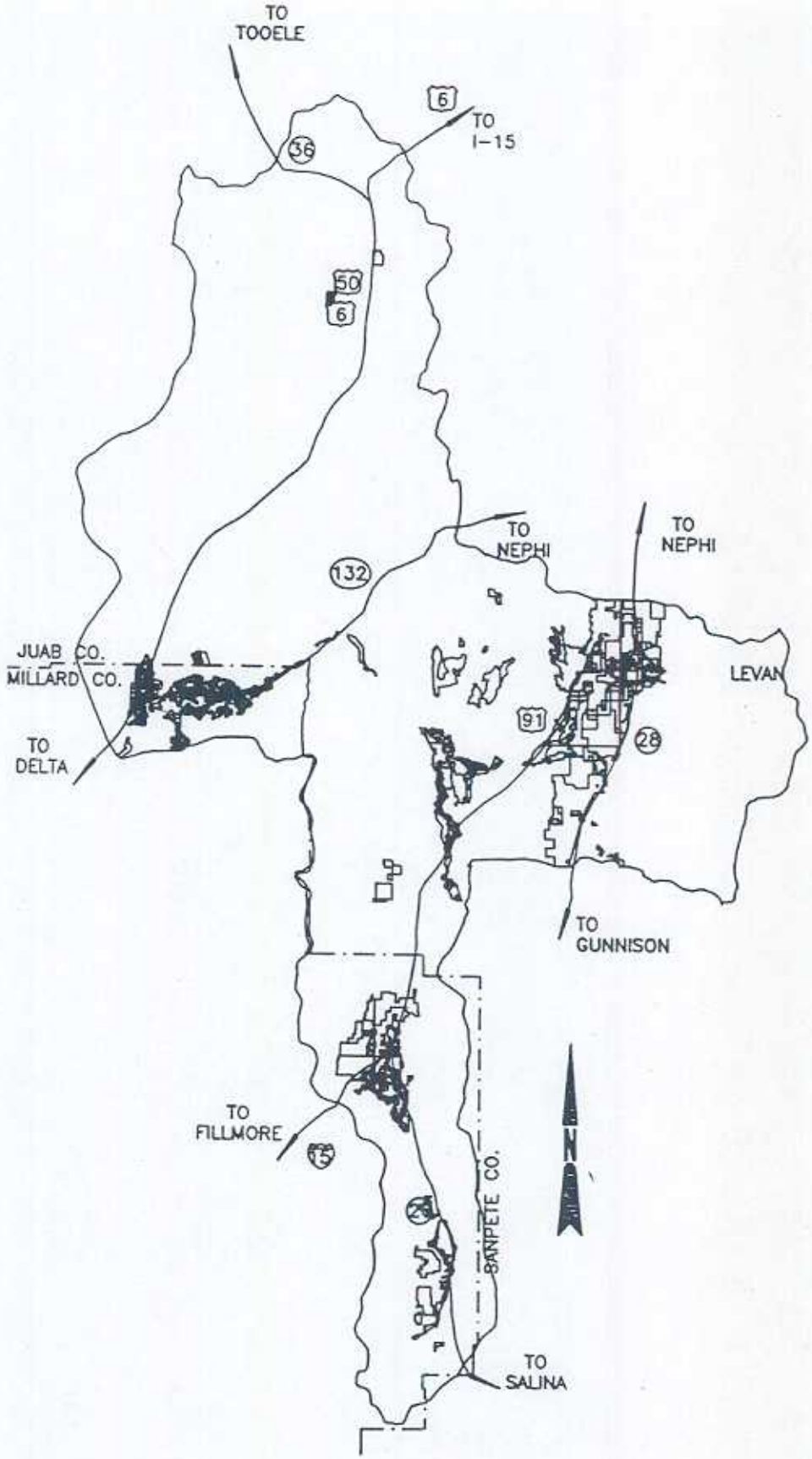

Figure 14. Water-related land use areas, Scipio-Tintic Subarea (5-2-1).

Land Cover Summary for the Delta Subarea[a]
(5-2-2). Reference Figure 15.

Code	Land Cover	Acres	Counties	
			Juab	Millard
IA1a	Fruit/Orchard	28.0	0	28.0
IA2a	Grain	21,865.6	41.5	21,824.1
IA2a1	Corn	5,608.9	0	5,608.9
IA2b2	Onions	13.4	0	13.4
IA3a	Alfalfa	27,649.2	53.7	27,595.5
IA3b	Grass/Hay	352.8	0	352.8
IA3d	Pasture	5,565.4	0	5,565.4
IA4a	Fallow	3,589.8	252.1	3,337.7
IA4b	Idle	4,837.7	417.2	4,420.5
IB1a[b]	Non-Irrigated Grain/Beans/Seeds[b]	835.6[b]	0	835.6
IB2a[b]	Non-irrigated Alfalfa[b]	695.9[b]	0	695.9
IB2b[b]	Non-Irrigated Pasture[b]	984.7[b]	0	984.7
IB3a[b]	Non-Irrigated Fallow[b]	5.4[b]	0	5.4
IIE	Riparian Areas	4,092.8	0	4,092.8
IIF	Open Water	6,372.3	800.4	5,571.9
IIF4a	Temporarily Flooded	2,918.8	0	2,918.8
IIF4b	Sewage Lagoon	163.7	0	163.7
VA1	Bldgs/Homes (Rural)	5.3	5.3	0
VB	Residential	4,153.2	0	4,153.2
VB4	Open Spaces (Parks, golf courses)	121.5	0	121.5
VC	Commercial/Industrial	361.5	0	361.5
	Total	90,221.5	1,570.2	88,651.3

[a] Data from the division in its 1985 land use survey of the lower Sevier River Basin.

[b] In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the subarea.

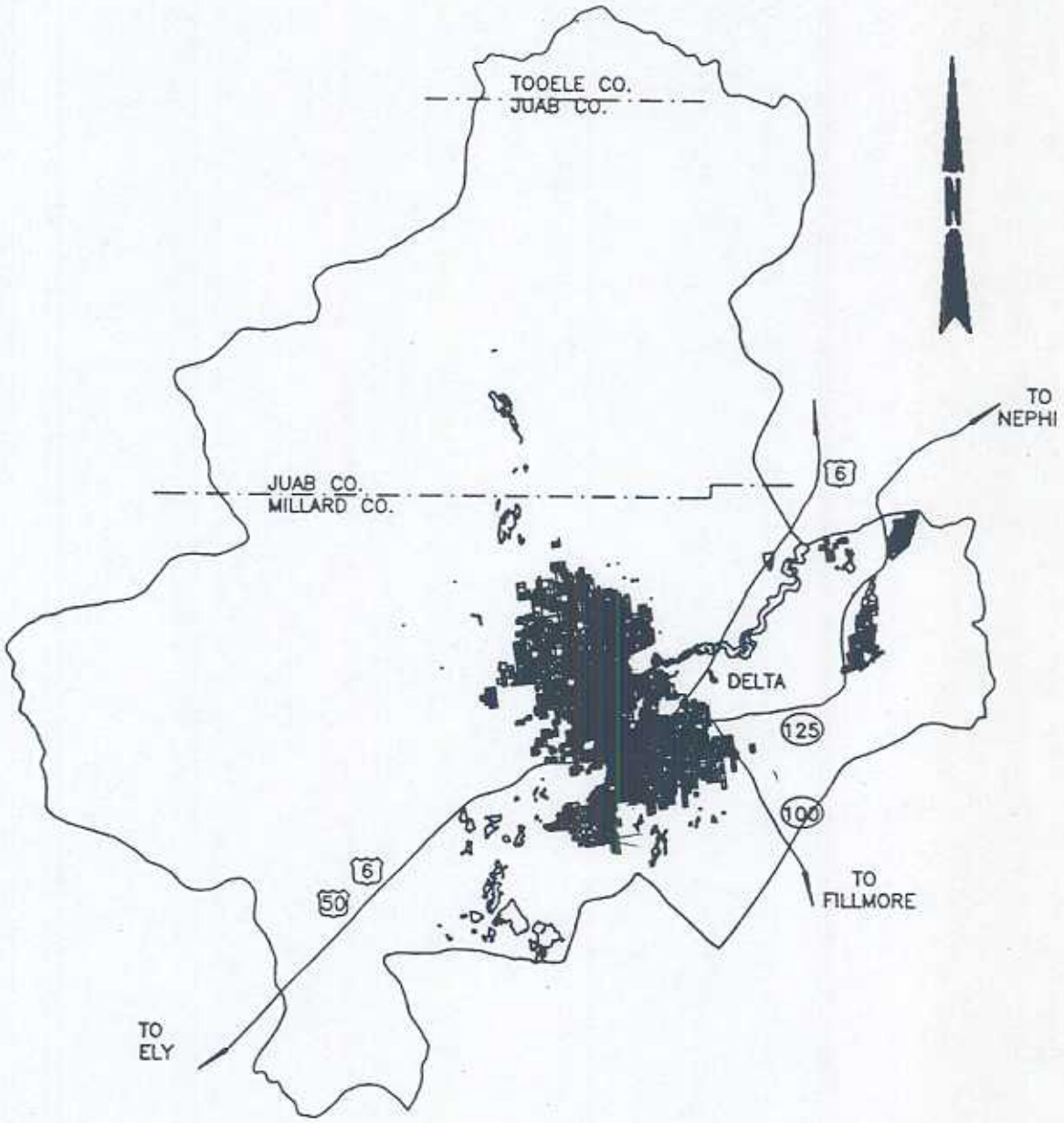

Figure 15. Water-related land use areas in the Delta Subarea (5-2-2).

Land Cover Summary for the Fillmore Study Area[a]
(5-1). Reference Figure 16.

Code	Land Cover	Acres	Counties: Millard	
IA2a	Grain	13,373.7	13,373.7	All water-related land use in this study area is located within Millard County.
IA2a1	Corn	2,994.2	2,994.2	
IA2a2	Sorghum	55.8	55.8	
IA2b1	Potatoes	1,526.4	1,526.4	
IA2b2	Onions	13.4	13.4	
IA3a	Alfalfa	20,120.0	20,120.0	
IA3b	Grass/Hay	404.2	404.2	
IA3d	Pasture	6,099.3	6,099.3	
IA4a	Fallow	4,494.6	4,494.6	
IA4b	Idle	2,276.0	2,276.0	
IIA2a	Sub-Irrigated Pasture	71.4	71.4	
IB1a[b]	Non-Irrigat. Grains/Beans/Seeds[b]	15,948.6[b]	15,948.6	
IB2a[b]	Non-Irrigated Alfalfa[b]	35.5[b]	35.5	
IB2b[b]	Non-Irrigated Pasture[b]	6,649.2[b]	6,649.2	
IB3a[b]	Non-Irrigated Fallow[b]	3,899.3[b]	3,899.3	
IIE	Riparian Areas	25.2	25.2	
IIF	Open Water	307.1	307.1	
IIF4b	Sewage Lagoon	28.5	28.5	
VB	Residential	2,297.6	2,297.6	
VB4	Open Spaces (Parks, golf courses)	20.0	20.0	
VC	Commercial/Industrial	148.2	148.2	
	Total	80,788.2	80,788.2	

[a]Data from the division in its 1985 land use survey of the lower Sevier River Basin.

[b]In conducting water-related land use inventories, the division attempts to inventory all lands or areas that consume or evaporate water other than natural precipitation. Non-irrigated agriculture lands are generally mapped if they fall within or border irrigated lands. Non-irrigated lands away from irrigated lands are normally not mapped. Acres shown for this catagory reflect only the number of acres mapped, not the number of acres that may be in this catagory in the study area.

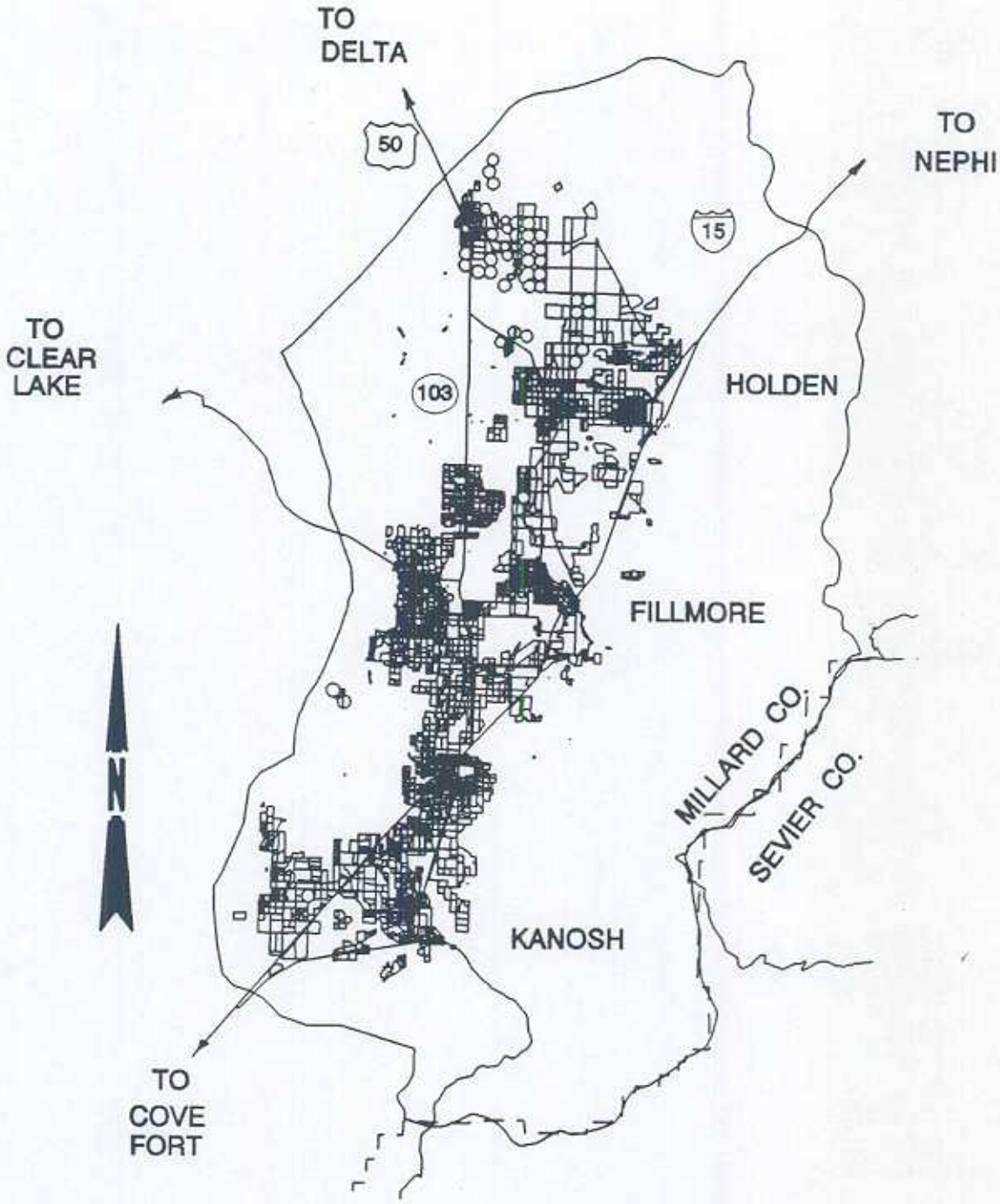

Figure 16. Water-related land use areas in the Fillmore Study Area (5-7).

Land Cover Summary for the Sevier Lake Study Area[a] (5-8). Reference Figure 17.

Code	Land Cover	Acres	Counties: Millard	Counties:
IA	Irrigated Cropland	Not available	N/A	Sevier Lake is located entirely within Millard County.
IIF	Open Water[b]	120,422[b]	120,422	
IIE	Riparian Areas[c]	Not available[c]	N/A	
VC	Commercial/Industrial	Not available[d]	N/A	
	Total	120,422	120,422	

[a] Data from the division in its 1985 land use survey of the lower Sevier River Basin.

[b] Approximate surface area of Sevier Lake as digitized from 1:24,000 scale topographic maps. This area varies from year to year depending upon precipitation and agricultural needs upstream.

[c] The perimeter of the lake as digitized was approximately 95.9 miles. Some of this must be considered riparian area, but the true extent varies from year to year and was not estimated during this inventory.

[d] At the time the land use inventory was conducted there was no commercial development at the lake. This has since changed, but the current extent is unknown.

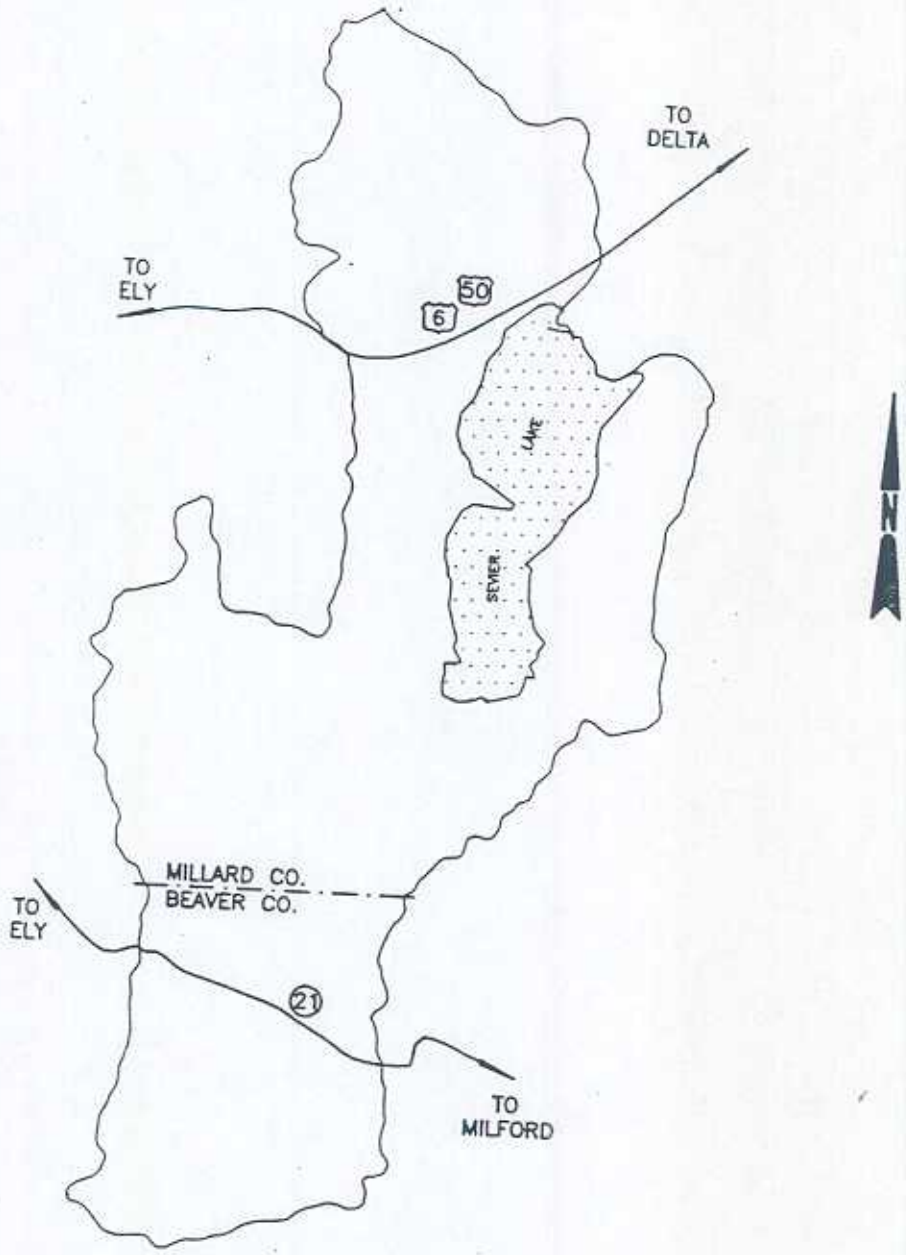

Figure 17. Water-related land use areas in the Sevier Lake Study Area (5-8).

The water-related land use data for the Sevier River Basin has been displayed in this report by study/subarea (Figures 5 through 17). That data has also been tabulated by study/subarea and by county in Tables 2 and 3.

As shown in these tables, 461,802 acres of land in Juab, Millard, Sanpete, Sevier, Piute, Kane, Iron and Garfield counties have been inventoried. This represents about seven percent of the entire Sevier River Basin (approximately 6.7 million acres). Areas not inventoried are mainly national forests and open rangeland. Of the 461,802 inventoried acres, 381,057 are irrigated cropland; 30,918 are grasses, hays, and pastureland which receive subsurface irrigation; 49,615 are phreatophytes and wet/open water areas; and 31,130 are residential/industrial areas. In addition, approximately 36,919 acres have been classified as idle agricultural land.

Table 2. Summary of Land Cover (in acres) by Study/Subarea for the Sevier River Basin.

Code	Cover	Study/Subareas Mammoth (5-6-1)	Panguitch (5-6-2)	East Fork (5-5-1)	Otter Creek (5-5-2)	Piute (5-6-3)	Marysvale (5-4-1)	Richfield (5-4-2)
IA1a	Orchard	0	0	0	0	0	0	2
IA2a	Grain	0	558	817	403	218	304	5,576
IA2a1	Corn	0	0	5	0	472	0	2,674
IA2b1	Potatoes	0	0	17	0	3	0	0
IA3a	Alfalfa	123	3,375	3,028	3,302	4,379	1,479	14,975
IA3b	Grass/Hay	0	0	0	0	0	0	0
IA3d	Pasture	665	3,916	875	980	1,212	1,074	6,998
IA4a	Idle Plowed	0	0	56	0	0	18	407
IA4b	Idle Overgrown	0	0	0	0	27	329	4,406
IIA1a	Pasture (Subject to spring flooding)	911	2,923	368	2,160	1,556	766	3,197
IIA1b	Grass/Hay (Subject to spring flooding)	221	498	1,382	2,940	0	0	0
Surface Irrigated Cropland Subtotal		1,919	11,269	6,547	9,784	7,866	3,970	38,235
IIA2a	Sub-Irrigated Pasture	102	1,906	531	673	1,752	1,090	3,025
IIA2b	Sub-Irrigated Grass/Hay	0	0	0	0	0	0	0
Sub-Irrigated Cropland Subtotal		102	1,906	531	673	1,752	1,090	3,025
Total Irrigated Croplands		2,021	13,175	7,078	10,458	9,617	5,060	41,261
IIC	Wet Flats (cattails/bullrush, etc)	0	0	0	0	0	52	519
IIE	Riparian Areas	202	687	491	308	423	1,068	574
IIF	Open Water	600	1,241	457	2,915	1,927	228	597
IIF4a	Temporarily Flooded	0	27	94	268	359	463	1,133
IIF4b	Sewage Lagoon	3	0	4	0	0	0	3
Wet/Open Water Areas Subtotal		805	1,954	1,045	3,492	2,709	1,811	2,825
VB	Residential	1,184	1,235	204	304	701	452	6,723
VB4	Public Open Space (parks, golf courses)	0	0	12	18	0	4	0
VC	Commercial/Industrial	0	34	0	0	0	0	0
Residential/Industrial Subtotal		1,184	1,269	216	322	701	456	6,723
Land Use/Land Cover Totals		4,011	16,398	8,339	14,271	13,027	7,326	50,809

Table 2. Continued.

Code	Cover	San Pitch (5-1)	Gunnison (5-3)	Scipio/Tintic (5-2-1)	Fillmore (5-7)	Delta (5-2-2)	Sevier Lake (5-8)	Total
		Study/Subareas						
IA1a	Orchard	0	0	0	0	28	0	30
IA2a	Grain	8,107	5,903	2,874	13,374	21,866	0	60,000
IA2a1	Corn	641	2,871	532	3,050	5,609	0	15,853
IA2b1	Potatoes	0	0	5	1,526	0	0	1,551
IA2b2	Onions	3	0	0	13	13	0	29
IA3a	Alfalfa	25,820	17,037	10,802	20,120	27,649	0	132,087
IA3b	Grass/Hay	4,117	0	0	404	353	0	4,874
IA3d	Pasture	21,598	6,303	1,801	6,099	5,565	0	57,085
IA4a	Idle Plowed	682	133	917	4,495	3,590	0	10,297
IA4b	Idle Overgrown	2,971	10,379	11,640	2,276	4,838	0	36,865
IIA1a	Pasture (Subject to spring flooding)	10,712	3,862	0	0	0	0	26,453
IIA1b	Grass/Hay (Subject to spring flooding)	0	0	0	0	0	0	5,040
Surface Irrigated Cropland Subtotal		74,648	46,487	28,571	51,358	69,511	0	350,166
IIA2a	Sub-Irrigated Pasture	9,087	6,454	6,232	71	0	0	30,922
IIA2b	Sub-Irrigated Grass/Hay	0	0	0	0	0	0	0
Sub-irrigated Cropland Subtotal		9,087	6,454	6,232	71	0	0	30,922
Total Irrigated Croplands		83,735	52,941	34,803	51,429	69,511	0	381,088
IIC	Wet Flats (Cattails/bullrush, etc)	588	3,383	1,904	0	0	N/A[a]	6,447
IIE	Riparian Areas	444	730	399	25	4,093	0	9,444
IIF	Open Water	2,583	6,638	1,541	307	6,372	120,422[b]	25,406[c]
IIF4a	Temporarily Flooded	458	1,045	1,242	0	2,919	0	8,006
IIF4b	Sewage Lagoon	119	0	0	29	164	0	321
Wet/Open Water Areas Subtotal		4,192	11,796	5,087	361	13,548	120,422[b]	49,624[c]
VB	Residential	7,396	3,546	1,299	2,298	4,159	0	29,500
VB4	Public Open Space (Parks, golf courses)	308	0	0	20	122	0	483
VC	Commercial/Industrial	581	0	27	148	362	N/A	1,152
Built-up Land Areas Subtotal		8,285	3,546	1,326	2,466	4,642	N/A	31,135
Land Use/Land Cover Totals		96,211	68,283	41,216	54,256	87,700	461,847[d]	461,847

[a,b,c,d]Figures for Sevier Lake are not included in the totals. See footnotes on page opposite Figure 17 for explanation.

Table 3. Summary of Land Cover (in acres) by County for the Sevier River Basin.

Code	Cover	Counties								
		Iron	Piute	Garfield	Kane	Sevier	Sanpete	Millard	Juab	Total
IA1a	Orchard	0	0	0	0	2	0	28	0	30
IA2a	Grain	0	915	1,207	0	7,563	12,202	36,722	1,391	60,000
IA2a1	Corn	0	477	0	0	4,601	1,584	9,107	84	15,853
IA2b1	Potatoes	0	10	9	0	0	0	1,532	0	1,551
IA2b2	Onions	0	0	0	0	0	3	27	0	29
IA3a	Alfalfa	0	8,434	6,250	0	24,077	34,755	53,128	5,444	132,087
IA3b	Grass/Hay	0	0	0	0	0	4,117	757	0	4,874
IA3d	Pasture	0	3,031	4,833	31	10,381	25,343	12,526	940	57,085
IA4a	Idle Plowed	0	74	0	0	443	779	8,063	939	10,297
IA4b	Idle Overgrown	0	356	0	0	8,796	8,960	11,338	7,416	36,865
IIA1a	Pasture (Subject to spring flood)	233	2,733	3,676	115	0	13,323	0	0	26,453
IIA1b	Grass/Hay (Subject to spring flood)	0	2,909	1,444	0	687	0	0	0	5,040
Surface Irrigated Cropland Subtotal		233	18,940	17,421	146	62,921	101,065	133,227	16,213	350,166
IIA2a	Sub-Irrigated Pasture	18	3,288	2,211	52	5,089	13,962	825	5,478	30,922
IIA2b	Sub-Irrigated Grass/Hay	0	0	0	0	0	0	0	0	0
Sub-Irrigated Cropland Subtotal		18	3,288	2,211	52	5,089	13,962	825	5,478	30,922
Total Irrigated Croplands		251	22,228	19,633	198	68,009	115,027	134,052	21,691	381,088
IIC	Wet Flats (Cattails/bullrush, etc)	0	52	0	0	630	3,860	0	1,904	6,447
IIE	Riparian Areas	0	1,785	1,328	0	1,193	621	4,368	149	9,444
IIF	Open Water	46	4,566	1,744	502	1,813	5,816	6,802*	4,118	25,406*
IIF4a	Temporarily Flooded	27	1,064	120	0	1,734	901	3,320	841	8,006
IIF4b	Sewage Lagoon	0	0	4	3	3	119	192	0	321
Wet/Open Water Areas Subtotal		72	7,467	3,195	505	5,372	11,318	14,682	7,012	49,624
VB	Residential	0	1,273	1,572	753	9,272	8,655	7,030	726	29,500
VB4	Open Spaces (Parks, golf courses)	0	22	12	0	0	308	142	0	483
VC	Commercial/Industrial	0	0	34	0	0	581	537	0	1,152
Built-Up Land Areas Subtotal		221	1,294	1,618	753	9,272	9,544	7,708	726	31,135
Land Use/Land Cover Totals		545	30,989	24,445	1,456	82,653	135,888	156,442	29,428	461,847

*This total does not include the surface area of Sevier Lake because it is so highly variable from season to season and year to year. For a further explanation, see the footnote for the table opposite the Sevier Lake Study Area figure, page 28.

METHODOLOGY FOR GATHERING LAND USE DATA

Background

The methodology used by the division over the past 25 years in conducting water-related land use studies has varied with regard to procedures used, detail, etc. Earlier inventories were prepared with large format vertical/aerial photographs supplemented with field surveys to label boundaries, vegetation types, and other water use information.

After identifying crops and labeling photographs, the photographs were projected onto a base map and then planimetered or "dot-counted" to determine the acreage. Tables for individual townships and ranges were prepared showing the total land within each section and the amount of land in each land use category. Data was then available for use in preparing water budgets.

The water-related land use inventories completed by the division and the U.S. Soil Conservation Service (SCS) over the last 25 years have essentially covered the entire state. The two agencies have inventoried about 4 million acres (which included 1.4 million acres of irrigated land) in order to acquire the data needed to prepare hydrologic inventories and to conduct other water-related studies in Utah.

In the early 1980s, the division faced the task of updating its methodology for collecting water-related land use data to take advantage of the rapidly growing fields of remotely sensed data and computerized Geographic Information Systems (GIS). Updating land use data for each hydrologic area of the state is an on-going process, and the division has

now developed procedures for consistent data gathering and updating at 7 to 10 year intervals.

For several years, the division contracted with the University of Utah Research Institute, Center for Remote Sensing and Cartography (CRSC), to prepare water-related land use inventories. During this period, water-related land use data was obtained by using high altitude color infrared photography and laboratory interpretation, with field checking. More recently, the division has entered into cooperative agreements with several federal and other state agencies to complete and update all land use data for the state of Utah. For a further discussion of the university methods relating to the Sevier River Basin, refer to CRSC Reports 81-6 and 84-5, Supplements I and II to this report.

Present Method

In March 1984, several division staff members visited the California Department of Water Resources to observe its methodology for collecting water-related land use data for state water planning purposes. The division, based on its review of the California methodology and its own experience, developed a water-related land use inventory program. This program includes the use of 35mm slides, USGS 7 ½ minute quadrangle maps, field-mapping using base maps produced from the 35mm photography, and a computerized geographic information system to process, store, and retrieve land use data.

The first step in a water-related land use inventory is to identify areas to be covered with aerial photography for any individual year. These areas are identified on maps of suitable scale (usually

1:100,000) using previous land use studies and other available information such as maps generated from high altitude color infrared photography or Landsat. Flight lines are plotted on the maps to show land areas to be covered with aerial photography. Flight lines are generally plotted running north and south through the center of the sections to be photographed. An exception to the practice is a long narrow canyon with irrigated land only in the bottom. When this situation is encountered, the flight line will follow the canyon without regard to section lines or compass directions.

During the second step identified areas are photographed using 35mm slide film. Ideally, the 35mm photography should be conducted at a time of year that shows the highest contrast between the water-related land use areas (mainly irrigated land) and surrounding areas. When field mapping/checking is to be conducted in the same season, the photographs are taken as early in the growing season as possible. The division has generally found that the period from June 15 to July 15 is the best time for this photography.

The division specifies that aerial photographs be obtained using an aircraft (Figure 18) carrying a high quality 35mm single lens reflex camera mounted to focus along a vertical axis to the earth. A 24mm lens is used and photos must be taken between 6,000 and 6,500 feet above the ground. This procedure allows each slide to cover a little more than one square mile with approximately 30 percent overlap on the wide side of the slide and 5 percent on the slide's narrow side. High quality commercial color positive film is used with appropriate commercial processing after each day's flight. The slides are then cataloged according to the

flight-line number and shown on a location map. All 35mm slides are filed and stored at the division offices and are cataloged according to individual quadrangle map location.

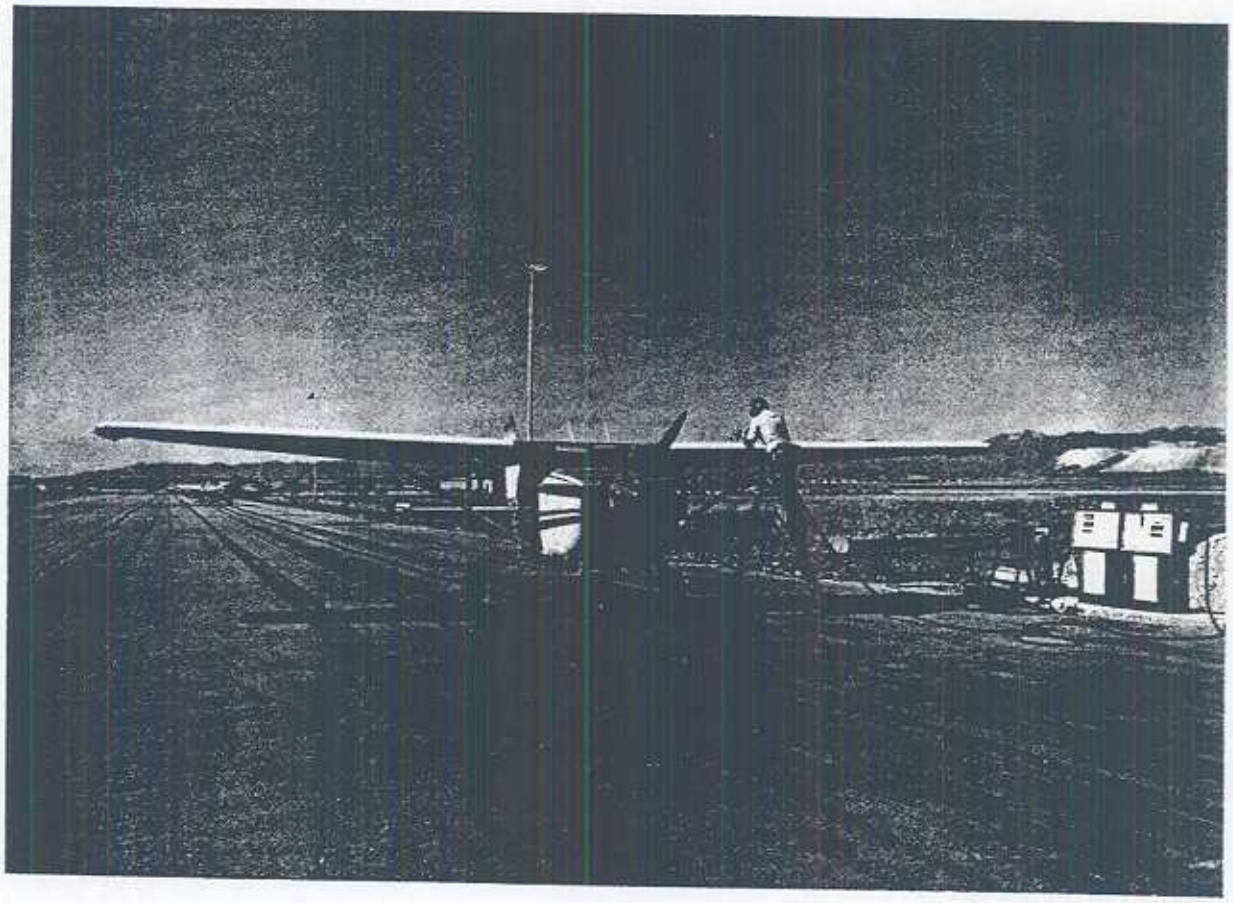

Figure 18. Typical aircraft used for aerial photography.

After cataloging the slides, the division transfers boundaries of water-related areas from the slide to USGS 7½ minute quadrangle maps using a standard slide projector with a 100-200mm zoom lens. The image is directed from the projector, located below a glass table top, to a 45-degree first surface mirror to the back of a quadrangle map. The image showing through the map is adjusted to the map scale with the zoom lens.

Field boundaries and other water-use boundaries are then traced onto the 7½ minute quadrangle map. At the same time, the technician attempts to identify the category of land use/cover and uses a code for the appropriate category in each water use area on the field map. The date that transfer of slide data was completed is also noted on the map. Figure 19 illustrates this basic procedure.

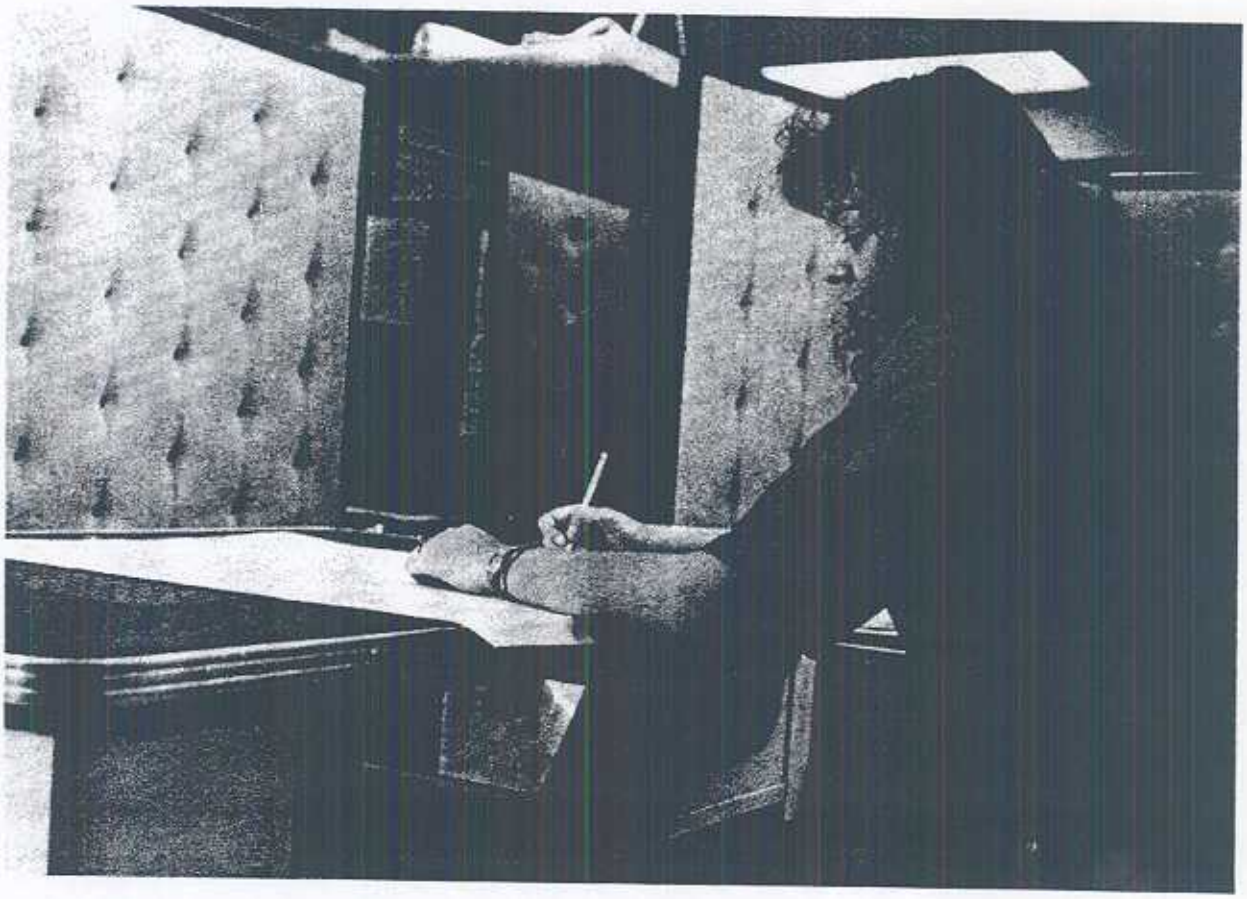

Figure 19. Transferring slide data to field map.

After the slide data is transferred to the quadrangle map, a two-person team uses the map in the field to check the boundaries and land use data on the quadrangle, and marks in red the actual land use or land covercategory if it is different than the category originally identified.

After the land classification on the quadrangle map has been field-checked, the field team marks the completion date on the edge of the map. Figure 20 shows a Division of Water Resources field map after field-checking has been completed.

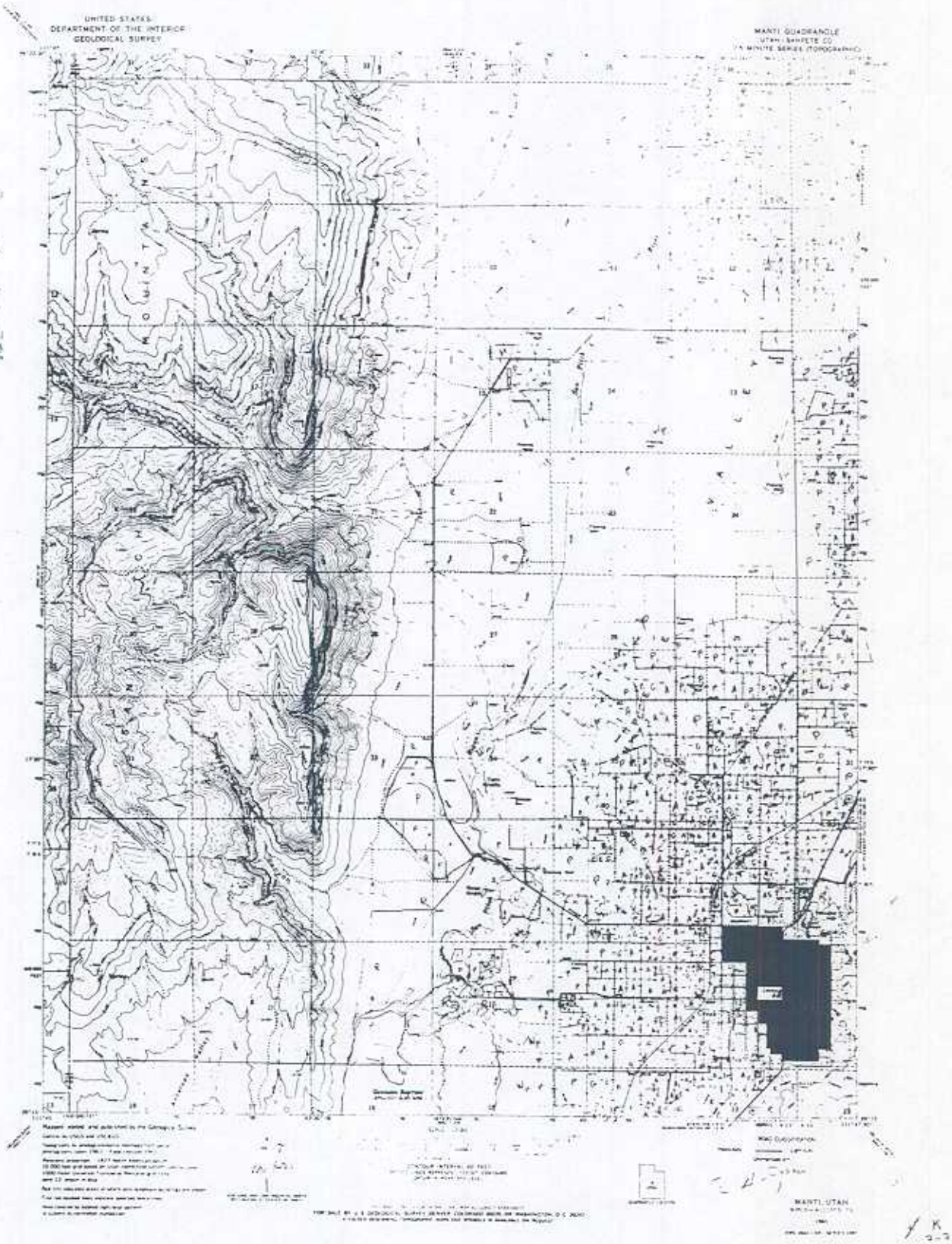

Figure 20. Field map after field checking has been completed (Manti Quadrangle).

The next step is to digitize and process the field data. Digitizing is the process of converting data from map or image form to digital form for computer analysis. Typically, digitizing and entering the categories of land use into the computer is performed during the fall and winter following the aerial photography. This is accomplished by using ESRI ARC/INFO Software and a digitizer board large enough to hold a quadrangle map. The division's digitizing work station is shown in Figure 21. All processed data is filed in the State AGRC database. The division uses the special data management and geographic information management capabilities of the AGRC system to produce tabulated water-related land use maps.

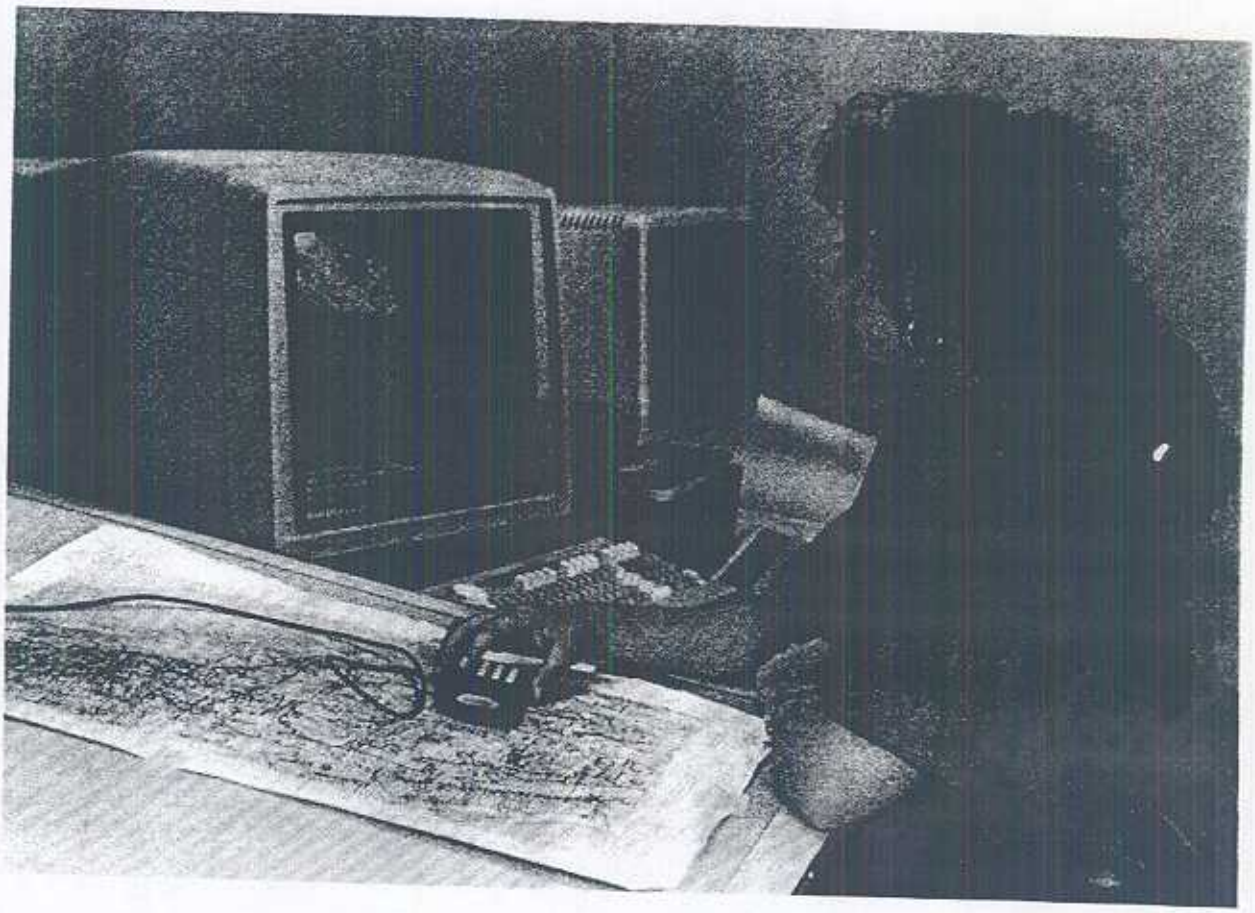

Figure 21. Digitizing work station.

Once the land use data has been digitized and processed through the AGRC system, the division plots out a 7½ minute quadrangle line map of the data. These plots are overlaid on the field maps to check for errors in recording or digitizing. An example of a line map of the Manti quadrangle is shown in Figure 22.

Once checked, the data in the AGRC system becomes available for use in water resource planning studies. The final computer-generated map of the Manti quadrangle, similar to what might be obtained from the AGRC, is shown in Figure 23.

Legend for Computer-Generated Line Maps in the Sevier River Basin, referenced to Figure 22.

Label	Code	Cover Type
O	IA1a	Orchards
BR	IA1e	Vineyards & Other Horticulture
G	IA2a	Grain
C	IA2a1	Corn
V	IA2b	Vegetables
PO	IA2b1	Potatoes
ON	IA2b2	Onions
B	IA2b3	Beans
T	IA2b4	Tomatoes
S	IA2c	Other Row Crops
A	IA3a	Alfalfa
P1	IA3b	Grass/Hay
P	IA3d	Pasture
TF	IA3e	Turf/Grass Yards
F	IA4a	Fallow
I	IA4b	Idle
DG	IB1a	Non-Irrigated Cropland
DA	IB2a	Non-Irrigated Alfalfa
DP	IB2b	Non-Irrigated Pasture
DF	IB3a	Non-Irrigated Fallow
DI	IB3b	Non-Irrigated Idle
IWP	IIA1a	Pasture (subject to spring flooding)
IWP1	IIA1b	Grass/Hay (subject to spring flooding)
WP	IIA2a	Sub-irrigated Pasture
WP1	IIA2b	Sub-irrigated Grass/Hay
WF	IIB	Wet Areas (cattails/bullrush, etc)
WR	IIC	Wet Flats (mud flats w/little vegetation)
RIP	IIE	Riparian Areas
W	IIF	Open Water
WM	IIF4a	Temporarily Flooded
SL	IIF4b	Sewage Lagoons
EP	IIF4c	Evaporation Pond
R	VB1	Buildings/Homes (high density)
R2	VB2	Buildings/Homes (low density)
RP	VB3	Irr. Open Spaces (parks, golf courses, etc)
CM	VC1	Commercial
CI	VC2	Industrial
CS	VC3	Open Spaces

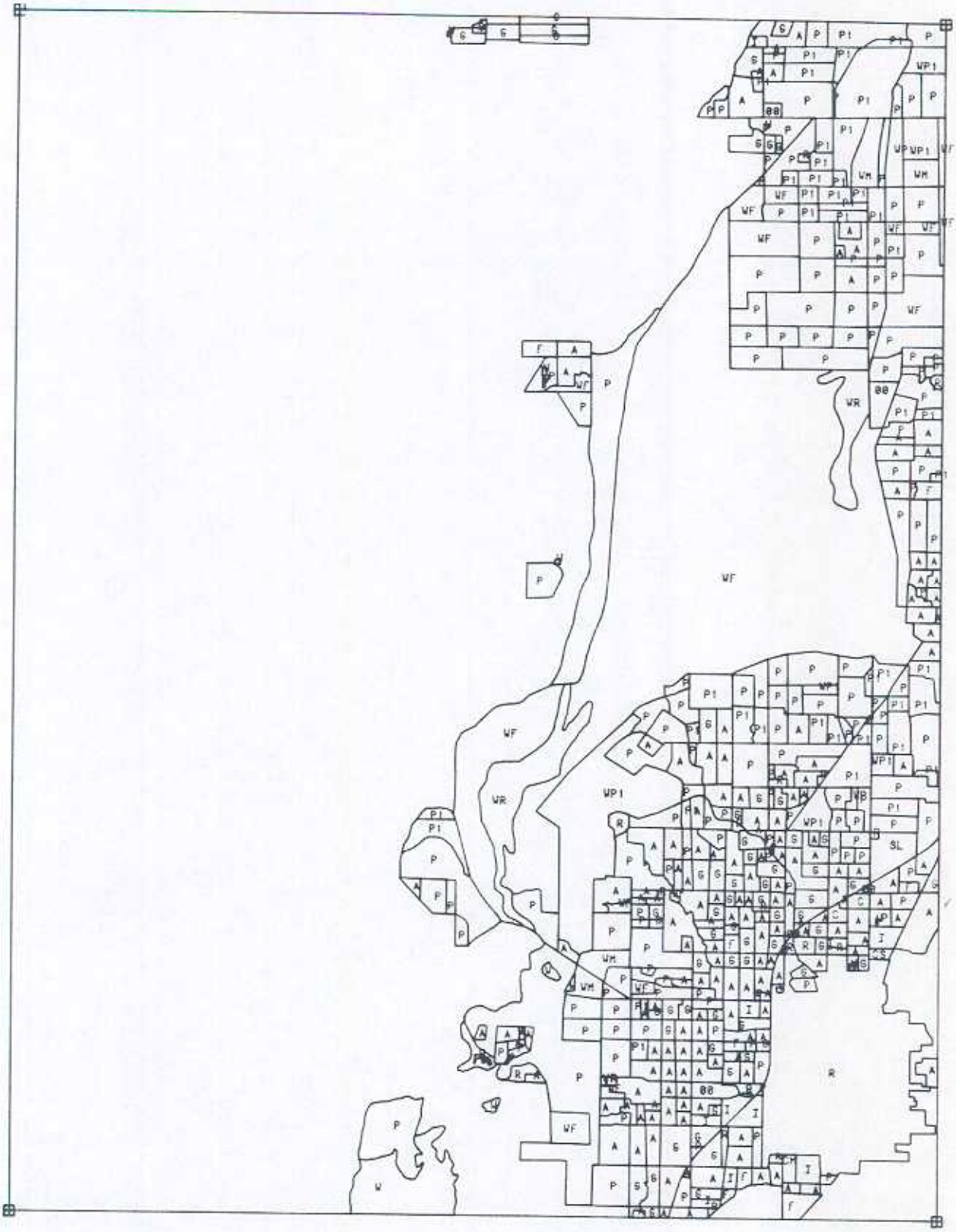

Figure 22. Computer-generated line map of the Manti 7½ minute quadrangle.

IA1a	FRUIT	IRRIG. CROPLAND
IA1e	BERRIES	
IA2a	GRAIN	
IA2a1	CORN	
IA2a2	SORGHUM	
IA2b	VEGETABLES	
IA2b1	POTATOES	
IA2b2	ONIONS	
IA2b3	BEANS	
IA2c	OTHER ROW CROPS	
IA3a	ALFALFA	
IA3b	GRASS HAY	
IA3c	GRASS/TURF	
IA3d	PASTURE	
IA4a	FALLOW	
IA4b	IDLE	
IIA1a	PASTURE	GRASSY/PHREATO.
IIA1b	HAYLAND	
IIA2a	PASTURE	
IIA2b	HAYLAND	
IB	NON IRR. CROPLAND	NON-IRRIG. CROPLAND
IB1a	GRAIN	
IB2a	ALFALFA	
IB2b	PASTURE	
IB3a	FALLOW	
IB3b	IDLE	
IIC	WET FLATS	GRASSY/PHREATO./WATER
IIE	RIPARIAN	
IIF	OPEN WATER	
IIF4a	TEMP. FLOODED	
IIF4b	SEWAGE LAGOON	
VB	RESIDENTIAL	BUILT-UP LAND
VB4	OPEN SPACES	
VC	COMMERCIAL/INDUSTR.	

Legend for Final Computer-generated Maps of the Sevier River Basin, referenced to Figure 23.

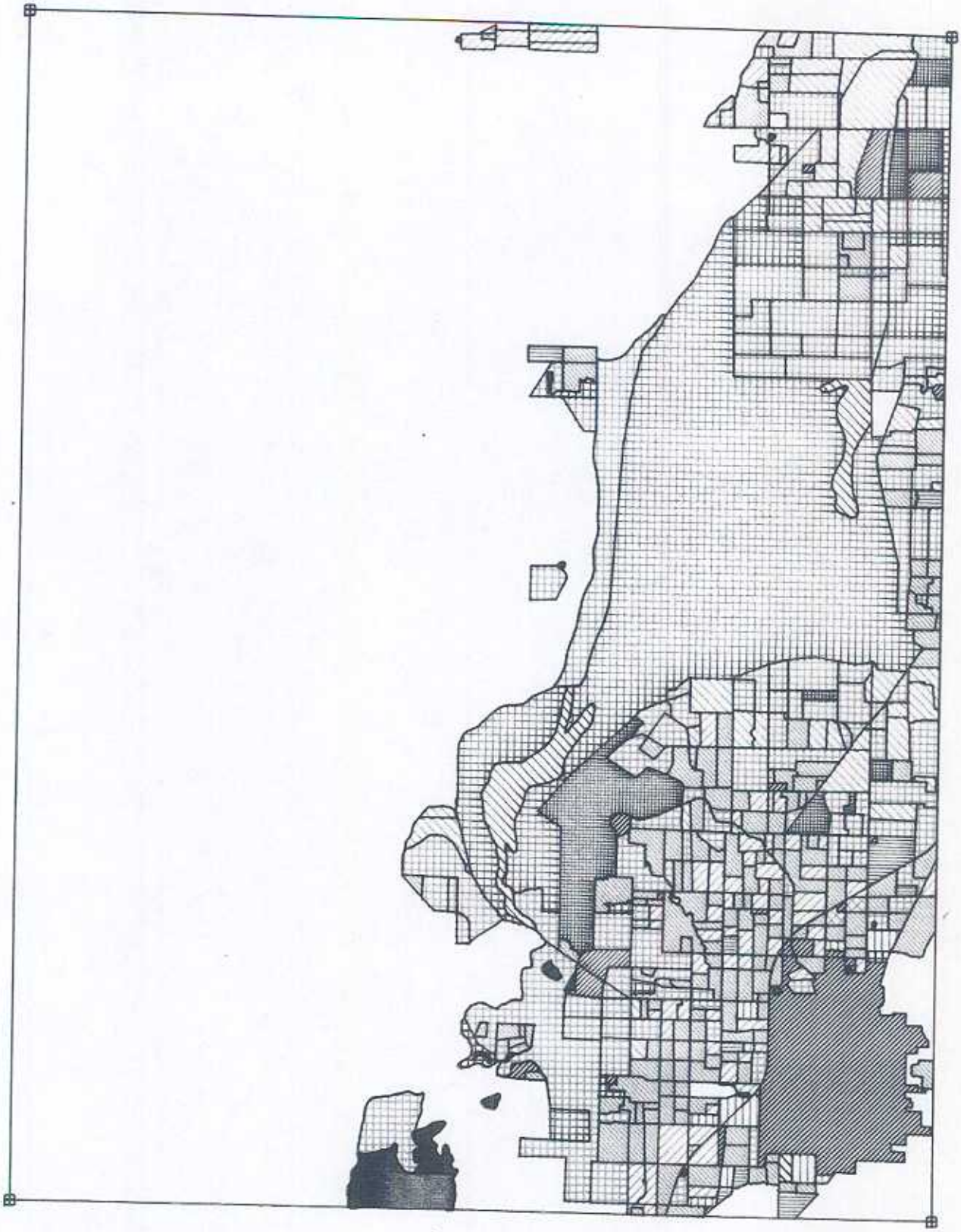

Figure 23. Computer-generated map (Manti Quadrangle).

LAND USE CATEGORIES

During the division's years of collecting water-related land use data, land use categories and map codes have varied from inventory to inventory.

In late 1984, at the beginning of the division's new phase of mapping water-related land use, an Active Mappers Committee was formed. The committee reviewed all ongoing mapping efforts in the state and then focused on the issue of coordinating and standardizing map data. A summary of the committee's work is given in Appendix B. The division is committed to using the "1988 Standard Cover Types and Codes" list developed from this committee. Codes from this standard cover type list, with descriptive information (where necessary), are shown in Table 4.

As each water-related land use inventory for the state is completed, and as some areas are re-inventoried, it is often times useful to tabulate and compare changes in these inventories. Because of the different cover type names and codes that have been used in the past, it is necessary to reference earlier codes and land cover types to the 1988 Standard Cover Types and Codes. Table 5 shows the codes from earlier studies that relate to the standard cover types and codes. Data sets from studies prior to 1988, which have been entered into the AGRC library data base, have been adjusted to the 1988 Standard Code in this table. Some published reports may show the codes used prior to 1988. Appendix C lists the previous land use studies conducted by the division.

Table 4. List of 1988 Standard Cover Types and Codes for the State of Utah.

Code	Cover Type	Comments/Explanations
I	Cropland	
IA	Irrigated Cropland*	(Rotation Crops)
IA1	Horticulture & Specialty Crops*	
IA1a	Fruit	(Orchards)
IA1a1	Cherry	
IA1a2	Apple	
IA1a3	Peach	
IA1a4	Pear	
IA1a5	Apricot	
IA1a6	Other	
IA1b	Nuts	(Groves)
IA1b1	Walnut	
IA1b2	Pecan	
IA1b3	Other	
IA1c	Vineyard	(Grapes)
IA1d	Bush Fruit	
IA1e	Berries	
IA1f	Other Horticulture	(Nurseries)
IA1g	Other Specialty Crops	
IA2	Row and Close Grown Crops*	
IA2a	Grain	
IA2a1	Corn	
IA2a2	Sorghum	
IA2a3	Wheat	
IA2a4	Barley	
IA2a5	Oats	
IA2a6	Other Grains	
IA2b	Vegetables	
IA2b1	Potatoes	
IA2b2	Onions	
IA2b3	Beans	
IA2b4	Tomatoes	
IA2b5	Sweet Corn	
IA2b6	Other	(Melons, Squash, Etc.)
IA3	Forage Crops*	
IA3a	Alfalfa	
IA3b	Grass Hay	
IA3c	Grass/Turf	(Turf Farms)
IA3d	Pasture	
IA3e	Other	
IA4	Other*	
IA4a	Fallow	(Plowed or disked.)
IA4b	Idle	(Overgrown more than one season.)
IB	Non-Irrigated Cropland*	(Rotation Crops)
IB1	Row and Close-Grown Crops	
IB1a	Grain, Beans, Seeds	
IB1a1	Wheat	

Table 4. Continued.

Code	Cover Type	Comments/Explanations
IB1a2	Other Grains	(Barley, etc.)
IB1a3	Dry Beans	
IB1a4	Safflower	
IB1a5	Other	
IB2	Hayland Crops*	
IB2a	Alfalfa	
IB2b	Pasture	
IB2c	Other	
IB3	Other*	
IB3a	Fallow	(Plowed, Stubble, Mulch)
IB3b	Idle	(Overgrown more than one season.)
II	Grassy/Phreatophytes/Open Water Areas	
IIA	Grassy Aspect*	
IIA1	Irrigated*	
IIA1a	Pasture	(Subject to spring flooding.)
IIA1b	Hayland	(Subject to spring flooding.)
IIA2	Non-Irrigated*	
IIA2a	Pasture	(Receives subsurface water.)
IIA2b	Hayland	(Receives subsurface water.)
IIA2c	Non-Agricultural Use	(Receives subsurface water.)
IIB	Cattail/Bullrush Aspect*	
IIC	Wet Flats*	(Mud flats w/little or no vegetation.)
IID	Shrub Aspect*	(Salt Brush, Sagebrush)
IIE	Riparian*	
IIE1	Forested Aspect	(Cottonwoods, Birch)
IIE2	Shrub Aspect	(Willows)
IIF	Open Water*	
IIF1	Streams*	
IIF2	Reservoirs*	(Man-Made)
IIF3	Ponds & Lakes*	
IIF4	Other*	
IIF4a	Temporary Flooded	
IIF4b	Sewage Lagoon	
IIF4c	Evaporation Pond	
III	Rangeland and Forestland	
IIIA	Alpine Plant Communities*	
IIIB	Conifer*	
IIIB1	Douglas Fir - White Fir	
IIIB2	Ponderosa Pine	
IIIB3	Fir - Spruce	
IIIB4	Lodgepole Pine	
IIIB5	Pinion Pine - Juniper	
IIIB6	Other	

Table 4. Continued.

Code	Cover Type	Comments/Explanations
IIIC	Deciduous*	
IIIC1	Aspen	
IIIC2	Mountain Brush	(Oak Brush, Maples, Chaparral)
IIIC3	Other	
IIID	Grass Aspect*	
IIID1	Dry Pastures - Improved	(Chained & Reseeded)
IIID2	Native Grasses	
IIID3	Other	(Forbs)
IIIE	Shrub Aspect*	
IIIE1	Northern Desert Shrubs*	
IIIE1a	Sagebrush	
IIIE1b	Other	(Shadscale, Greaseweed, Halogeton)
IIIE2	Southern Desert Shrubs*	
IIIE2a	Creosote Bush	
IIIE2b	Other	(Forbs, Annual Grasses)
IIIE3	Salt Desert Shrubs*	
IIIE3a	Shadscale	
IIIE3b	Greasewood	
IIIE3c	Saltbrush	
IIIE3d	Desert Molley	
IIIE3e	Other	(Halogeton)
IV	Barren Lands	
IVA	Bare Soil/Sand*	
IVA1	Dry Salt Flats	
IVA2	Beaches	
IVA3	Sandy Areas Other Than Beaches	(Desert Sand Dunes)
IVA4	Other	
IVB	Rock Outcrops*	
IVC	Excavated Lands*	(Quarries, Gravel Pits)
IVD	Other*	
V	Built-Up Land*	
VA	Farmsteads*	
VA1	Buildings/Homes	
VA2	Open Spaces	(Feed Lots, Etc.)
VB	Residential*	
VB1	Buildings/Homes	(High density)
VB2	Buildings/Homes	(Low density)
VB3	Open Spaces	(Parks, Golf Courses)
VB4	Idle Spaces	(Not irrigated)
VC	Commercial/Industrial*	
VC1	Commercial	
VC2	Industrial	
VC3	Open Spaces	
VD	Transportation, Communications, Utilities*	
VE	Other*	

*Required for the basic vegetative cover information of the state.

Table 5. List of cover types and land use codes for the State of Utah (as standardized in 1988); with comparisons of the 1988 standardized cover type codes to the codes used in previous land use inventories.

STATE CODE	COVER TYPES (Standardized in 1988)	UTAH LK. (66)[a] BEAR R. (69) WEBER R. (70)	UINTAH (67) W. COLO. (67) VIRGIN R.(78) UINTA B. (80)	SALT LAKE COUNTY (82)	U. SEVIER (81) M. SEVIER (83) L. SEVIER (85) BEAR R. (86) WEBER R. (87)
I	Cropland	-[b]	-	-	*[c]
IA	Irrigated	A[d]	A	-	*
IA1	Hort. & Specialty Crops	-	-	-	*
IA1a	Fruit	A8	A16	-	*
IA1a1	Cherry	-	-	-	*
IA1a2	Apple	-	-	-	*
IA1a3	Peach	-	-	-	*
IA1a4	Pear	-	-	-	*
IA1a5	Apricot	-	-	-	*
IA1a6	Other	-	-	-	*
IA1b	Nuts	-	-	-	*
IA1b1	Walnut	-	-	-	*
IA1b2	Pecan	-	-	-	*
IA1b3	Other	-	-	-	*
IA1c	Vineyard	-	-	-	*
IA1d	Bush Fruit	-	-	-	*
IA1e	Berries	-	-	-	*
IA1f	Nurseries	-	-	-	*
IA1g	Other	-	-	-	*
IA2	Row & Close-Grown Crops	-	-	-	*
IA2a	Grain	A4	-	Ag	*
IA2a1	Corn	A5	A1	-	*
IA2a2	Sorghum	-	-	-	*
IA2a3	Wheat	-	A9	-	*
IA2a4	Barley	-	A7	-	*
IA2a5	Oats	-	A8	-	*
IA2a6	Other	-	-	-	*
IA2b	Vegetables	-	-	-	*
IA2b1	Potatoes	A7	A3	-	*
IA2b2	Onions	-	-	-	*
IA2b3	Beans	A13	-	-	*
IA2b4	Tomatoes	A10	A5	-	*
IA2b5	Sweet Corn	-	-	-	*
IA2b6	Other	A6,A9,A11	A2,A4,A6	-	IA2b5[e]

[a] The data in parentheses (66) identifies the year the field checking was conducted for the various inventories.
[b] The dash (-) indicates that there was no corresponding cover type mapped for the above inventories.
[c] The asterisk (*) indicates that the cover type for the above inventories is the same as the 1988 standard cover types.
[d] The use of a code, such as the (A) footnoted, indicates that the code used for the above inventory corresponds to the 1988 standard cover types.
[e] The codes that appear in this column are those that are different than the 1988 standard code.

Table 5. Continued.

STATE CODE	COVER TYPES (Standardized in 1988)	UTAH LAKE (66)[a] BEAR R. (69) WEBER R. (70)	UINTAH (67) W. COLO. (67) VIRGIN R.(78) UINTA B. (80)	SALT LAKE COUNTY (82)	U. SEVIER (81) M. SEVIER (83) L. SEVIER (85) BEAR R. (86) WEBER R. (87)
IA3	Forage Crops	-	-	A	*
IA3a	Alfalfa	A1	A10	-	*
IA3b	Grass Hay	A3	A12	-	*
IA3c	Grass/Turf	-	-	-	IA3e
IA3d	Pasture	A2	A13	-	*
IA3e	Other	-	A11	-	IA3c
IA4	Other	-	A18	Ai	*
IA4a	Fallow Plowed	-	-	-	*
IA4b	Idle (Overgrown)	A12	A17	-	*
IB	Non-Irrigated	E	B	D	*
IB1	Row & Close-Grown Crops	-	-	-	*
IB1a	Grain (Beans, Seeds)	E1	-	-	*
IB1a1	Wheat	-	B2	-	*
IB1a2	Other Grains	-	B3	-	*
IB1a3	Dry Beans	-	B4	-	*
IB1a4	Safflower	-	-	-	*
IB2	Hayland Crops	-	-	-	*
IB2a	Alfalfa	E2	B1	-	*
IB2b	Pasture	E3	B5	-	*
IB2c	Other	E5	-	-	*
IB3	Other (Plowed)	-	B7	-	*
IB3a	Fallow	E4	B6	Df	*

[a] The data in parentheses (66) identifies the year the field checking was conducted for the various inventories.
[b] The dash (-) indicates that there was no corresponding cover type mapped for the above inventories.
[c] The asterisk (*) indicates that the cover type for the above inventories is the same as the 1988 standard cover types.
[d] The use of a code, such as the (A) footnoted, indicates that the code used for the above inventory corresponds to the 1988 standard cover types.
[e] The codes that appear in this column are those that are different than the 1988 standard code.

Table 5. Continued.

STATE CODE	COVER TYPES (Standardized in 1988)	UTAH LAKE (66)[a] BEAR R. (69) WEBER R. (70)	UINTAH (67) W. COLO. (67) VIRGIN R.(78) UINTA B. (80)	SALT LAKE COUNTY (82)	U. SEVIER (81) M. SEVIER (83) L. SEVIER (85) BEAR R. (86) WEBER R. (87)
II	Meadow/Wetlands/Open Water	C	O,F	-	*
IIA	Grassy Aspect	-	-	-	*
IIA1	Irrigated	-	-	-	*
IIA1a	Pasture	-	A14	-	IIA1a1,2a1
IIA1b	Hayland	-	A15	-	IIA1a2,2a2
IIA2	Non-Irrigated	-	-	-	*
IIA2a	Pasture	C4	8,F8	Ws	IIA1b1,2b1
IIA2b	Hayland	-	-	-	IIA1b2,1b2
IIA2c	Non-Agricultural Use	-	-	-	IIA1b3,2b3
IIB	Cattail/Bullrush	C1	F4	Wc	*
IIC	Wet Flats (barren)	-	-	M	*
IID	Shrub Aspect	C5	F2	-	*
IIE	Riparian	C2	-	Wr	*
IIE1	Forested Aspect	-	F1	-	*
IIE2	Shrub Aspect	C3	3,5,6,7,9	-	*
IIF	Open Water	B	E	-	*
IIF1	Streams	-	-	-	*
IIF2	Reservoirs	-	E1,E2	-	*
IIF3	Ponds/Lakes	-	E4	-	*
IIF4	Other	-	E3	-	*
IIF4a	Temporarily Flooded	-	-	-	*
IIF4b	Sewage Lagoon	-	-	-	*
IIF4c	Evaporation Pond	-	-	S	IIFAC,VC2

[a] The data in parentheses (66) identifies the year the field checking was conducted for the various inventories.
[b] The dash (-) indicates that there was no corresponding cover type mapped for the above inventories.
[c] The asterisk (*) indicates that the cover type for the above inventories is the same as the 1988 standard cover types.
[d] The use of a code, such as the (A) footnoted, indicates that the code used for the above inventory corresponds to the 1988 standard cover types.
[e] The codes that appear in this column are those that are different than the 1988 standard code.

Table 5. Continued.

STATE CODE	COVER TYPES (Standardized in 1988)	UTAH LAKE (66)[a] BEAR R. (69) WEBER R. (70)	UINTAH (67) W. COLO. (67) VIRGIN R.(78) UINTA B. (80)	SALT LAKE COUNTY (82)	U. SEVIER (81) M. SEVIER (83) L. SEVIER (85) BEAR R (86) WEBER R. (87)
III	Range & Forest Land	-	-	-	*
IIIA	Alpine Plants	-	-	-	*
IIIB	Conifer	-	-	Uc	*
IIIB1	Douglas/White Fur	-	-	-	*
IIIB2	Ponderosa	-	-	-	*
IIIB3	Fir/Spruce	-	-	-	*
IIIB4	Lodgepole Pine	-	-	-	*
IIIB5	Pinyon-Juniper	-	-	-	*
IIIB6	Etc.	-	-	-	*
IIIC	Deciduous	-	-	Ud	*
IIIC1	Aspen	-	-	-	*
IIIC2	Mountain Brush	-	-	-	*
IIIC3	Etc.	-	-	-	*
IIID	Grass Aspect	-	-	-	*
IIID1	Dry Pasture	-	-	-	*
IIID2	Native Grasses	-	-	Ug	*
IIID3	Etc.	-	-	-	*
IIIE	Shrub Aspect	-	-	-	*
IIIE1	Northern Desert Shrub	-	-	Um	*
IIIE1a	Sagebrush	-	-	-	*
IIIE1b	Etc.	-	-	-	*
IIIE2	Southern Desert Shrub	-	-	-	*
IIIE2a	Creosote Bush	-	-	-	*
IIIE2b	Etc.	-	-	-	*
IIIE3	Salt Desert Shrub	-	-	-	*
IIIE3a	Shadescale	-	-	-	*
IIIE3b	Greasewood	-	-	-	*
IIIE3c	Saltbrush	-	-	-	*
IIIE3d	Desert Molley	-	-	-	*
IIIE3e	Etc.	-	-	-	*

[a] The data in parentheses (66) identifies the year the field checking was conducted for the various inventories.
[b] The dash (-) indicates that there was no corresponding cover type mapped for the above inventories.
[c] The asterisk (*) indicates that the cover type for the above inventories is the same as the 1988 standard cover types.
[d] The use of a code, such as the (A) footnoted, indicates that the code used for the above inventory corresponds to the 1988 standard cover types.
[e] The codes that appear in this column are those that are different than the 1988 standard code.

Table 5. Continued.

STATE CODE	COVER TYPES (Standardized in 1988)	UTAH LAKE (66)[a] BEAR R. (69) WEBER R. (70)	UINTAH (67) W. COLO. (67) VIRGIN R.(78) UINTA B. (80)	SALT LAKE COUNTY (82)	U. SEVIER (81) M. SEVIER (83) L. SEVIER (85) BEAR R. (86) WEBER R. (87)
IV	Barren Lands	-	-	-	*
IVA	Bare Soil/Sand	-	-	-	*
IVA1	Dry Salt Flats	-	-	-	*
IVA2	Beaches	-	-	-	*
IVA3	Other Sandy Areas	-	-	-	*
IVA4	Other	-	-	-	*
IVB	Rock Outcrop	-	-	Ur	*
IVC	Excavated Land	-	-	E	*
IVD	Other	-	-	-	*
V	Built-Up Land	D	C	-	*
VA	Farmstead	-	-	-	*
VA1	Builds/Homes	-	C1,C5	-	*
VA2	Open Spaces	-	C4	-	*
VB	Residential	-	-	-	*
VB1	High Density	-	C3	Rt,R	VB1,VB2,VB6a
VB2	Low Density	-	-	R1	VB3
VB3	Open Spaces	-	C2	L	VB4
VB4	Idle	-	-	-	*
VC	Commercial/Industrial	F	D	C	*
VC1	Commercial	-	-	-	*
VC2	Industrial	-	-	-	VC4
VC3	Open Spaces	-	-	X	*
VD	Transportation & Utilities	-	-	D	VD,VE
VE	Other	-	-	-	*

[a] The data in parentheses (66) identifies the year the field checking was conducted for the various inventories.
[b] The dash (-) indicates that there was no corresponding cover type mapped for the above inventories.
[c] The asterisk (*) indicates that the cover type for the above inventories is the same as the 1988 standard cover types.
[d] The use of a code, such as the (A) footnoted, indicates that the code used for the above inventory corresponds to the 1988 standard cover types.
[e] The codes that appear in this column are those that are different than the 1988 standard code.

APPENDICES

APPENDIX A

Hydrologic Inventories

Utah Lake Drainage Area. In cooperation with Utah State University. November 1969. 136 pages - includes substantial climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, geology, economy, history, and physiography.

Uintah Study Unit. In cooperation with Utah State University. March 1970. 181 pages - includes substantial climatic, streamflow, and groundwater data, detailed water budgets, and more general information on topography, geology, arable lands, history, economy, water quality and water development and management. (out of print, file copy only)

Weber River Study Unit. In cooperation with Utah State University. August 1970 - includes substantial climatic, streamflow and groundwater data, detailed water budgets, and more general information on topography, geology, economy, and water quality.

Great Salt Lake Desert Area. In cooperation with Utah State University. November 1971. 70 pages - includes substantial climatic and water resources data, water budget for Tooele Valley, and more general information on physiography, economy, geology, and water management aspects.

Bear River Study Unit. In cooperation with Utah State University. February 1973. 126 pages - includes substantial climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

Price River Study Unit. June 1975. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

Escalante River Study Unit. December 1976. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

Dirty Devil River Study Unit. January 1977. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

APPENDIX A Continued

San Rafael River Study Unit. January 1977. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

Update of the Price River Study Unit. June 1978. Includes updated climatic, streamflow, and water use data and detailed water budgets.

Update of the San Rafael River Study Unit. December 1979. Includes updated climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

Virgin and Kanab Study Units (Utah's Lower Colorado River Area). February 1983. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology, and economy.

Hydrologic Inventory of the Colorado, Dolores, and San Juan Study Units. September 1987. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology and economy.

Hydrologic Inventory of the Sevier River Basin. January 1991. Includes climatic, streamflow, and groundwater data, detailed water budgets, and more general information on water quality, topography, geology and economy.

APPENDIX B

In late 1984 at the beginning of Division of Water Resource's new phase of mapping water-related land use, an Active Mappers Committee was formed. Water Resources of the Department of Natural Resource and Agriculture Development and Conservation of the Department of Agriculture co-chaired this committee. Lloyd Austin of Water Resources and Jim Christensen of Agriculture filled these roles. Member agencies were:

Utah State Automated Geographic Reference System

U.S. Bureau of Land Management

U.S. Bureau of Reclamation

University of Utah Center for Remote Sensing and Cartography

Utah Department of Transportation

Utah Department of Agriculture

Utah Department of Natural Resource

Utah Department of Health - Water Pollution

Utah Division of Water Resources

Utah Division of Water Rights

Utah Division of Wildlife Resource

U.S. Soil Conservation Service

Utah Division of State Lands and Forestry

Utah Geological and Mineral Survey

U.S. Fish and Wildlife Service

U.S. Forest Service

U.S. Geological Survey

Utah State University Extension Service

The committee surveyed all ongoing mapping efforts and then focused on the issue of coordinating and standardizing map data. The relationships between several state agencies and the AGRC program of the Office of Planning and Budget were also clarified. Three specific products came from this committee's work. The first was a standardized definition of a base resource data map file as follows:

APPENDIX B Continued

Layers of Data	Level of Detail
Infrastructure & Base	Map Quad Sheet (USGS Topo) 1:24,000 scale
Ownership	Federal/State/Private, 1:250,000 scale
Soils	Level 3 definition with preferred input at 1:24,000 scale
Land Cover	Standard legend using 1:24,000 scale
Climate	Precipitation/Temperature at 1:250,000 scale

Secondly, a standard legend for a cover map was developed and agreed upon which allows a hierarchy of data entry. This is shown as Table 4. The headings which are marked with an asterisk were minimum required for the base data set. Individual agencies could use finer breakdowns as needed for their specific programs.

The Division of Water Resources used only certain categories in the Bear River mapping which were considered necessary for the water use budgets being prepared. All rangeland and forestland categories were left off while some categories were subdivided further than required by the base data set standards.

The third agreement reached by the committee was the use of a standard set of watershed units for the state. It was agreed that the maps developed by the United States Geological Survey working with National Water Resources Council would serve as the base standard. Individual agencies could then further subdivide these larger units for specific study purposes. This proposal was also presented to the Resource Development Coordinating Committee (RDCC) during the year 1986 and ratified.

APPENDIX C

Water-Related Land Use Studies

Utah Lake Drainage Area. In cooperation with Utah State University. February 1968 - detailed water-related land use tables and maps.

Bear River Drainage Area. In cooperation with Utah State University. April 1969 - detailed water-related land use tables and maps.

Weber River Drainage Area. In cooperation with Utah State University. February 1970 - detailed water-related land use tables and maps.

Uinta Hydrologic Area. Staff Report No. 7. September 1971 - detailed water-related land use tables and maps.

West Colorado Hydrologic Area. Staff Report No. 8. January 1972 - detailed water-related land use tables and maps.

Uintah Basin. In cooperation with U.S. Soil Conservation Services and National Aeronautics and Space Administration. 1980. Contains detailed water-related land use maps and tables. Investigates the use of landsat data concurrently with the high altitude color infrared photography to update the changing patterns of land use. Performed under contract with the Center for Remote Sensing and Cartography of the University of Utah Research Institute. 109 pages plus maps.

Sevier River Basin (Upper Portion), 1981. Contains detailed water-related land use maps and tables. Performed under contract with the Center for Remote Sensing and Cartography of the University of Utah Research Institute. 27 pages plus maps.

Salt Lake County, 1982. Contains detailed water related land use maps and tables. Performed under contract with the Center for Remote Sensing and Cartography of the University of Utah Research Institute. 24 pages plus maps.

Sevier River Basin (Middle Portion), 1984. Contains detailed water related land use maps and tables. Performed under contract with the Center for Remote Sensing and Cartography of the University of Utah Research Institute. 34 pages plus maps.

Sevier River Basin (Lower Portion), 1985. Contains detailed water-related land use maps and tables.

Virgin River Area, 1990. Contains detailed water-related land use maps and tables. Performed in cooperation with USDA Soil Conservation Service, St. George, Utah office and Utah Division of Water Rights, Cedar City Area Office. 56 pages plus maps.

APPENDIX C Continued

Bear River Basin, 1991. Contains detailed water-related land use maps and tables. Performed in cooperation with Utah Division of Water Rights. 50 pages plus maps.

Columbia River Basin (Utah portion), 1991. Contains detailed water-related land use maps and tables. 46 pages plus maps.

Southeast Colorado Basin (Utah Portion), 1991. Contains detailed water-related land use maps and tables. 57 pages plus maps.

SUPPLEMENT I

CRSC Report 81-6

APPENDIX A. Explanation of Wetland Classes Mapped in the Sevier River Basin.

The material is taken from "Classification of Wetlands and Deepwater Habitats of the United States" by Cowardin, et al. (1979). Only information regarding riverine, lacustrine, and palustrine systems is included.

THE CLASSIFICATION SYSTEM

The structure of this classification is hierarchical, progressing from systems and subsystems, at the most general levels, to classes, subclasses, and dominance types. Figure 1 illustrates the classification structure to the class level. Table 1 lists the classes and subclasses for each system and gives an example of a dominance type for each subclass. Artificial keys to the systems and classes are given in Appendix E. Modifiers for water regime, water chemistry, and soils are applied to classes, subclasses, and dominance types. Special modifiers describe wetlands and deepwater habitats that have been either created or highly modified by man or beavers.

Hierarchical Structure

Systems and Subsystems

The term SYSTEM refers here to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. We further subdivide systems into more specific categories called SUBSYSTEMS.

The characteristics of the five major systems—Marine, Estuarine, Riverine, Lacustrine, and Palustrine—have been discussed at length in the scientific literature and the concepts are well recognized; however, there is frequent disagreement as to which attributes should be used to bound the systems in space. For example, both the limit of tidal influence and the limit of ocean-derived salinity have been proposed for bounding the upstream end of the Estuarine System (Caspers 1967). As Bormann and Likens (1969) pointed out, boundaries of ecosystems are defined to meet practical needs.

Riverine System

Definition. The Riverine System (Fig. 4) includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5‰. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iséri 1960:5).

Limits. The Riverine System is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. In braided streams, the system is bounded by the banks forming the outer limits of the depression within which the braiding occurs.

The Riverine System terminates at the downstream end where the concentration of ocean-derived salts in the water exceeds 0.5‰ during the period of annual average low flow, or where the channel enters a lake. It terminates at the upstream end where tributary streams originate, or where the channel leaves a lake. Springs discharging into a channel are considered part of the Riverine System.

Description. Water is usually, but not always, flowing in the Riverine System. Upland islands or Palustrine wetlands may occur in the channel, but they are not included in the Riverine System. Palustrine Forested Wetlands, Emergent Wetlands, Scrub-Shrub Wetlands, and Moss-Lichen Wetlands may occur adjacent to the Riverine System, often on a floodplain. Many biologists have suggested that all the wetlands occurring on the river floodplain should be a part of the Riverine System because they consider their presence to be the result of river flooding. However, we concur with Reid and Wood (1976:72,84) who stated, "The floodplain is a flat expanse of land bordering an old river. . . . Often the floodplain may take the form of a very level plain occupied by the present stream channel, and it may never, or only occasionally, be flooded. . . . It is this subsurface water [the ground water] that controls to a great extent the level of lake surfaces, the flow of streams, and the extent of swamps and marshes."

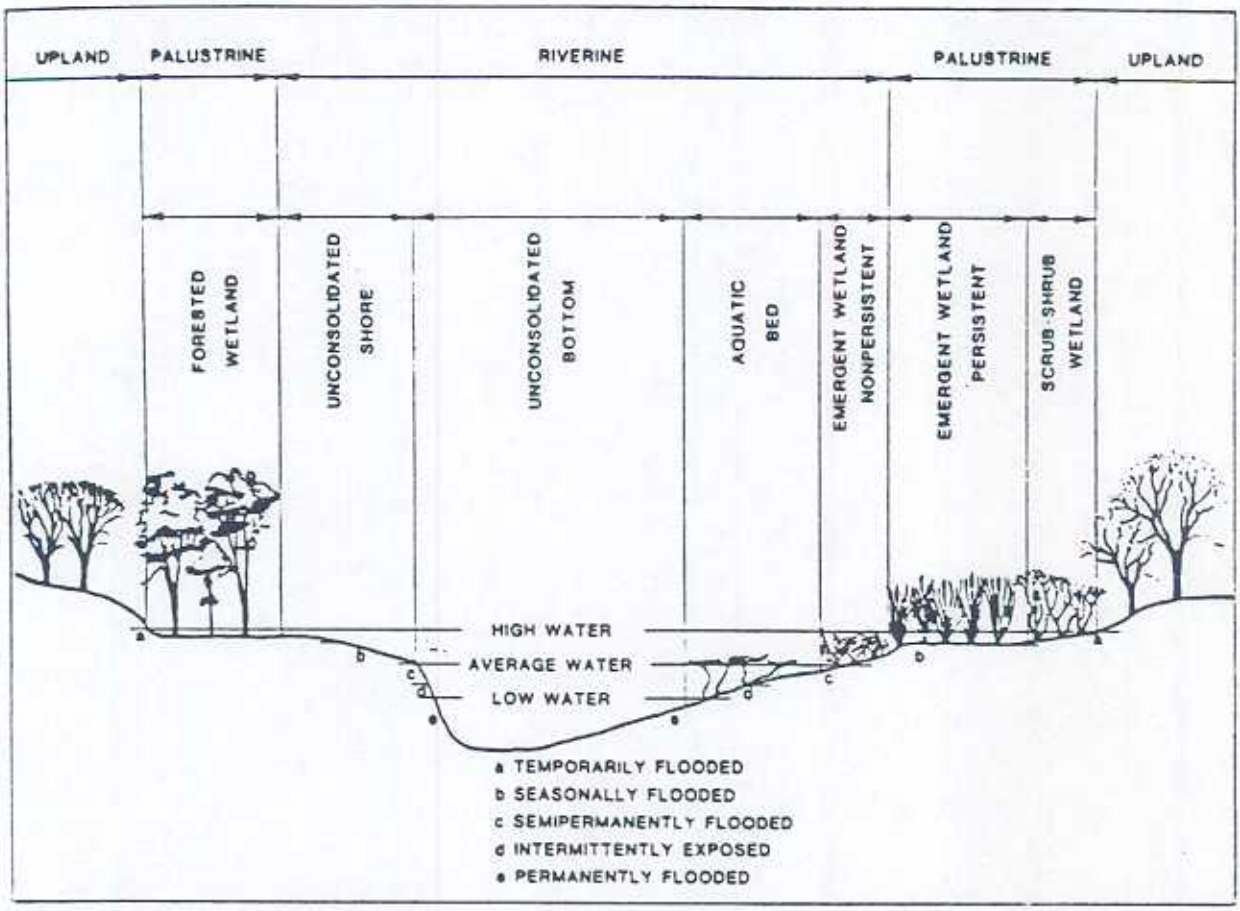

Fig. 4. Distinguishing features and examples of habitats in the Riverine System.

Subsystems. The Riverine System is divided into four subsystems: the Tidal, the Lower Perennial, the Upper Perennial, and the Intermittent. Each is defined in terms of water permanence, gradient, water velocity, substrate, and the extent of floodplain development. The subsystems have characteristic flora and fauna (see Illies and Botosaneau 1963; Hynes 1970; Reid and Wood 1976). All four subsystems are not necessarily present in all rivers, and the order of occurrence may be other than that given below.

Tidal.—The gradient is low and water velocity fluctuates under tidal influence. The streambed is mainly mud with occasional patches of sand. Oxygen deficits may sometimes occur and the fauna is similar to that in the Lower Perennial Subsystem. The floodplain is typically well developed.

Lower Perennial.—The gradient is low and water velocity is slow. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur, the fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.

Upper Perennial.—The gradient is high and velocity of the water fast. There is no tidal influence and some water flows throughout the year. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation. The fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared with that of the Lower Perennial Subsystem, and there is very little floodplain development.

Intermittent.—In this subsystem, the channel contains nontidal flowing water for only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Streambed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent).

Lacustrine System

Definition. The Lacustrine System (Fig. 5) includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 ha (20 acres). Similar wetland and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 2 m (6.6 feet) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5‰.

Limits. The Lacustrine System is bounded by upland or by wetland dominated by trees, shrubs, per-

Table 2. *Salinity modifiers used in this classification system.*

Coastal modifiers[a]	Inland modifiers[b]	Salinity (parts per thousand)	Approximate specific conductance (μMhos at 25 °C)
Hyperhaline	Hypersaline	> 40	> 60,000
Euhaline	Eusaline	30.0-40	45,000-60,000
Mixohaline (brackish)	Mixosaline[c]	0.5-30	800-45,000
Polyhaline	Polysaline	18.0-30	30,000-45,000
Mesohaline	Mesosaline	5.0-18	8,000-30,000
Oligohaline	Oligosaline	0.5-5	800- 8,000
Fresh	Fresh	< 0.5	< 800

[a]Coastal modifiers are used in the Marine and Estuarine systems.
[b]Inland modifiers are used in the Riverine, Lacustrine, and Palustrine systems.
[c]The term Brackish should not be used for inland wetlands or deepwater habitats.

sistent emergents, emergent mosses, or lichens. Lacustrine systems formed by damming a river channel are bounded by a contour approximating the normal spillway elevation or normal pool elevation, except where Palustrine wetlands extend lakeward of that boundary. Where a river enters a lake, the extension of the Lacustrine shoreline forms the Riverine–Lacustrine boundary.

Description. The Lacustrine System includes permanently flooded lakes and reservoirs (e.g., Lake Superior), intermittent lakes (e.g., playa lakes), and tidal lakes with ocean-derived salinities below 0.5‰ (e.g., Grand Lake, Louisiana). Typically, there are extensive areas of deep water and there is considerable wave action. Islands of Palustrine wetland may lie within the boundaries of the Lacustrine System.

Subsystems.

Limnetic.—All deepwater habitats within the Lacustrine System; many small Lacustrine systems have no Limnetic Subsystem.

Littoral.—All wetland habitats in the Lacustrine System. Extends from the shoreward boundary of the system to a depth of 2 m (6.6 feet) below low water or to the maximum extent of nonpersistent emergents, if these grow at depths greater than 2 m.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent).

Palustrine System

Definition. The Palustrine System (Fig. 6) includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5‰. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2 m at low water; and (4) salinity due to ocean-derived salts less than 0.5‰.

Limits. The Palustrine System is bounded by upland or by any of the other four systems.

Description. The Palustrine System was developed to group the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie, which are found throughout the United States. It also includes the small, shallow, permanent or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; in isolated catchments; or on slopes. They may also occur as islands in lakes or rivers. The erosive forces of wind and water are of minor importance except during severe floods.

The emergent vegetation adjacent to rivers and lakes is often referred to as "the shore zone" or the "zone of emergent vegetation" (Reid and Wood 1976), and is generally considered separately from the river itself. As an example, Hynes (1970:85) wrote in reference to riverine habitats, "We will not here consider the long list of emergent plants which may occur along the banks out of the current, as they do not belong, strictly speaking, to the running water habitat." There are often great similarities between wetlands lying adjacent to lakes or rivers and isolated wetlands of the same class in basins without open water.

Subsystems. None.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Unconsolidated Shore, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland, and Forested Wetland.

Classes, Subclasses, and Dominance Types

The CLASS is the highest taxonomic unit below the subsystem level. It describes the general appearance of the habitat in terms of either the dominant life form

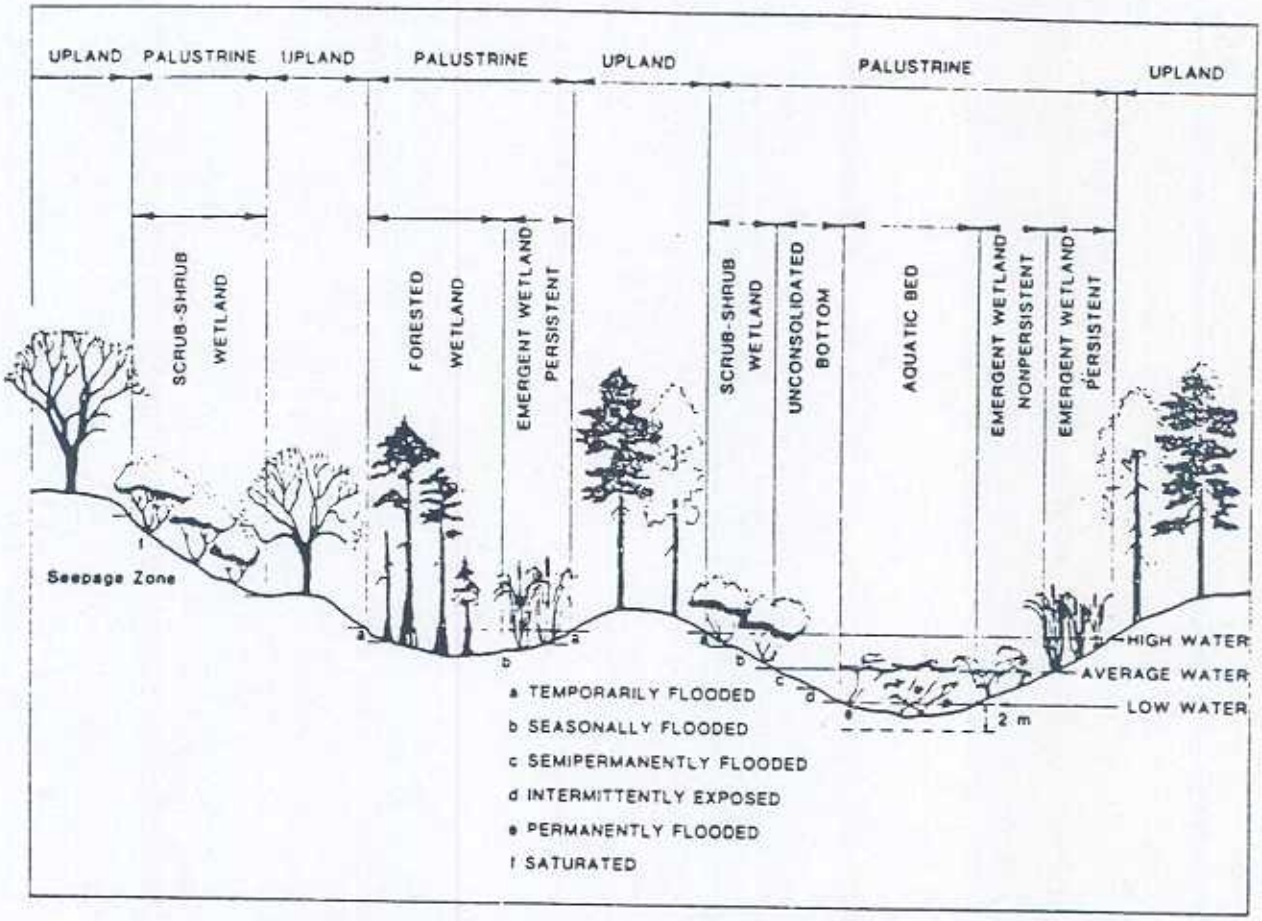

Fig. 6. Distinguishing features and examples of habitats in the Palustrine System.

assigned to the class Scrub-Shrub. When trees and shrubs cover less than 30% of the area but the total cover of vegetation (except pioneer species) is 30% or greater, the wetland is assigned to the appropriate class for the predominant life form below the shrub layer. Finer differences in life forms are recognized at the SUBCLASS level. For example, Forested Wetland is divided into the subclasses Broad-leaved Deciduous, Needle-leaved Deciduous, Broad-leaved Evergreen, Needle-leaved Evergreen, and Dead. Subclasses are named on the basis of the predominant life form.

If vegetation covers less than 30% of the substrate, the physiography and composition of the substrate are the principal characteristics used to distinguish classes. The nature of the substrate reflects regional and local variations in geology and the influence of wind, waves, and currents on erosion and deposition of substrate materials. Bottoms, Shores, and Streambeds are separated on the basis of duration of inundation. In the Riverine, Lacustrine, and Palustrine systems, Bottoms are submerged all or most of the time, whereas Streambeds and Shores are exposed all or most of the time. In the Marine and Estuarine systems, Bottoms are subtidal, whereas Streambeds and Shores are intertidal. Bottoms, Shores, and Streambeds are further divided at the class level on the basis of the important characteristic of rock versus unconsolidated substrate. Subclasses are based on finer distinctions in substrate material unless, as with Streambeds and Shores, the substrate is covered by, or shaded by, an aerial coverage of pioneering vascular plants (often nonhydrophytes) of 30% or more; the subclass is then simply vegetated. Further detail as to the type of vegetation must be obtained at the level of dominance type. Reefs are a unique class in which the substrate itself is composed primarily of living and dead animals. Subclasses of Reefs are designated on the basis of the type of organism that formed the reef.

The DOMINANCE TYPE is the taxonomic category subordinate to subclass. Dominance types are determined on the basis of dominant plant species (e.g., Jeglum et al. 1974), dominant sedentary or sessile animal species (e.g., Thorson 1957), or dominant plant and animal species (e.g., Stephenson and Stephenson 1972). A dominant plant species has traditionally meant one that has control over the community (Weaver and Clements 1938:91), and this plant is also usually the predominant species (Cain and Castro

1959:29). When the subclass is based on life form, we name the dominance type for the dominant species or combination of species (codominants) in the same layer of vegetation used to determine the subclass.* For example, a Needle-leaved Evergreen Forested Wetland with 70% areal cover of black spruce and 30% areal cover of tamarack (*Larix laricina*) would be designated as a *Picea mariana* Dominance Type. When the relative abundance of codominant species is nearly equal, the dominance type consists of a combination of species names. For example, an Emergent Wetland with about equal areal cover of common cattail (*Typha latifolia*) and hardstem bulrush (*Scirpus acutus*) would be designated as *Typha latifolia-Scirpus acutus* Dominance Type.

When the subclass is based on substrate material, the dominance type is named for the predominant plant or sedentary or sessile macroinvertebrate species, without regard for life form. In the Marine and Estuarine systems, sponges, alcyonarians, mollusks, crustaceans, worms, ascidians, and echinoderms may all be part of the community represented by the *Macoma balthica* Dominance Type. Sometimes it is necessary to designate two or more codominant species as a dominance type. Thorson (1957) recommended guidelines and suggested definitions for establishing community types and dominants on level bottoms.

Unconsolidated Bottom

Definition. The class Unconsolidated Bottom includes all wetland and deepwater habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semipermanently flooded.

Description. Unconsolidated Bottoms are characterized by the lack of large stable surfaces for plant and animal attachment. They are usually found in areas with lower energy than Rock Bottoms, and may be very unstable. Exposure to wave and current action, temperature, salinity, and light penetration determine the composition and distribution of organisms.

Most macroalgae attach to the substrate by means of basal hold-fast cells or discs; in sand and mud, however, algae penetrate the substrate and higher plants can successfully root if wave action and currents are not too strong. Most animals in unconsolidated sediments live within the substrate, e.g., *Macoma* and the amphipod *Melita*. Some, such as the polychaete worm *Chaetopterus*, maintain permanent burrows, and others may live on the surface, especially in coarse-grained sediments.

In the Marine and Estuarine systems, Unconsolidated Bottom communities are relatively stable. They vary from the Arctic to the tropics, depending largely on temperature, and from the open ocean to the upper end of the estuary, depending on salinity. Thorson (1957) summarized and described characteristic types of level bottom communities in detail.

In the Riverine System, the substrate type is largely determined by current velocity, and plants and animals exhibit a high degree of morphologic and behavioral adaptation to flowing water. Certain species are confined to specific substrates and some are at least more abundant in one type of substrate than in others. According to Hynes (1970:208), "The larger the stones, and hence the more complex the substratum, the more diverse is the invertebrate fauna." In Lacustrine and Palustrine systems, there is usually a high correlation, within a given water body, between the nature of the substrate and the number of species and individuals. For example, in the profundal bottom of eutrophic lakes where light is absent, oxygen content is low, and carbon dioxide concentration is high, the sediments are ooze-like organic materials and species diversity is low. Each substrate type typically supports a relatively distinct community of organisms (Reid and Wood 1976:262).

Emergent Wetland

Definition. The Emergent Wetland class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed.

Description. In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central United States, violent climatic fluctuations cause them to revert to an open water phase in some years (Stewart and Kantrud 1972). Emergent Wetlands are found throughout the United States and occur in all systems except the Marine. Emergent Wetlands are known by many names, including marsh, meadow, fen, prairie pothole, and slough. Areas that are dominated by pioneer plants that become established during periods of low water are not Emergent Wetlands and should be classified as Vegetated Unconsolidated Shores or Vegetated Streambeds.

Subclasses and Dominance Types.

Persistent.—Persistent Emergent Wetlands are dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the Estuarine and Palustrine systems.

Persistent Emergent Wetlands dominated by saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), big cordgrass (*S. cynosuroides*), needlerush (*Juncus roemerianus*), narrow-leaved cattail (*Typha angustifolia*), and southern wild rice (*Zizaniopsis miliacea*) are major components of the Estuarine Systems of the Atlantic and Gulf coasts of the United States. On the Pacific Coast, common pickleweed (*Salicornia virginica*), sea blite (*Suaeda californica*), arrow grass (*Triglochin maritima*), and California cordgrass (*Spartina foliosa*) are common dominants.

Palustrine Persistent Emergent Wetlands contain a vast array of grasslike plants such as cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), saw grass (*Cladium jamaicense*), sedges (*Carex* spp.); and true grasses such as reed (*Phragmites communis*), manna grasses (*Glyceria* spp.), slough grass (*Beckmannia syzigachne*), and whitetop (*Scolochloa festucacea*). There is also a variety of broad-leaved persistent emergents such as purple loosestrife (*Lythrum salicaria*), dock (*Rumex mexicanus*), waterwillow (*Decodon verticillatus*), and many species of smartweeds (*Polygonum*).

Nonpersistent.—Wetlands in this subclass are dominated by plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious sign of emergent vegetation. For example, wild rice (*Zizania aquatica*) does not become apparent in the North Central States until midsummer and fall, when it may form dense emergent stands. Nonpersistent emergents also include species such as arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), and arrowheads (*Sagittaria* spp.). Movement of ice in Estuarine, Riverine, and Lacustrine systems often removes all traces of emergent vegetation during the winter. Where this occurs, the area should be classified as Nonpersistent Emergent Wetland.

Scrub-Shrub Wetland

Definition. The class Scrub-Shrub Wetland includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. All water regimes except subtidal are included.

Description. Scrub-Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities. They occur only in the Estuarine and Palustrine systems, but are one of the most widespread classes in the United States (Shaw and Fredine 1956). Scrub-Shrub Wetlands are known by many names, such as shrub swamp (Shaw and Fredine 1956), shrub carr (Curtis 1959), bog (Heinselman 1970), and pocosin (Kologiski 1977). For practical reasons we have also included forests composed of young trees less than 6 m tall.

Modifiers

To fully describe wetlands and deepwater habitats, one must apply certain modifiers at the class level and at lower levels in the classification hierarchy. The modifiers described below were adapted from existing classifications or were developed specifically for this system.

Special Modifiers

Many wetlands and deepwater habitats are man-made, and natural ones have been modified to some degree by the activities of man or beavers. Since the nature of these modifications often greatly influences the character of such habitats, special modifying terms have been included here to emphasize their importance. The following modifiers should be used singly or in combination wherever they apply to wetlands and deepwater habitats.

Farmed

The soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become reestablished if farming is discontinued.

Diked

Created or modified by a man-made barrier or dike designed to obstruct the inflow of water.

Relationship to Other Wetland Classifications

There are numerous wetland classifications in use in the United States. Here we relate this system to three published classifications that have gained widespread acceptance. It is not possible to equate these systems directly for several reasons: (1) The criteria selected for establishing categories differ; (2) some of the classifications are not applied consistently in different parts of the country; and (3) the elements classified are not the same in various classifications.

The most widely used classification system in the United States is that of Martin et al. (1953) which was republished in U. S. Fish and Wildlife Service *Circular 39* (Shaw and Fredine 1956). The wetland types are based on criteria such as water depth and permanence, water chemistry, life form of vegetation, and dominant plant species. In Table 4 we compare some of the major components of our system with the type descriptions listed in *Circular 39*.

In response to the need for more detailed wetland classification in the glaciated Northeast, Golet and Larson (1974) refined the freshwater wetland types of *Circular 39* by writing more detailed descriptions and subdividing classes on the basis of finer differences in plant life forms. Golet and Larson's classes are roughly equivalent to Types 1-8 of *Circular 39*, except that they restricted Type 1 to river floodplains. The Golet and Larson system does not recognize the coastal (tidal) fresh wetlands of *Circular 39* (Types 12-14) as a separate category, but classifies these areas in the same manner as nontidal wetlands. In addition to devising 24 subclasses, they also created 5 size categories, 6 site types giving a wetland's hydrologic and topographic location; 8 cover types (modified from Stewart and Kantrud 1971) expressing the distribution and relative proportions of cover and water; 3 vegetative interspersion types; and 6 surrounding habitat types. Since this system is based on the classes of Martin et al. (1953), Table 4 may also be used to compare the Golet and Larson system with the one described here. Although our system does not include size categories and site types, this information will be available from the results of the new inventory of wetlands and deepwater habitats of the United States.

Table 4. *Comparison of wetland types described in U. S. Fish and Wildlife Service* Circular 39 *with some of the major components of this classification system.*

	Classification of wetlands and deepwater habitats		
Circular 39 type, and references for examples of typical vegetation	Classes	Water regimes	Water chemistry
Type 1—Seasonally flooded basins or flats Wet meadow (Dix and Smeins 1967; Stewart and Kantrud 1972) Bottomland hardwoods (Braun 1950) Shallow-freshwater swamps (Penfound 1952)	Emergent Wetland Forested Wetland	Temporarily Flooded Intermittently Flooded	Fresh Mixosaline
Type 2—Inland fresh meadows Fen (Heinselman 1963) Fen, northern sedge meadow (Curtis 1959)	Emergent Wetland	Saturated	Fresh Mixosaline
Type 3—Inland shallow fresh marshes Shallow marsh (Stewart and Kantrud 1972; Golet and Larson 1974)	Emergent Wetland	Semipermanently Flooded Seasonally Flooded	Fresh Mixosaline
Type 4—Inland deep fresh marshes Deep marsh (Stewart and Kantrud 1972; Golet and Larson 1974)	Emergent Wetland Aquatic Bed	Permanently Flooded Intermittently Exposed Semipermanently Flooded	Fresh Mixosaline
Type 5—Inland open fresh water Open water (Golet and Larson 1974) Submerged aquatic (Curtis 1959)	Aquatic Bed Unconsolidated Bottom	Permanently Flooded Intermittently Exposed	Fresh Mixosaline
Type 6—Shrub swamps Shrub swamp (Golet and Larson 1974) Shrub-carr, alder thicket (Curtis 1959)	Scrub-Shrub Wetland	All nontidal regimes except Permanently Flooded	Fresh
Type 7—Wooded swamps Wooded swamp (Golet and Larson 1974) Swamps (Penfound 1952; Heinselman 1963)	Forested Wetland	All nontidal regimes except Permanently Flooded	Fresh
Type 8—Bogs Bog (Dansereau and Segadas-vianna 1952; Heinselman 1963) Pocosin (Penfound 1952; Kologiski 1977)	Scrub-Shrub Wetland Forested Wetland Moss-Lichen Wetland	Saturated	Fresh (acid only)
Type 9—Inland saline flats Intermittent alkali zone (Stewart and Kantrud 1972)	Unconsolidated Shore	Seasonally Flooded Intermittently Flooded Temporarily Flooded	Eusaline Hypersaline
Type 10—Inland saline marshes Inland salt marshes (Ungar 1974)	Emergent Wetland	Seasonally Flooded Semipermanently Flooded	Eusaline
Type 11—Inland open saline water Inland saline lake community (Ungar 1974)	Unconsolidated Bottom	Permanently Flooded Intermittently Flooded	Eusaline
Type 12—Coastal shallow fresh marshes Marsh (Anderson et al. 1968) Estuarine bay marshes, estuarine river marshes (Stewart 1962) Fresh and intermediate marshes (Chabreck 1972)	Emergent Wetland	Regularly Flooded Irregularly Flooded Semipermanently Flooded-Tidal	Mixohaline Fresh

Inventory of Wetlands and Agricultural Land Cover in the Upper Sevier River Basin, Utah

CRSC Report 81-6

By

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ABSTRACT

This report describes the techniques and results from the use of color infrared aerial photography in the mapping of agriculture land use and wetlands in the Sevier River Basin of south-central Utah. A discussion of the efficiency and cost effectiveness of utilizing Landsat multi-spectral scanner digital data to augment photographic interpretations is presented.

The final products include this report and transparent overlays for 27 U.S.G.S. quadrangles showing delineations of wetlands and agricultural land cover. A table is also provided which summarizes the acreage represented by each class on each quadrangle overlay.

INTRODUCTION

The Sevier River Valley in south-central Utah is an area undergoing rapid change as oil, gas, and coal resource development alter the land resource base and stimulate population growth. A fundamental key to present and future resource development is the efficient and wise use of the limited water resources available in this semi-arid region of the Western U.S. A primary part of the Soil Conservation Service's (SCS) mission is to assist farmers in increasing the efficiency with which agricultural products are produced: this includes planning efficient water application systems.

Recent legislation about wetland preservation serves to complicate the management issue, making it more difficult for the SCS to support changes in farming practices which would eliminate wetlands. Better information about quality, type, and distribution of wetlands is required in order to properly assess any impacts due to site disturbance or reallocation of the water source.

Objectives

Consistent with the contract between the SCS and the Center for Remote Sensing and Cartography (CRSC), the project study plan has the following objectives:

1. Classify and map the wetlands and agriculture-related land cover of the upper Sevier River Basin.
2. Establish the cost effectiveness of utilizing Landsat multi-spectral scanner digital data to compliment photographic interpretation.

Purposes

The SCS has several intended uses for the final products of this study. A major purpose of the study is to provide a basis for the Utah State Office of the SCS to carry out its assigned responsibilities under legislation and

regulations which protect wetland environments. The inventory will also provide maps and a table of all agricultural land use in the study area, for the purpose of aiding in farm and ranch resource planning. The coordinated mapping of wetland habitat and agricultural land use will also assist SCS personnel and local land owners in determining the interaction (e.g., hydrologic, biological) between wetlands and farms. Finally, the study will provide basic inventory information about land cover types and potential water consumption use for application in basin water resource management.

Study Area

The study area includes approximately 2,450 square miles of land in the upper Sevier River Valley. The two principle drainages in this region are the Sevier River and the East Fork of the Sevier River. The agricultural and wetland valleys are bounded on the east by Parker Mountain, Escalante Mountains, and the Paunsaugunt Plateau. To the south, the study area extends to the headwaters of the Sevier River and its East Fork. To the west, the Markagunt Plateau and the Tushar Mountains, and to the north Piute Reservoir, Otter Creek Reservoir, and the headwaters of Otter Creek near Koosharem form natural boundaries. All of the wetlands and agricultural land in the valley floor have been inventoried, but no mountain area wetlands have been included. Figure 1 shows the extent of the study area. Twenty-seven U.S.G.S. quadrangles in the study area were found to contain agricultural and wetland types. These quads, for which map overlays have been prepared, are listed in Table 1. The location of the quads in Table 1 within the study area is shown in Figure 2.

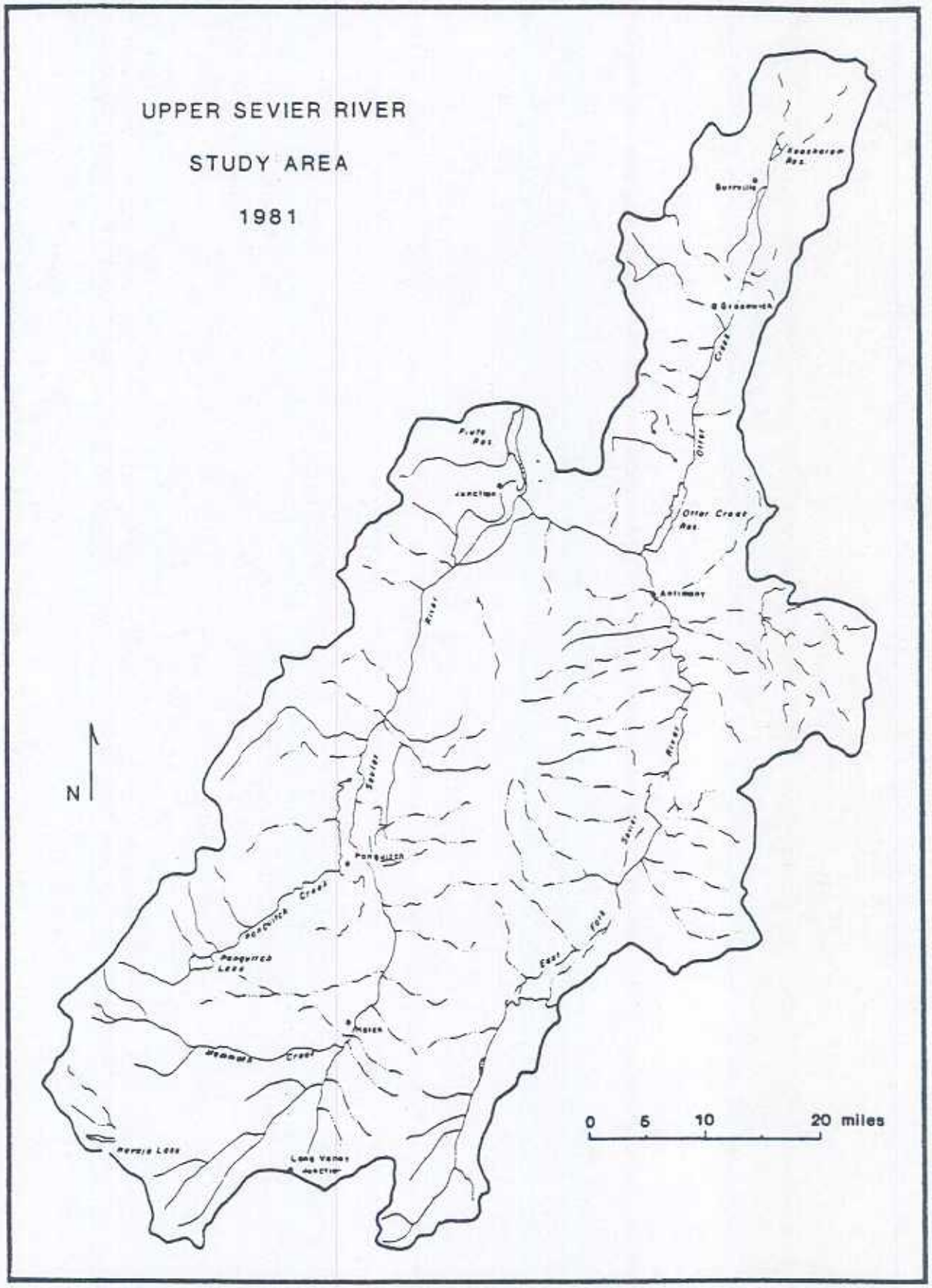


Figure 1. Upper Sevier River Basin Study Area.

Table 1. List of U.S.G.S. Quadrangles for Which Wetland and Agricultural Land Cover Map Overlays Have Been Prepared.

Quadrangle # in Figure 2.	Quadrangle Name	Quadrangle # in Figure 2.	Quadrangle Name
1	Abe's Knoll	15	George Mountain
2	Angle	16	Grass Lakes
3	Antimony	17	Greenwich
4	Blind Spring Mtn.	18	Hatch
5	Boobe Hole Res.	19	Junction
6	Bull Rush Peak	20	Koosharem
7	Burrville	21	Panguitch
8	Casto Canyon	22	Panguitch NW
9	Circleville	23	Parker Knoll
10	Cow Creek	24	Phonolite Hill
11	Deep Creek	25	Piute Reservoir
12	Fivemile Ridge	26	Sweetwater Cr.
13	Flake Mtn. East	27	Wilson Peak
14	Fremont Pass		

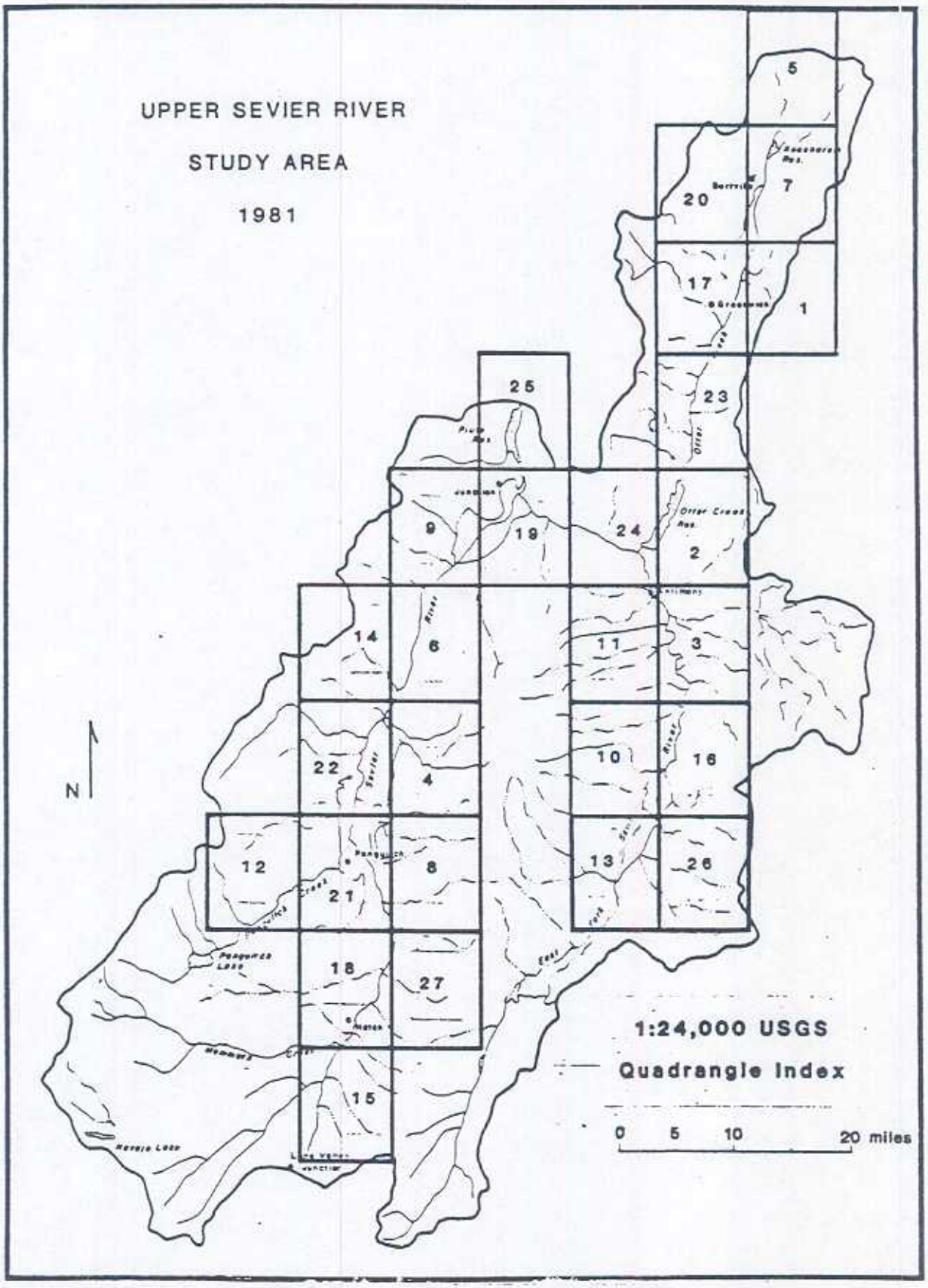


Figure 2. U.S.G.S. Quadrangle Index.

LITERATURE REVIEW

Three types of literature were surveyed in connection with the study: wetland classification; remote sensing applications to wetlands; and Utah water resource documents.

For wetland classification work, the standard document used in the United States over the past two decades is Circular 39, Wetlands of the United States by Shaw and Fredine for the U.S. Fish and Wildlife Service (1956). The U.S. Fish and Wildlife Service has published a new document called Classification of Wetlands and Deepwater Habitats of the United States by Cowardin, et al. (1979).

The literature in remote sensing applied to wetlands is increasing as more attention is given to the development of photo-interpretation techniques as well as use of satellite imagery. Some satellite investigations have been pursued from manual and digital approaches (Anderson, et al., 1973; Cowardin, et al., 1973; Carter and Shubert, 1974; Bartlett, et al., 1977; and others), but the more definitive work is done with photography, especially color-infrared photo-interpretation (Anderson, 1969; Seher and Tueller, 1973; Enslin and Sullivan, 1974; and others). Since applications have been in environments quite different from the Sevier River Valley, the techniques developed at CRSC were tailored to meet the specifications of this study.

Experience acquired by CRSC in performing an inventory of wetlands and agricultural land cover in the Uinta Basin (Ridd, et al., 1980) contributed substantially to the approach outlined in the project study plan.

LAND USE/COVER CLASSIFICATION

Three general classes of land use/cover were identified in this study: agriculture; wetlands; and rangelands.

The main agricultural land cover types found in this study area include the following:

1. Hay. Grass, alfalfa, or a mixture of both, mowed and cured for fodder.
2. Grain. Pure stands or mixtures of oats, wheat, barley, or rye.
3. Irrigated Pasture. Introduced or native grasses, which are irrigated to produce maximum forage for grazing livestock.
4. Corn.
5. Miscellaneous Garden Crops. Crops such as corn, squash, tomatoes, etc., grown mostly for domestic consumption.

All of the agricultural types listed above have been mapped in this study, with the exception of the miscellaneous garden crop; such areas were not mapped because of their small size. Small garden crop areas have been included under the urban classification because they were usually located quite closely to associated farmsteads.

The next major land cover type identified was wetlands. In an effort to incorporate the most recent classification system for wetlands with the study, CRSC and SCS personnel decided to apply the new U.S. Fish and Wildlife publication, Classification of Wetlands and Deepwater Habitats of the United States. Cowardin et al., (1979). The complete list of wetland classes mapped in this study is presented in Table 2.

The environment in the study area contained three distinct wetland systems: palustrine; lacustrine; and riverine. Appropriate modifiers such as "diked" and "farmed" were also included to more completely explain the use of the wetlands.

Although a complete discussion of the wetland cover types mapped in the study area appears in Appendix A, a brief interpretation is provided here.

Table 2. Map Legend for Wetland Vegetation Classes Studied in the Upper Sevier River Basin.

WETLANDS

P	Palustrine	L	Lacustrine
EM	Emergent	1	Limnetic
SS	Scrub/Shrub	2	Littoral
UB	Unconsolidated Bottom	UB	Unconsolidated Bottom
		EM	Emergent
R	Riverine	Modifiers	
2	Lower Perennial	f	Farmed
3	Upper Perennial	h	Diked/Impounded

Basically, wetlands occuring in the upper Sevier River Basin which neither fit the definition of riverine or lacustrine wetlands are classified as palustrine. Riverine wetlands in the study area are found in stream channels with vegetation dominated by non-peristent vegetation. Similarly, lacustrine wetlands are areas not dominated by peristent emergent vegetation, trees, or shrubs which occupy an area of 20 acres (8 ha) or more; such areas are associated with lakes or reservoirs in topographic depressions or dammed river channels. Thus, streams and large bodies of water, and the non-persistent vegetation zones adjacent to such areas, respectively represent riverine and lacustrine wetlands.

From the foregoing, it is clear that the definition of persistent and non-peristent vegetation is the key to the process of classifying wetlands. Peristent emergent vegetation (see Page A-7, Appendix A) consists of erect, rooted, herbaceous hydrophytic vegetation which normally remains standing at least until the beginning of the next growing season (i.e., cattails, bullrushes, sedges). Non-peristent vegetation falls to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious sign of emergent vegetation. In the study area, most of the emergent vegetation associated with lacustrine and palustrine areas consists of grasses, sedges, and rushes. Initially, such vegetation was considered to be non-persistent, at least with regard to emergent wetlands associated with major reservoirs. Thus, several areas were mapped as lacustrine shore (or littoral) emergent wetlands. In further considering the definition of persistent vegetation, such areas should be regarded as palustrine emergent wetlands, since there is year-round evidence of emergent vegetation.

The palustrine wetland system may be broken down into three classes: unconsolidated bottom; emergent wetland; and scrub-shrub wetland. The unconsolidated bottom class (map symbol PUB) consists of natural or man-made ("diked")

ponds which are smaller than 20 acres (8 ha); such areas correspond to Type 5 wetlands under the Circular 39 classification system (see Appendix B).

The palustrine emergent (map symbol PEM) class generally corresponds to Type 2 or 3 wetlands in Circular 39 (Appendix B) terms. Such areas occur above the high water mark of lakes or reservoirs and are dominated by peristent grasses, sedges, and rushes. Where persistent emergent areas are pastured, they bear the modifying symbol "f" for "farmed"; this corresponds to Circular 39 Type 2 wetlands. Where persistent emergent vegetation occurs below seasonal high water marks of reservoirs, the modifier "h" for "diked" is added; this correlates with the Circular 39 Type 3 wetlands, and should also include areas mapped as "L2EMh" for lacustrine, littoral, emergent, diked.

One palustrine area near Piute Reservoir was dominated by willows and has been mapped as a scrub/shrub, diked wetland.

The riverine system was mapped by using a dashed line. This system includes the stream channel as well as adjacent wetland areas. Typically adjacent wetlands, dominated by non-persistent emergent vegetation, do not extend beyond three to ten feet from the edge of the channel. Consequently, no acreage determinations were possible for this wetland type.

The lacustrine system consists of reservoirs and are mapped with the symbol "L1UBh" for "lacustrine, limnetic, unconsolidated bottom, diked" (see Appendix A). Such areas actually include the fairly narrow (and, therefore, difficult to map) littoral zone which extends from the two meter water depth shoreward.

Riparian vegetation, which was not considered hydrophytic for wetland mapping purposes, was also mapped. Such areas occur adjacent to open water and support various phreatophytic vegetation such as cottonwoods, box elders, and willows.

Rangeland areas adjacent to agricultural and wetland areas have been identified in a general fashion. The rangeland types noted on the maps are pinyon-juniper, brush-grass, and greasewood.

METHODS

Mapping Techniques

In this study several different techniques were used to compile and transfer aerial photographic and field observation data to the final map product.

The basic mapping product was color-infrared aerial photography. These photographs were transparent film positives at a scale of 1:31,680 (flown July 1975).

The first stage of map production was to delineate the wetland and agricultural zones which were visable on the photographs. Vegetation cover was identified by examining the following: the color, texture, and patterns on the photographs; hydrologic features; and topography.

The next stage of production was to transfer the delineations on the photo overlays to the final map scale, which is 1:24,000, and to register delineations with the standard 7½ minute U.S.G.S. quadrangle base. This step was accomplished by two different techniques, one of which was to use a K&E Kargl projector, an enlarging light table. The second method was to photographically enlarge the delineations from photo scale to the final map scale; the photo mechanical transfer (PMT) technique was used to accomplish such method, and was found to be quite efficient as compared to conventional photographic processes. That is, the PMT process allows photographic enlargement in one step, whereas the traditional process requires a negative to be made first, from which the positive transparency is developed.

After the delineations were enlarged to the U.S.G.S. quad scale, they were ready to be field checked to verify the interpretations and delineations in the study area.

Once in the field, the CRSC personnel made a point to visit all agricultural and wetland basins within the study area. The field team was able to quickly

make final delineations and interpretations once the type and extent of the land cover was identified on the aerial photographs.

In choosing the map symbolization for wetlands, a document of mapping conventions by Charles R. Elliott, the Regional Wetland Coordinator of the U.S. Fish and Wildlife Service, was consulted. The wetland data was first placed on the U.S.G.S. base map by a series of letters and numbers: the first letter representing the system or major cover class, and subsequent letters and numbers representing subordinate levels of detail (see Table 3).

Simple alphabetic symbols were selected for agricultural and rangeland cover types. After the appropriate symbols were placed on the quads, the final overlays were drafted using waterproof black ink on a single matte stable drafting film. Final drafting was carefully performed to make sure that the agricultural and wetland polygons were located as planimetrically correct as possible.

After completion of the map overlays, the final step was to determine the acreage represented by each land cover type per quad. A computerized digitizer and a software program designed specifically to perform area measurement were used to accomplish this task. This procedure was found to be quite accurate in making the acreage estimates, which are summarized in Table 4 (presented in the next section).

Landsat Analysis

As a second part of the contract agreement, CRSC agreed to examine the cost effectiveness of utilizing Landsat MSS digital data to augment photographic interpretations. Landsat digital tapes were purchased and analyzed to allow the same sort of merging of digital print maps with photos that proved helpful in the Uinta Basin wetland/land use study (CRSC Report 80-2) completed for the SCS. The methods used to analyze the tapes is outlined below.

Table 3. Wetland Legend Mapping Conventions Used by the U.S. Fish and Wildlife Service.

Systems and Subsystems

M Marine
- 1 Subtidal
- 2 Intertidal

E Estuarine
- 1 Subtidal
- 2 Intertidal

P Palustrine
- 1 No Subsystem

U Upland

R Riverine
- 1 Tidal
- 2 Lower Perennial
- 3 Upper Perennial
- 4 Intermittent

L Lacustrine
- 1 Limnetic
- 2 Littoral

Classes and Subclasses

RB Rock Bottom
- 1 Bedrock
- 2 Rubble

UB Unconsolidated Bottom
- 1 Cobble-Gravel
- 2 Sand
- 3 Mud
- 4 Organic

AB Aquatic Bed
- 1 Algal
- 2 Aquatic Moss
- 3 Rooted Vascular
- 4 Floating Vascular

RF Reef
- 1 Coral
- 2 Mollusk
- 3 Worm

SB Streambed
- 1 Bedrock
- 2 Rubble
- 3 Cobble-Gravel
- 4 Sand
- 5 Mud
- 6 Organic
- 7 Vegetated

RS Rocky Shore
- 1 Bedrock
- 2 Rubble

US Unconsolidated Shore
- 1 Cobble-Gravel
- 2 Sand
- 3 Mud
- 4 Organic
- 5 Vegetated

ML Moss-Lichen
- 1 Moss
- 2 Lichen

EM Emergent
- 1 Persistent
- 2 Nonpersistent

SS Scrub-Shrub
- 1 Broad-leaved Deciduous
- 2 Needle-leaved Deciduous
- 3 Broad-leaved Evergreen
- 4 Needle-leaved Evergreen
- 5 Dead
- 6 Deciduous
- 7 Evergreen

FO Forested
- 1 Broad-leaved Deciduous
- 2 Needle-leaved Deciduous
- 3 Broad-leaved Evergreen
- 4 Needle-leaved Evergreen
- 5 Dead
- 6 Deciduous
- 7 Evergreen

Other Modifiers

Special

- b Beaver
- d Partially Drained/ Ditched
- f Farmed

Special (con't)

- h Diked/Impounded
- r Artificial
- s Spoil
- x Excavated

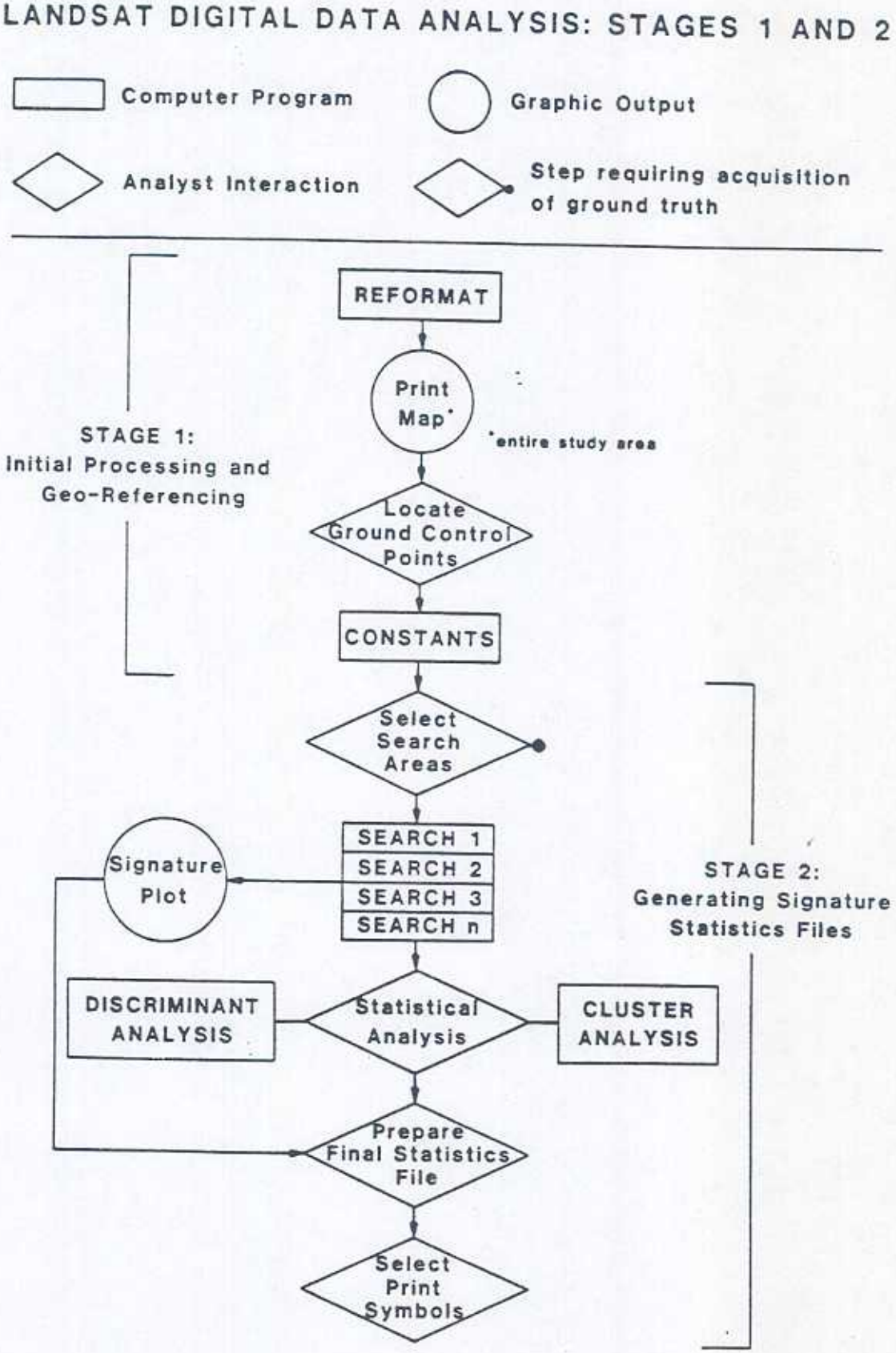
Soils

- g Organic
- n Mineral

Initially, selected intense study areas (ISA) were located for the purpose of finding spectral signatures for land cover classification. A spectral signature is the mean reflectance in green, red, and two near-infrared bands of light energy which is sensed by the Landsat multi-spectral scanner (MSS). Landsat senses reflectance values for over 10 million picture elements or "pixels" in a given scene. The Koosharem Reservoir and Antimony areas were ISA's for wetland and agriculture signatures, and the Parker Mountain area was studied for rangeland signatures. Two Landsat scenes, sensed on July 28, 1979, provided the data for all digital processing.

After the digital data had been read into the computer and geographically corrected, a software package called "ELAS" was applied to analyze the data (see Stage 1 in Figure 3). Within ELAS there is a program entitled SEARCH, which is utilized to generate statistics that characterize pixel groups having similar spectral features across the four bands (see Stage 2 in Figure 3). SEARCH is a routine which is used to provide training statistics for a program called MAXL, which classifies individual pixels into groups based upon each pixel's highest statistical probability of belonging to a given group. In SEARCH, each contiguous six scan line (Landsat pixel matrix "row") by six element block (pixel matrix "column") is evaluated; if the spectral data within the six by six block is too heterogeneous, the program will switch to the use of a three by three block of pixels. The statistics generated by SEARCH include mean pixel light radiance values for each of the four bands, a covariance matrix, and a priori values. A set of statistics is generated by SEARCH representing various classes of light reflectance patterns found in the study area "searched". The four mean light reflectance values, one for each MSS band, are plotted to form a curve called a "light signature" which characterizes each class. SEARCH thus "trains" MAXL to recognize different ground cover patterns

Figure 3. Summary of Steps in Landsat Digital Data Analysis: Stage 1 and 2.

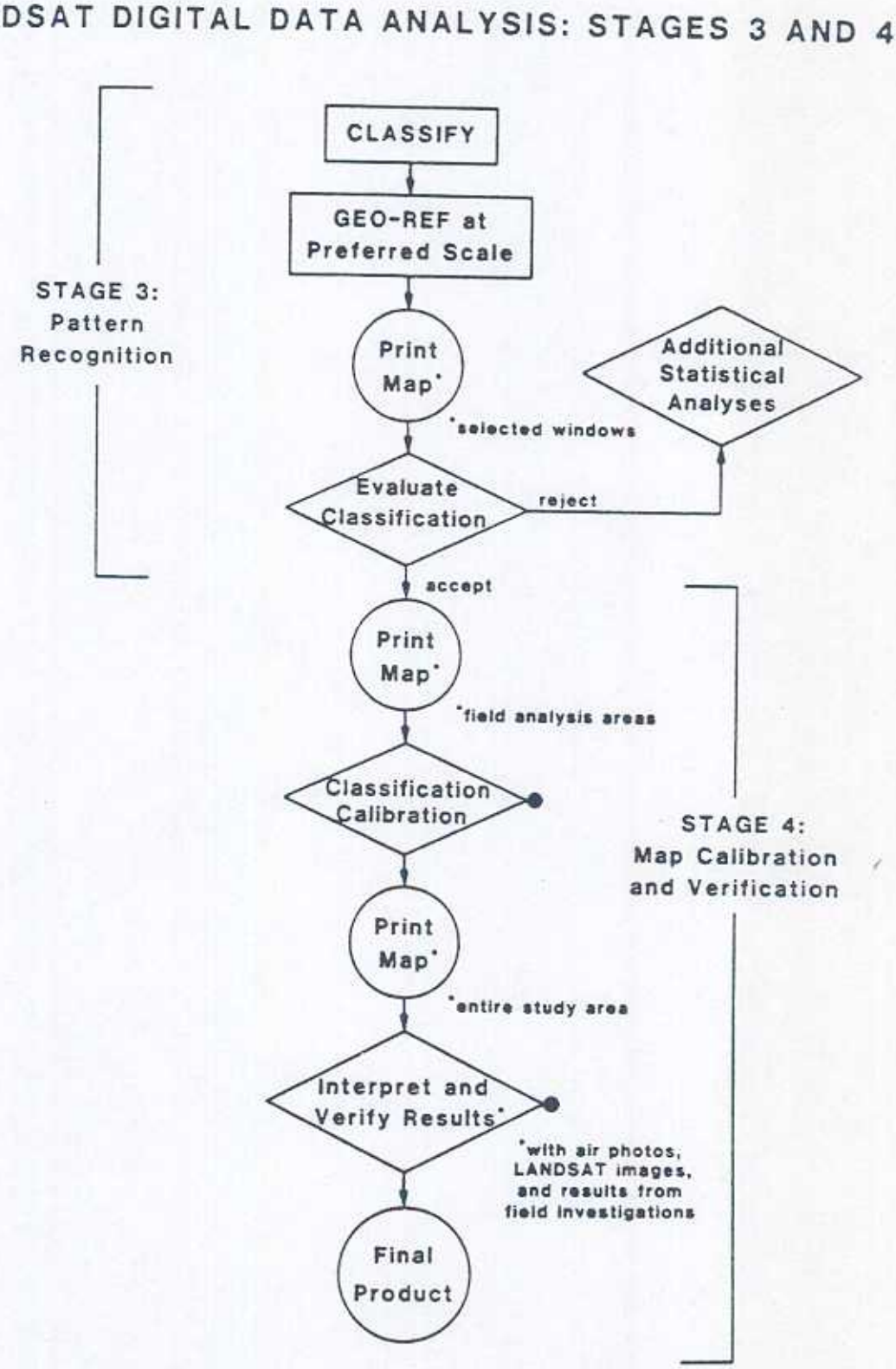


as it places individual pixels into classes. A knowledge of the manner in which different land cover features form spectral signatures, combined with the analysis of aerial photography and field checking of digital classifications, allows remote sensing researchers to provide an interpretation of Landsat-derived classes.

In this study, 77 spectral signatures were derived from the SEARCH program; of the 77, only about half were considered to be associated with cover types of primary interest. The next step was to selectively eliminate signatures which were of little utility. This process of reducing the number of signatures was accomplished through use of a combination of statistical routines and by generating print maps of selected areas and calibrating print symbols with ground observations (see Stage 2 in Figure 3, and Stage 3 in Figure 4).

The statistical routines used at CRSC included principal components, cluster analysis, and discriminant analysis. Application of the statistical analyses results to information gathered by comparing aerial photographs with light signature map print symbols allowed the combination of some signatures and further refinement of others. Consequently, 52 signatures were produced which were used to classify the entire study area.

Figure 4. Summary of Steps in Landsat Digital Data Analysis: Stage 3 and 4.



RESULTS

Final products from this study include a locator map, quadrangle overlays, and tables, as outlined below.

Locator Map: Two Landsat false color composite images have been mosaiced to provide an overview of the study area. A clear overlay showing watershed boundaries, cities, and reservoirs has been added. The map scale is 1:250,000.

Overlays: One transparent overlay for each 1:24,000 quadrangle in the study area containing wetlands or agricultural land has been provided. These overlays show the land cover classes and class boundaries. They may be placed directly on the U.S.G.S. quadrangle and registered to the border lines for direct reading. Figure 5 displays a portion of an overlay.

Tables: A summary and detailed listings of all agricultural and wetland classes, showing acreage per quadrangle, have been prepared. Table 4 presents the total acreage by cover type in the entire study area.

The most abundant cover type among the five agricultural types was hay, with 13,818 acres. The other agricultural types occupied the following amounts of area: irrigated pasture, 7,237 acres; grain, 1,992 acres; corn, 481 acres; and potatoes, 17.4 acres. Among the 8 wetland classes, for which acreage measurements were made, the farmed emergent palustrine cover type was the most extensive with nearly 15,957 acres. The second largest type was open water in reservoirs (lacustrine, limnetic, unconsolidated bottom, diked), with nearly 4,699 acres. Riverine wetland areas were mapped but not measured because of their linear nature and variable width. Riparian cover, dominated mostly by fremont cottonwood (Populus Fremontii), box elder (Acer negundo), and willow (Salix spp.), represented 2,392 acres.

As mentioned above, the mapping of areas in this study was based primarily upon the interpretation color-infrared aerial photography. Such medium provided an excellent resource for making accurate delineations of agricultural field and natural vegetation boundaries, but the fact that the photography was

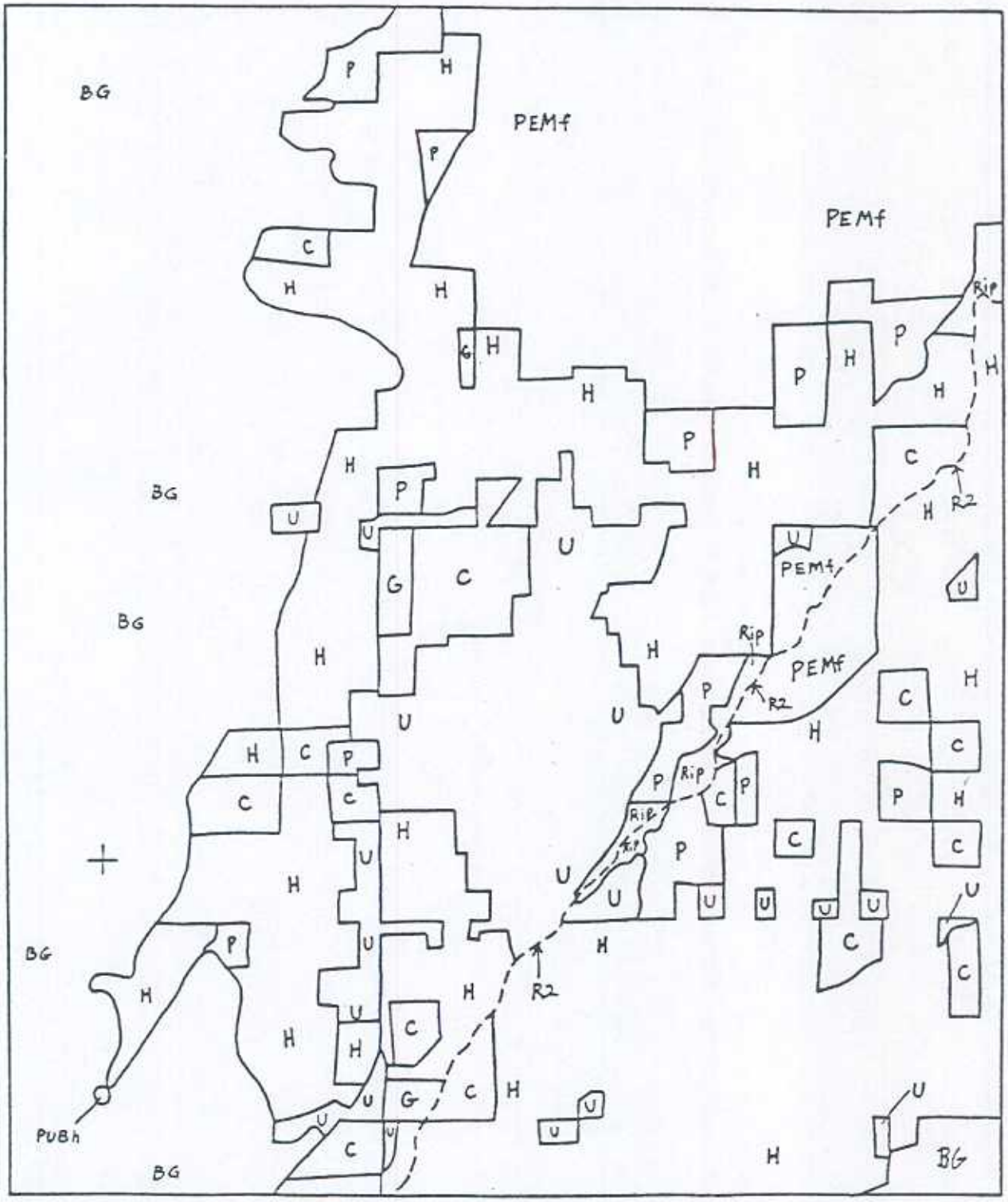


Figure 5. Portion of Wetland and Agricultural Land Cover Overlay for the Circleville Quadrangle.

Table 4. Land Cover Acreage

USGS Quadrangle Name	Agricultural					Wetlands								Riparian
						Palustrine						Lacustrine		
	Hay	Grain	Pasture	Corn	Potatoes	EM	EMf	EMh	UB	UBh	SSh	1UBh	2EMh	Rip
Abe's Knoll	88.4							467	1.3					
Angle	486.6	1.4	1.3				28.4			2.8		1722	269	
Antimony	1040.7	262.9	64.0				289.3			8.4				412.7
Blind Spring Mtn.							109							
Boobe Hole Reservoir							130.0							13.9
Bull Rush Peak	20.4						577.0			2.7				182.3
Burrville	586.9	140.7	651.4				2682.0					351.0		
Casto Canyon			55.9							1.3				
Circleville	2445.0	65.9	274.7	269.1			1266.3			5.0				30.1
Cow Creek		30.7					8.3							
Deep Creek	1.1	8.3	113.7				55.9							20.3
Fivemile Ridge							685.0							35.3
Flake Mtn. East		16												
Fremont Pass		5.6					82.1			.6				
George Mtn.			93.9			9.2	573.8	3.3		14.1		24.5		107.0
Grass Lakes	929	231.8			8.5		283.7			6.4				
Greenwich	1582.4	239.7	107.4				2394.5			17.2				165.3
Hatch	121.7		1006.0			9.4	269.7			41.1				615.1
Junction	2051.0	298.0	1024.1	211.9	8.9	30.0	2116.8		4.5	4.6			398	344.9
Koosharem	247.5	24.1	22.5											
Panguitch	2021.6	405.1	1907.8				1020.8		1.4	18.7				250.3
Panguitch N.W.	1318.0	138.6	1282.5				2091.9		7.9	27.3				
Parker Knoll	347.4		51.2							3.2				161.8
Phonolite Hill	259.7	20.2	580.5				1268.0			5.6		693.0		28.9
Piute Reservoir	117.0										21.6	1908	57	
Sweetwater Creek	153.6	103												
Wilson Peak							24.2			1.2				23.8
TOTALS	13818.9	1992.0	7236.9	481.0	17.4	48.6	15956.7	470.3	15.1	160.2	21.6	4698.5	724	2391.7

EM Emergent
EMf Emergent, farmed
EMh Emergent, diked
UB Unconsolidated Bottom
UBh Unconsolidated Bottom, diked
SSh Scrub/Shrub, diked
1UBh Limnetic, Unconsolidated Bottom, diked
2EMh Littoral, Emergent, diked

over five years old presented a major item of concern. Originally, it was thought that the 1979 Landsat data would provide the primary means to update the land cover classification process by creating photo digital overlays, as was done in the Uinta Basin Wetland/Land Use Study (Ridd, et al., 1980). Although the initial processing of Landsat data (discussed above) showed promise for augmenting the analysis of agriculture and wetland areas, several factors led to the decision to not use Landsat as a primary analytical medium. The Sevier River Basin situation turned out to be quite different from that in the Uinta Basin study in several respects: the available photography in the Sevier Basin area is five years more "out of date"; wetland and agricultural areas in the Sevier Basin are typically much smaller and are more accessible to vehicles than in Uinta Basin; the best available (i.e., cloud free, proper season, most complete coverage of the study area with a minimum number of scenes) Landsat digital data was recorded July 28, 1979; four years from the date of the photography and two years from the time of field work. Consequently, the need to field check maps and the ease with which field checking could be accomplished resulted in the decision to emphasize the "direct sensing" aspect of the mapping process. The circumstances of the study were such that to complete and refine the Landsat digital analysis would have taken as much time and cost as an extra trip to the field. Since the primary objective of the study is to provide maps which are as detailed and current as available remote sensing media will allow, it was quite clear that additional field work should be the proper approach.

Landsat digital data was considered for use in differentiating brush-grass rangeland from pinyon-juniper woodlands. Digital print maps were checked against the photography to ascertain the ability of make such discriminations. The results of such checking led to the conclusion that further refinements

would be needed to accurately delineate the two rangeland types with Landsat. The green colored areas on the U.S.G.S. base maps were compared with vegetation patterns on the photographs. Since the green areas on the foothills correlated highly with pinyon-juniper, it was decided that delineating such woodlands from brush-grass areas would be redundant. Consequently, overlay map users can examine the areas labeled pinyon-juniper and brush-grass in combination with the U.S.G.S. base map to ascertain where the two rangeland types occur.

CONCLUSIONS

Both high altitude color infrared aerial photography and Landsat digital data were examined in this study to determine the feasibility of using either or both data sources to produce wetland/agriculture maps. Landsat digital tapes were analyzed and print maps produced to overlay over the CIR photography in a similar manner to that which proved useful in the Uinta Basin project. When mapping an area of the size and nature of the upper Sevier Basin, high altitude color infrared photography, coupled with a fair amount of field work, proved to be the most accurate and cost-effective means of mapping wetlands and agricultural lands.

Since a certain amount of uncertainty accompanies any research effort, it is not always clear at the outset whether Landsat analysis will be a cost-effective dimension of a study. However, experience in the Sevier River study area has proved invaluable in terms of allowing CRSC the opportunity to explore the use of Landsat and develop some criteria which will help assure cost-effective use of Landsat in future projects. By asking a series of questions, and comparing the responses to our experience base (which includes vicarious experiences through others in the literature), we are provided with a means of selecting a study approach which will produce the desired final product. The primary questions are:

Objective - What is to be studied and mapped?

Purpose - Why is it to be mapped, how and by whom will the map be used?

Resources - What maps, aerial photography, and imagery are available?

Study Area - What is the size, topography, and nature, in terms of contrasts between surficial features, of the study area? How accessible are areas of special interest for purposes of facilitating field checking?

Standards - What are the mapping accuracy standards, in terms of scale, legend categories, size of minimum mapping units, etc.

Limits - What are the practical limits to the project in terms of time, budget, and personnel?

Reflection upon the questions above, in light of an ever-increasing experience base with Utah environments, remote sensing media, and analytical techniques will do much to assure production of resource inventories meeting accuracy standards with minimum cost.

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APPENDIX B

Circular 39 Wetland Classification System Definitions of Type 1-11 Wetlands

A. Wetlands

1. Seasonally Flooded Basins or Flats

The soil is covered with water or is water logged during variable seasonal periods, but usually is well drained during much of the growing season. This type is found both in upland depressions and in overflow bottom lands; along river courses, flooding occurs in late fall, winter, or spring. In the uplands, basins or flats may be filled with water during periods of heavy rains or melting snow. Vegetation varies greatly according to the season and the duration of flooding. Where the water has receeded early in the growing season, smartweeds, wild millet, fall panicum, tealgrass, and weeds, such as marsh elder, ragweed, and cockleburs are likely to occur. Shallow basins that are submerged only very temporarily usually develop little or no wetland vegetation.

2. Inland Fresh Meadows

The soil is without standing water during most of growing season but is waterlogged within at least a few inches of the surface. Vegetation includes grasses, sedges, rushes, and various broadleaf plants. Representative plants are carex, brushes, redtop, reedgrasses, managrasses, prairie cordgrass, and mints. Meadows may fill shallow lake depressions, sloughs or farmland sags, or these meadows may border shallow marshes on the landward side. Wild hay is often cut from such areas.

3. Inland Shallow Fresh Marshes

The soil is usually waterlogged during the growing season. Often, it is covered by as much as six inches or more of water. Vegetation includes grasses, bullrushes, spikerushes, or other various marsh plants such as cattails, arrowheads, and smartweeds. These marshes may nearly fill shallow lake basins or sloughs or they may border deep marshes on the landward side. They are also common as seep areas on irrigated lands.

4. Inland Deep Fresh Marshes

The soil is covered with six inches to three feet or more of water during the growing season. Vegetation includes cattails, bullrushes, reeds, spikerrushes, and wildrice. In open areas, pondweeds, naiads, coontail, watermilfoils, waterweeds, duckweeds, waterlilies or spatterdocks may occur. These deep marshes may almost fill shallow lake basins, potholes, limestone sinks and sloughs or they may border open water in such depressions.

5. Inland Open Fresh Water

Shallow ponds and reservoirs are included in this type. Water is usually less than 10 feet deep and is fringed by a border of emergent vegetation. Vegetation mainly at water depths of less than six feet include pondweeds, naiads, wild celery, coontail, watermilfoils, muskgrasses, waterlillies, and spatterdocks.

6. Shrub Swamps

The soil is usually waterlogged during the growing season and is often covered with as much as six inches of water. Vegetation includes alders and willows.

7&8. Not found in Utah.

9. Inland Saline Flats

The soil is without standing water except after periods of heavy precipitation but it is waterlogged within at least a few inches of the surface during the growing season. Vegetation often sparse or patchy, consists of salt tollerant plants such as seablite, saltgrass, Nevada bullrush, saltbush, and burrowweed.

10. Inland Saline Marshes

The soil is usually waterlogged during the growing season and is often covered with as much as two or three feet of water. This type occurs mostly in shallow lake basins. Vegetation is mainly alkali or hardstem bullrushes often widgongrass or sego pondweed in the openings.

11. Inland Open Saline Water

These more permanent areas of shallow saline water are often closely associated with types 9 and 10. Depth of the water is variable. Vegetation, mainly at water depths of less than six feet, includes pondweeds and widgongrass.

SUPPLEMENT II

CRSC Report 84-5

INVENTORY OF AGRICULTURE-RELATED LAND COVER AND WETLANDS IN THE SEVIER RIVER BASIN (MIDDLE PORTION), UTAH

CRSC Report 84-5

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APPENDIX A. Excerpts from Cowardin Classification of Wetlands A-1

APPENDIX B. Circular 39 Wetland Classification System Definitions . . . B-1

ABSTRACT

This CRSC report describes the procedures and results from an agricultural and wetland inventory of a portion of the Sevier River drainage basin of central Utah. Transparent overlays depicting land cover characteristics were prepared for 28 U.S.G.S. quadrangles through interpretation of 70 x 230 mm Enviropod natural color and CIR aerial photographs. A table is also provided which summarizes the acreage of each agricultral and wetland class by quadrangle.

INTRODUCTION

Scope of Project

The Sevier River Valley in central Utah is undergoing many dynamic changes as natural resource development stimulates population growth. This semiarid region is very dependent on wise and efficient budgeting of its limited water resources. Utah's Division of Water Resources (DWR) is charged with monitoring and planning water use throughout the state. This requires accurate and current data concerning land use, water demand, and water supplies in order to effectively provide for the changing water needs in agricultural, industrial, and municipal uses.

The objective of this project is to classify and map the agricultural land and wetlands of the middle Sevier River Basin, encompassing the Sevier Valley, Scipio, and Levan subareas, as shown in Figure 1. This project involves: 1) interpretation of large scale color-infrared (CIR) and natural color aerial photography; 2) preparing map overlays matching 1:24,000 U.S.G.S. quadrangles; and 3) acreage tabulations for agricultural and wetland cover types, for the subject year, 1983.

The main purpose of the project is to provide a basic inventory of water-related land use for basin-wide water budgeting by the Division of Water Resources. The coordinated mapping of wetlands and agricultural lands will also assist farmers, managers, and planners, as well as federal and state agency personnel, in better understanding the hydrologic and biological relationship between wetlands and farms. Such information will promote more informed farm and ranch planning and assist agencies such as the Soil Conservation Service in carrying out their responsibilities under legislation and regulations which protect wetland environments. The project also provides a basis for documenting changes in agricultural

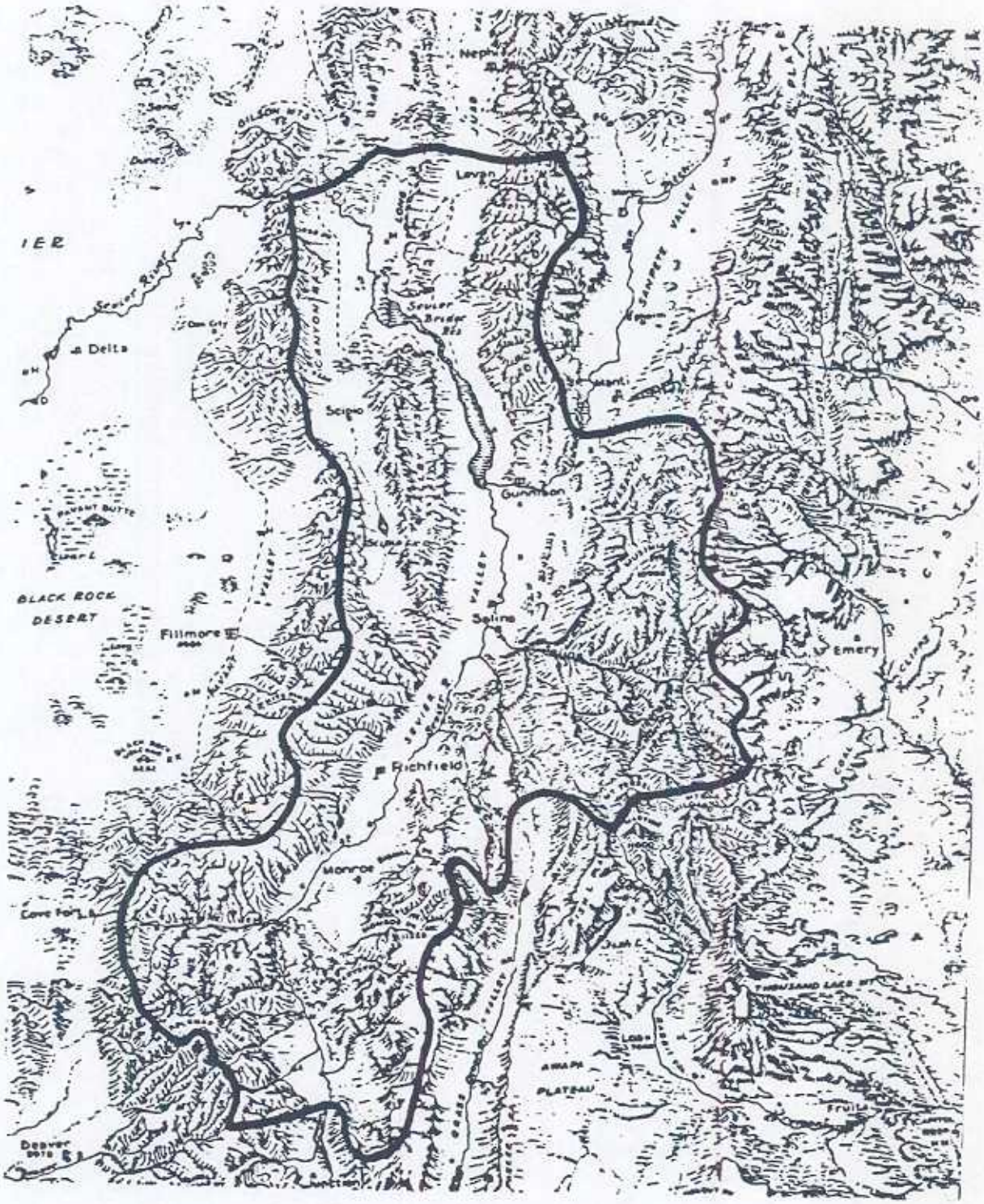

Figure 1. Sevier River Basin (Middle Portion) Study Area

land use since the last inventory, some 20 years ago. These base maps are designed to accommodate easy updating and may be used for future monitoring of water resources in the Sevier River Basin.

Final Products

The final products of the project are map overlays, acreage tabulations, and this summary report:

1. Transparent map overlays delineating agricultural and wetland cover types are printed on a clear diazo film at a scale of 1:24,000. Each U.S.G.S. 7½-minute topographic quadrangle in the study area has a scaled overlay map. Those areas which are now covered only by 15-minute U.S.G.S. quadrangles were also mapped at a 7½-minute map scale.

2. Acreage figures for each agricultural and wetland category were determined for each quadrangle. These tabulations are displayed in this report.

3. This technical report contains a description of objectives, study methods and procedures, the land cover classification scheme, and a discussion of results of the investigation.

Study Area

The study area for this project contains approximately 2,500 square miles of land along the Sevier River drainage from Piute Reservoir to Sevier Canyon. In addition to the Sevier River Valley, the project also includes the Scipio Valley drainage, parts of Juab Valley (near Levan), and a portion of the lower San Pitch River drainage (near Mayfield). Since the project focuses on irrigated farmland and wetlands, those areas are mapped in detail on each quadrangle. The bulk of the agricultural land is found surrounding the towns of Marysvale, Monroe, Richfield, Salina, Gunnison, Levan, and Scipio.

All of the wetlands and agricultural lands in the valley floor have been inventoried, but mountain area wetlands are generally not included. Twenty-eight U.S.G.S. quadrangles in the study area containing agriculture-related or wetland cover types were inventoried and map overlays were prepared. The names of these quads are listed in Table 1. A map of the study area with the locations of these quads is displayed as Figure 3.

Key to Land Cover Classification

Three general classes of land cover were identified in this study: irrigated agricultural land; wetland environments; and other areas pertinent to the study, such as dry farmed areas, reservoirs, and developed land (Table 2).

The irrigated agricultural land cover types delineated in this study, as of the summer growing season of 1983, include:

C - Corn. Including sweet corn or field corn cropped this year.(1983).

G - Wheat, barley, or oats. Grains cropped this year, including fields where barley is used as a nurse crop for alfalfa.

H - Alfalfa or hay grass. Mostly alfalfa (few fields may be grass that is cut for fodder) either actively irrigated or flooded this year.

P - Irrigated pasture. Introduced or native grasses which are usually irrigated to produce maximum forage for grazing livestock, could be flood irrigated this year.

Ai - Idle irrigated land. Areas below the canal line that are not irrigated this year. Some areas may have never been irrigated but have the potential for agriculture.

Ap - Plowed or disked land. Irrigated areas that are presently plowed. Fields could have been cropped previously this year, or may be disked for drying or preparing a seed base.

Table 1. List of U.S.G.S. Quadrangles for Which Agricultural and Wetland Land Cover Map Overlays Have Been Prepared.

Quadrangle # in Figure 2.	Quadrangle Name	Quadrangle # in Figure 2.	Quadrangle Name
1	Sage Valley	15	Scipio Lake
2	Nephi SW	16	Redmond Canyon
3	Nephi SE	17	Redmond
4	Scipio North NE	18	Mayfield
5	Skinner Peaks	19	Aurora
6	Scipio North SW	20	Salina
7	Scipio North SE	21	Richfield
8	Hells Kitchen Cyn SW	22	Sigurd
9	Hells Kitchen Cyn SE	23	Elsinore
10	Scipio Pass	24	Annabella
11	Scipio South	25	Marysvale Canyon
12	Hayes Canyon	26	Antelope Range
13	Gunnison	27	Marysvale
14	Sterling	28	Piute Reservoir

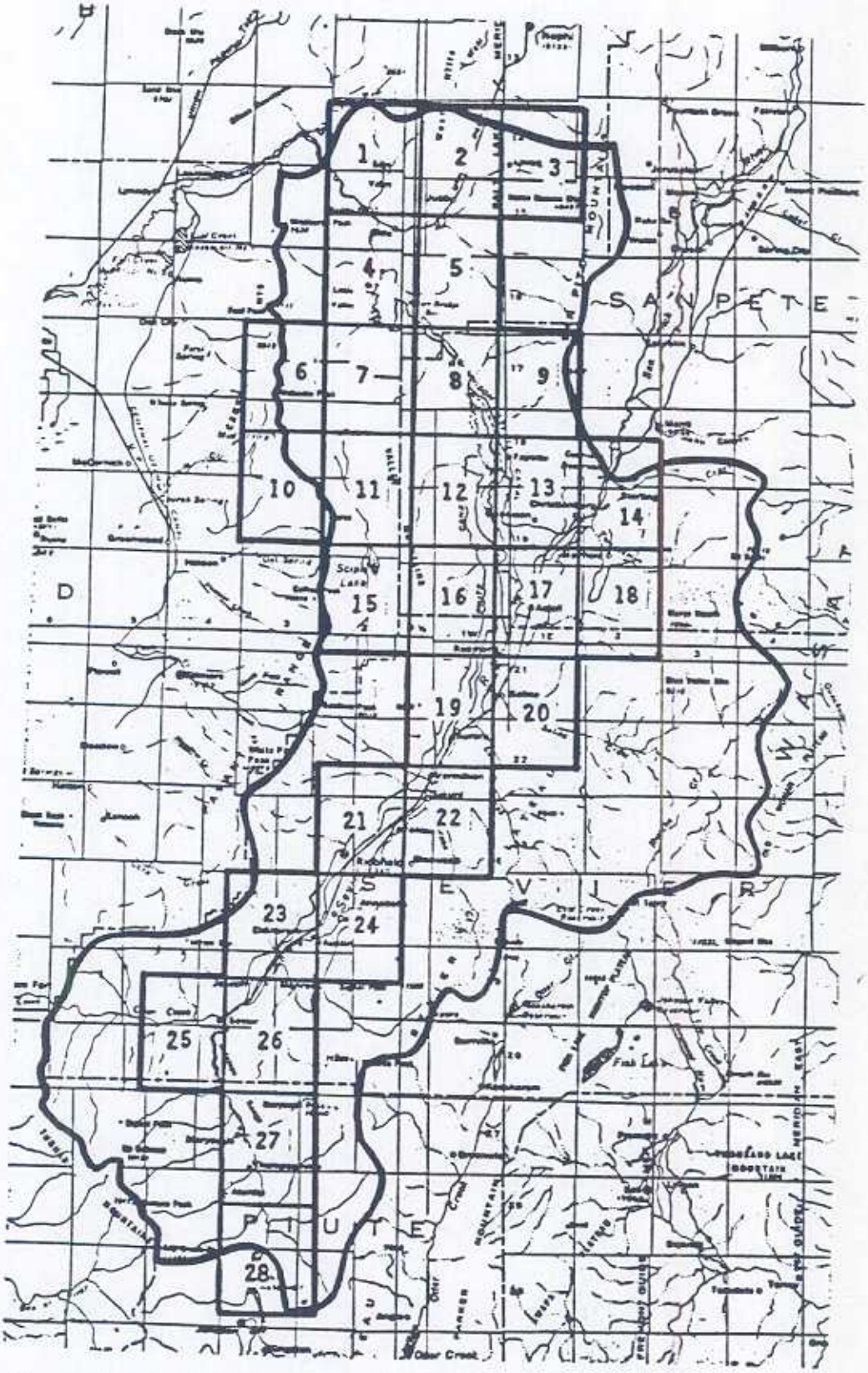

Figure 2, Sevier River Study Area U.S.G.S. Quadrangle Index.

Table 2. Map Legend for Land Cover Classification in the Sevier River Basin (Middle Portion)

Irrigated Agricultural Land

C	Corn
G	Wheat, barley, or oats
H	Alfalfa or hay grass
P	Irrigated pasture
Ai	Idle irrigated land
Ap	Plowed or disked land

Wetland Environments

Wr	Riparian tree and shrub
Wp	Floodplain pasture and meadow
Wm	Wet meadow and shallow marsh
W	Deep marsh and open water
Wf	Recent floodplain deposits

Other Areas Mapped

D	Dry farm areas
U	Undifferentiated uplands
F	Farmstead and developed land
R	Reservoirs

All major irrigated agricultural fields within the study area have been mapped. Miscellaneous household garden plots have not been separately mapped due to their small size. Garden plots are generally included in the "farmstead" classification because of their close proximity to residential areas.

The next major land cover type identified in this study concerns wetland environments. The wetland classification scheme was developed by modifying both the U.S. Fish and Wildlife Service Circular 39 (Shaw and Ferdine, 1956) and the more modern Cowardin system (Cowardin, et al., 1979). These modifications were made in order to best describe wetland conditions found in this specific study area. Table 3 presents a comparison of the wetland cover types used in this study to the Circular 39 and Cowardin systems. Summaries of the Circular 39 and Cowardin classification schemes may be found in the appendix.

The wetland cover types delineated in the Sevier River drainage include:

Wr - Riparian tree and shrub. Phreatopytic vegetation such as cottonwoods, box elders, and willows along stream channels. The ground is not continuously saturated but may be seasonally flooded. Usually has a deep water table.

Wp - Floodplain pasture and meadow. Innundated or waterlogged part of the year, but usually well-drained during much of the growing season. Although subirrigated rather than irrigated, this land is often pastured and occasionally cut as wild hay.

Wm - Wet meadow and shallow marsh. Ground is waterlogged during most of the growing season and may have shallow standing water. Some areas are depressions or seep areas on irrigated lands or bordering deep marshes. Often containing perennial grasses which may be cut or pastured.

Table 3. Comparison of the Sevier River Basin Wetland Classification with U.S. Fish and Wildlife Circular 39 and U.S. Fish and Wildlife Cowardin System Equivalent Classifications.

Sevier River Study	Circular 39	Cowardin System
Wr - Riparian tree and shrub	None	None
Wp - Floodplain pasture and meadow	Seasonally flooded basins or flats	Persistent emergent wetland (temporarily flooded)
Wm - Wet meadow and Shallow Marsh	Inland fresh meadows Inland shallow fresh marshes	Persistent emergent wetland (saturated, seasonally or semi-permanently flooded)
W - Deep marsh and open water	Inland deep fresh meadows Inland open fresh water	Persistent and non-persistent emergent wetland (permanently flooded or intermittently exposed) Aquatic bed Unconsolidated bottom
Wf - Recent floodplain deposits	None	Riverine - Unconsolidated shore (seasonally or intermittently flooded)

W - Deep marsh and open water. Covered with 6 inches to over 10 feet of standing water during the growing season. Usually filled or fringed with emergent hydrophytic vegetation. Includes oxbow lakes, sloughs, shallow ponds, or lake basins.

Wf - Recent floodplain deposits. Seasonally or intermittently flooded basins or flats which lack extensive vegetative cover. Areas of current or recent deposition such as mud flats, splays, overbank deposits, point bars, etc.

The last group of land cover types contain miscellaneous categories that do not clearly fit as irrigated agricultural lands or wetlands, but are still significant in terms of water planning. These cover types include:

D - Dry farmed areas. Could be actively dry farmed this year or in fallow, but with no useable irrigation network in place.

U - Undifferentiated upland. Contains rangeland, brush, natural grasses, pinyon juniper, wasteland, or land not otherwise classified.

F - Farmstead and developed land. Includes residential areas, farm yards, transportation corridors, gravel pits, landfills, industrial and commercial areas, and land otherwise developed.

R - Reservoirs. Ranging from large diked areas such as Sevier Bridge, Piute, and Rocky Ford Reservoirs, to small irrigation holding ponds.

A reduced scale sample of a land cover overlay map showing polygonal boundaries and labels is displayed as Figure 3.

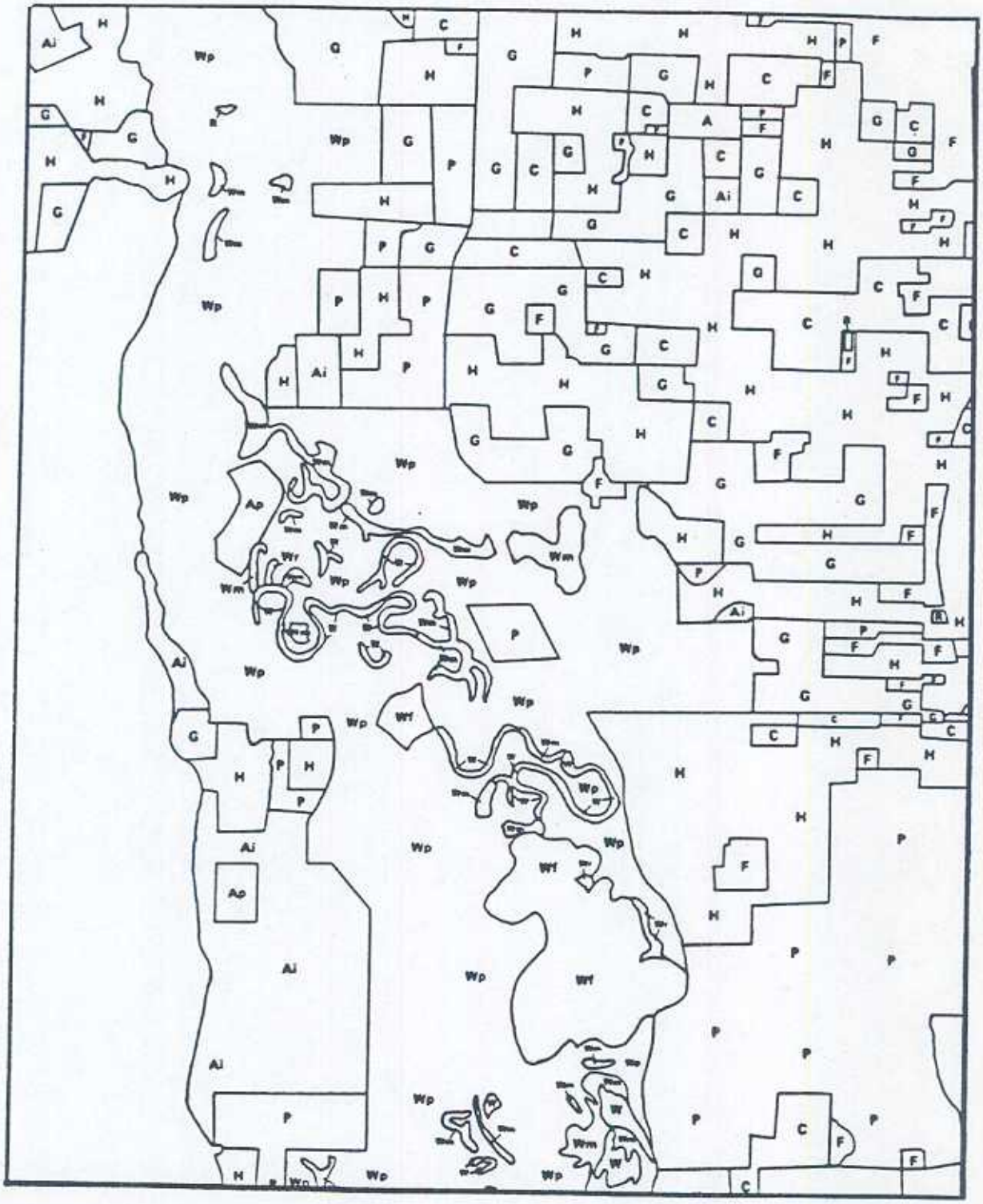

Figure 3. Portion of Agricultural and Wetland Land Cover Overlay for the Redmond Quadrangle.

METHODS

Information Gathering

Collection of land cover data was the first step in study procedures. This required the acquisition of various scales of aerial photography, maps, and ground reference information. Orthophotoquads and U.S.G.S. topographic quadrangles at a scale of 1:24,000 were ordered to use as a map base for photo interpretation. The orthophotoquads were especially valuable for delineating field boundaries and geographically referencing photo observations.

In order to use 1983 as a base year for water use in the Sevier River basin, it was necessary to obtain recent aerial photography. A portion of the study area near Elsinore and Richfield had been flown early in the summer (July 2) by CRSC using the Environmental Protection Agency's Enviropod panoramic camera system for the purpose of assessing flood damage along the Sevier River. This photography was useful for a preliminary assessment of land cover types along the river and for choosing several ground training sites that were representative of particular cover types. Since the imagery was obtained early in the growing season, however, many crops were difficult to distinguish.

Another mission was flown with the Enviropod camera on August 30, 1983 for the specific purpose of obtaining photography for use in determining land cover conditions for this study. The entire river valley in the study area was vertically photographed at 5,000 feet using 70 x 230mm CIR film. Concurrently, an oblique-angled camera was taking natural color photographs of the same area. The nominal scale of the vertical CIR photos was approximately 1:19,000 and the oblique natural color photography was variably scaled.

There were several gaps in the large scale photographic coverage of the study area due to camera malfunctions and the limited field of view available at such a low altitude. Land cover interpretation of these fringe areas was aided by the use of smaller scale MRIR color-infrared photography obtained from the Bureau of Land Management. The MRIR photography was flown in July 1975 at a scale of 1:31,680. Updating of information from this photography was primarily accomplished by field observations.

Two preliminary field sessions were spent in the Sevier River study area in August and September of 1983. The purpose of these sessions was to gather ground reference information about the characteristics of different land covers. Many suitable training sites were selected representing characteristic ground cover conditions throughout the study area. This ground reference data was used to calibrate photo interpretation techniques and allow interpolation of cover types during photo analysis. The land cover information was recorded onto the orthophotoquads in order to geographically reference training sites.

Interpretation and Analysis

Photo interpreted data were delineated onto an orthophotoquad base upon which ground reference information had previously been inscribed. Each 1:24,000 scale orthophotoquad was overlaid with a transparent mylar sheet. As boundaries for land cover types were interpreted from the natural color and CIR Enviropod photography, they were drawn in position onto the mylar overlay. Using the orthophotoquad as a base allowed the interpreter to geographically reference the imagery with the map through landmark identification. Since the orthophotoquad has been photogrammetrically rectified, the land cover delineations are drawn in correct planimetric position.

Agricultural and wetland related land cover types were identified from the photography by analysis of color, texture, and patterns on the photographs, and through ancillary hydrologic, topographic, and field data. Land cover types were inventoried only for the regions along the valley floor of the study area. Isolated dry farms, wetlands, and developed areas in the mountains that were not included in the photographic coverage of the basin were omitted from the land cover maps.

Throughout a study area of this size there is much diversity in cover types, as well as great heterogeneity within single cover types. An example of the latter is found with the idle irrigated land cover type (Ai) which may range from dry natural grasses and shrubs that may never have been cropped, to highly worked agricultural land which was flooded during the planting season in an unusually wet year. Many ground cover types with seemingly unsimilar characteristics are grouped into one land cover category. The criteria for the "Ai" category require that the land be below the canal line and not be too steep to make irrigation feasible. Much of the land has never been irrigated, or has not been irrigated for decades, yet still shows a potential for agricultural development.

The unusually wet conditions in 1983 created many difficulties in interpreting land use and related water needs. Increased snowpack-derived runoff and spring rains induced extensive flooding throughout the study area. Many lands that are usually irrigated during the growing season were flooded or subirrigated in the summer of 1983. This condition makes it especially difficult to draw the line between wetland environments and irrigated agricultural land that is presently flooded. Information gleaned from the orthophotoquads, MRIR photography from 1975, field observations, and conversations with local residents proved quite helpful in alleviating part of this problem.

One area where the increased water presented a particular concern was in differentiating between subirrigated wetland pastures and normally irrigated pastures that happened to be flooded or waterlogged during the spring of 1983. If irrigation facilities were in place surrounding the fields, they were considered to be irrigated pasture (P) rather than flood-plain pasture (Wp) whether or not they were actively irrigated during that growing season. Earlier land cover maps and aerial photos also aided in making a distinction between these categories.

Plowed fields presented another type of temporal problem. Using "single-date" photography it was impossible to determine whether a plowed field had contained an irrigated crop earlier in the season or had been idle. Often, the land was plowed to prepare a seed base or to aid in drying water-logged ground near rivers. Since it was not known if a crop was planted or harvested during the year, a separate classification symbol was assigned to plowed land (Ap), even though in most cases the land was idle in 1983.

Another puzzling photo interpretation problem was solved through field observation. It seems to be a common practice in the study region to plant barley as a "nurse" crop for alfalfa. The mature grain is harvested during the season, leaving a healthy start to the alfalfa, which will remain in the field for several years to come. The texture and color of these fields are difficult to interpret from the photographs, displaying a mixture of both grain and hay. These particular fields were usually classified as grain (G) since barley was the agricultural crop during that year. If the barley had been harvested very early, allowing a fall cropping of alfalfa, the fields were classified as hay (H).

The category of farmsteads (F) became a mixture of miscellaneous land covers within the study area that would not conveniently group into other classes. Since the contents of this category are so diverse, the acreage tabulations for farmsteads are not completely indicative of water use. This land cover type incorporates nearly all of man's developments in the study area that are not related to irrigated agriculture. While residential areas, farmyards, livestock corrals, and major transportation corridors were included in this category, many small areas, such as isolated roads, canals, or individual buildings were not delineated. Most areas smaller than one acre in size were not mapped.

During the air photo analysis stage each map was reinterpreted from the photos two or three times. This made it possible to improve the definitions of class categories and allow better calibration with ground reference data. Field observations proved to be very valuable when used to assist in delineation of land cover from aerial photographs.

Preparing Maps

Final land cover delineations were drafted from the base overlays with black ink on a single matte drafting mylar. Alphabetic symbols were placed on the drafted map by using specially developed press-on lettering. After careful proof-reading and revisions of the maps, the drafted mylar sheets were copied onto clear diazo film. These stable base diazo film copies may be used to overlay standard U.S.G.S. 7½ minute topographic quadrangles. Registration of the land cover overlay and the U.S.G.S. quadrangle is acheived by lining up the map borders. A legend explaining the land cover symbolization is also attached to each final overlay map.

Acreage calculations for each land cover type were tabulated by quadrangle. This was accomplished by using a computerized digitizer and software program specifically designed for area measurements. The sums of the land cover categories were compared with the total delineated land areas for each quadrangle and found to be within 99% accuracy. Table 4 contains a summary of cover type acreages per quadrangle.

Table 4. Land Cover Acreage by Quadrangle

U.S.G.S. Quadrangle	Irrigated Agricultural Land						Wetland Environment					Other		
	C	G	H	P	Al	Ap	Wr	Wp	Wm	W	Wf	D	F	R
Annabella	562.3	1782.6	3305.8	1950.6	486.3	112.4	80.8	2895.8	477.8	126.0	7.9		1852.8	6.6
Antelope Range	316.3	439.9	2002.2	352.0	1086.9	53.1	112.4	170.5	7.6		255.5	205.0	316.3	4.6
Aurora	1391.2	1150.9	5593.0	1088.7	2344.4	20.4	274.3	847.5	377.0	31.2	34.1		1048.5	12.2
Elsinore	945.2	969.1	3368.4	935.4	1244.0	50.3	33.5	249.1	153.8	30.9	190.3		1206.0	2.0
Gunnison	423.6	1284.7	3473.1	722.6	1485.7	11.1	99.2	3346.6	134.4	199.0	1154.9		1404.8	75.0
Hayes Canyon	107.0	1071.3	1907.5	957.4	2302.1		49.4	2078.7	137.5	294.6	1327.0	943.0	78.0	4.2
Hells Kitchen Cyn SE	31.6	20.6	108.7		107.4	20.9		48.4	6.6	2.3	23.1	111.0	26.1	
Hells Kitchen Cyn SW	35.1	46.7	17.7	10.9	465.7			407.1		10.7	1251.7	1083.6	5.0	3199.6
Marysvale		296.7	1117.6	883.6	301.5	17.6	682.7	1597.4	314.9	59.9	54.1		332.2	11.4
Marysvale Canyon	7.3	31.7	56.9	33.8	9.7		261.3						28.6	
Mayfield		442.2	814.3	314.3	295.7	126.7	57.4	10.5			12.3		252.5	67.5
Nephi SE	58.7	706.3	1745.6	325.3	2069.2	411.3	114.7				49.5	2541.6	430.9	4.3
Nephi SW	1.5	257.0	1924.8	540.8	3444.0	265.4		1487.3			487.5	7001.5	120.4	11.2
Piute Reservoir			251.7	185.1	26.5		219.3		161.9				2.6	1.4
Redmond	761.1	2270.0	5340.5	2597.2	2377.8	62.3	25.9	2985.6	252.6	172.8	247.3		989.7	54.9
Redmond Canyon	73.0	407.0	853.0	37.7	1736.0	4.1							39.0	1.2
Richfield	507.0	1603.0	4113.8	2877.1	565.4	152.6	4.5	1918.8	342.7	13.7			2332.0	6.2
Sage Valley								362.2	15.2	26.6	169.8	2818.0		
Salina	165.0	253.9	1029.9	560.5	509.2		231.0	675.7	141.2	172.9	37.6		922.1	4.8
Scipio Lake								683.7	230.9	0.3		1737.2	5.6	840.2
Scipio North NE		95.8	607.6	50.1	23.8	8.0		2693.6	817.6	106.2	793.2	855.9	75.4	1349.7
Scipio North SE	35.5	55.8	591.8	44.7	1222.1	29.8		14.0				1461.0	208.7	382.0
Scipio North SW			120.8	23.2	1135.4			51.6	61.4			683.7		1.6
Scipio Pass	23.7	42.4	133.3	56.5	1339.0	5.2						57.3	18.5	
Scipio South	57.6	266.1	1023.3	475.5	784.8	125.6						283.3	385.3	
Sigurd	211.0	752.7	1841.7	707.2	861.3	17.3	166.9	960.6	243.7	12.4	10.7	134.0	814.6	260.7
Skinner Peaks		318.8	410.0		1599.7			550.0	13.3		399.0	6311.9	93.4	779.8
Sterling		283.3	890.7	433.2	134.3	14.3	52.3		5.9		171.2		45.9	218.5
TOTALS	5713.7	14848.5	42643.7	16163.3	27957.9	1508.4	2465.6	24039.7	3896.0	1261.5	6576.7	25228.0	13034.9	7299.6

RESULTS

Acreage Totals

By far, the most abundant agricultural land cover type in the study area was irrigated alfalfa (and grass hay) symbolized (H), at 42,643.7 acres. Other irrigated agriculture land uses included grains (G), with 14,848.5 acres; corn (C) with 5,713.7 acres; and irrigated pasture (P) covering 16,163.3 acres. Much of the agricultural land is presently idle, with no irrigated crops this year. There are 27,957.9 acres of land in the study area that fall into the idle irrigated land (Ai) category. There are an additional 1,508.4 acres of land that were plowed or disked (Ap), and generally assumed to be idle during the main growing season.

Floodplain pastures and meadows (Wp) accounted for most of the wetland areas in the Sevier River study area. Much of the 24,039.7 acres of subirrigated pastureland in this category is used for pasturing livestock or cut for fodder. Wet meadows and shallow marshes (Wm) cover 3,896.0 acres and deep marshed with open water (W) account for 1.261.5 acres within the study area. No running water surfaces were delineated.

Bordering the stream channels and open water there are intermittent phreatophytic trees and shrubs, such as cottonwoods, box elder, and willows. Although the local water table along these natural levees was too deep for it to be classified as hydrophytic vegetation, the 2,465.6 acres of riparian (Wr) habitat was still included into the natural wetland environment due to its proximity to the water. In several locations recent floodplain deposits (Wf) have overtaken or

covered agricultural land. This was especially noticeable during a wet year, such as 1983. Further study might be pursued to evaluate agricultural land lost to flooding during 1983-1984. The total area delineated as recent floodplain deposits in this study was 6,676.7 acres.

Farmsteads and other developed areas within the valleys of the Sevier basin account for 13,034.9 acres. Dry farm areas, both in production this year or in fallow, cover 26,228.0 acres. Water that is contained in reservoirs covers a surface area of 7,299.6 acres, most of which is attributable to the six major reservoirs in the area: Sevier Bridge, Rocky Ford, Scipio Lake, Chicken Creek, Nine Mile, and Willow Creek. There was no attempt made to determine acreages for undifferentiated uplands as this environment was not included in the objectives of the project,

The results of these acreage tabulations show the total irrigated agricultural land that was in production in 1983 (alfalfa, grain, corn, and irrigated pasture) amounted to 79,269.5 acres. This is 73% of a potential irrigable land figure (adding idle and plowed land) of 108,835.5 acres. To determine the total land that is available for agricultural production it is necessary to aggregate dryfarm areas and floodplain pastures with the potential irrigated lands. This shows a potential of 159,090.2 acres in the Sevier River (middle portion study area) that may be put into agricultural use, excluding livestock pens and family gardens that are incorporated into the farmstead land cover categories.

Evaluation of Procedures

The incorporation of Enviropod photography with an orthophotoquad base has proven to be very successful in this study. The Enviropod natural color and CIR aerial photographs were inexpensive to obtain when compared to alternative imagery and were very high quality for

interpretation use when coupled with ground referenced data. The orthophotoquads provided this reference base by displaying field boundaries and landmarks situated in correct planimetric position. Sample field observations prior to interpretation are very useful in calibrating ground data with the photography.

With this base year (1983) inventory completed, overly maps could be easily updated in order to detect changes in irrigated acreages or dynamic wetland environments. The temporal frequency and methods of updating land cover maps are yet to be determined. The use of either Enviropod 70 mm or wing-mounted 35 mm aerial photography must be considered as inexpensive options for documenting changes in crop patterns.

By digitizing 1983 land cover delineations into an automated georeferenced data base, temporal land use changes and acreage tabulations may be evaluated more efficiently. Computer generated change detection maps may be plotted to quickly update water use coefficients for water budget planning. The automation of land cover mapping should definitely be investigated as an option for improving water modeling in the Sevier River drainage, as well as other areas of the state. It would be moreefficient to have the digitizing process for the above acreage determination placed directly into the State's Automatic Geographic Referencing (AGR) system, for all agencies and users to access.

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APPENDIX A.

The material is taken from "Classification of Wetlands and Deepwater Habitats of the United States" by Cowardin, et al. (1979). Only information regarding riverine, lacustrine, and palustrine systems is included.

THE CLASSIFICATION SYSTEM

The structure of this classification is hierarchical, progressing from systems and subsystems, at the most general levels, to classes, subclasses, and dominance types. Figure 1 illustrates the classification structure to the class level. Table 1 lists the classes and subclasses for each system and gives an example of a dominance type for each subclass. Artificial keys to the systems and classes are given in Appendix E. Modifiers for water regime, water chemistry, and soils are applied to classes, subclasses, and dominance types. Special modifiers describe wetlands and deepwater habitats that have been either created or highly modified by man or beavers.

Hierarchical Structure

Systems and Subsystems

The term SYSTEM refers here to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. We further subdivide systems into more specific categories called SUBSYSTEMS.

The characteristics of the five major systems—Marine, Estuarine, Riverine, Lacustrine, and Palustrine—have been discussed at length in the scientific literature and the concepts are well recognized; however, there is frequent disagreement as to which attributes should be used to bound the systems in space. For example, both the limit of tidal influence and the limit of ocean-derived salinity have been proposed for bounding the upstream end of the Estuarine System (Caspers 1967). As Bormann and Likens (1969) pointed out, boundaries of ecosystems are defined to meet practical needs.

Riverine System

Definition. The Riverine System (Fig. 4) includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5‰. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iseri 1960:5).

Limits. The Riverine System is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. In braided streams, the system is bounded by the banks forming the outer limits of the depression within which the braiding occurs.

The Riverine System terminates at the downstream end where the concentration of ocean-derived salts in the water exceeds 0.5‰ during the period of annual average low flow, or where the channel enters a lake. It terminates at the upstream end where tributary streams originate, or where the channel leaves a lake. Springs discharging into a channel are considered part of the Riverine System.

Description. Water is usually, but not always, flowing in the Riverine System. Upland islands or Palustrine wetlands may occur in the channel, but they are not included in the Riverine System. Palustrine Forested Wetlands, Emergent Wetlands, Scrub-Shrub Wetlands, and Moss-Lichen Wetlands may occur adjacent to the Riverine System, often on a floodplain. Many biologists have suggested that all the wetlands occurring on the river floodplain should be a part of the Riverine System because they consider their presence to be the result of river flooding. However, we concur with Reid and Wood (1976:72,84) who stated, "The floodplain is a flat expanse of land bordering an old river. . . . Often the floodplain may take the form of a very level plain occupied by the present stream channel, and it may never, or only occasionally, be flooded. . . . It is this subsurface water [the ground water] that controls to a great extent the level of lake surfaces, the flow of streams, and the extent of swamps and marshes."

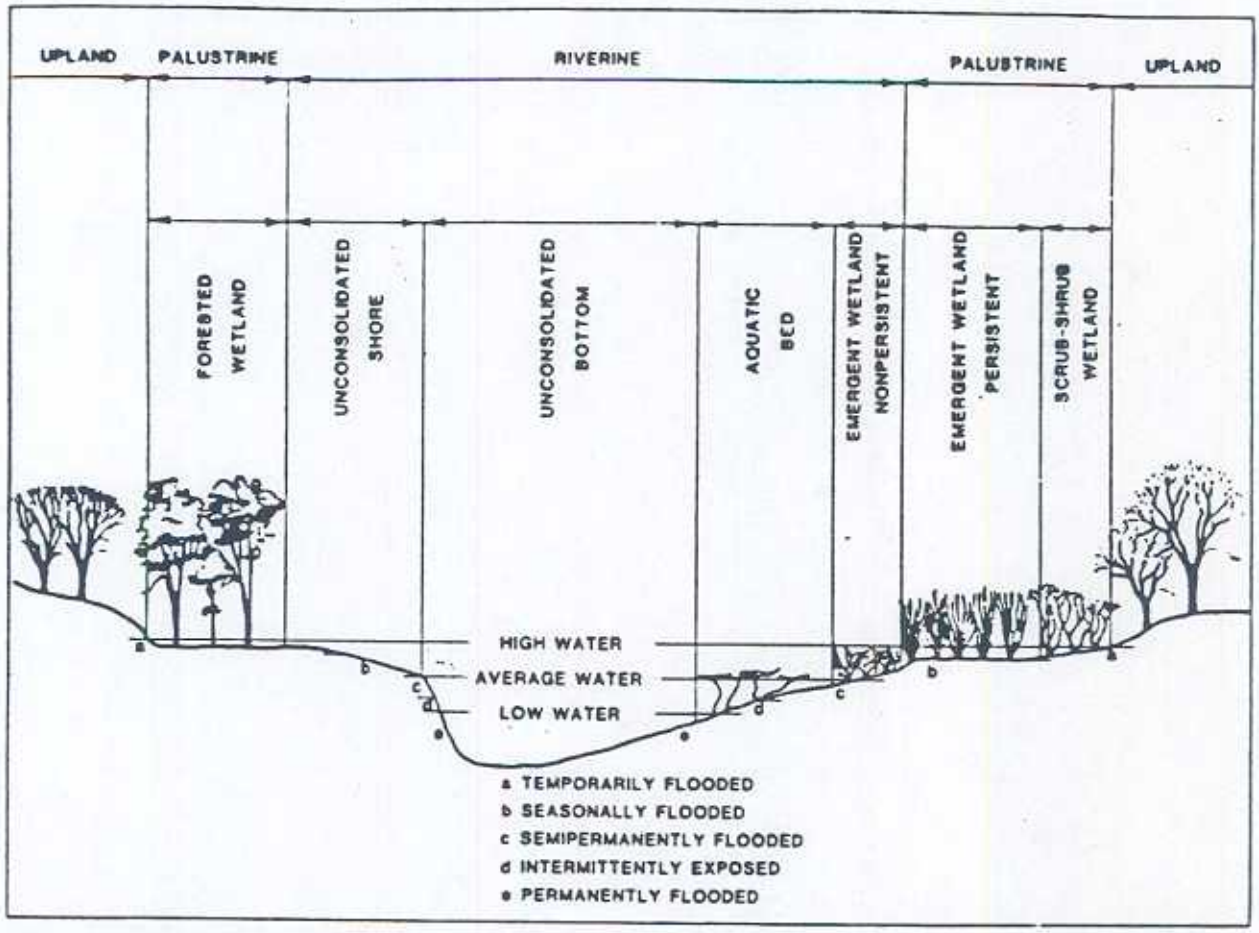

Fig. 4. Distinguishing features and examples of habitats in the Riverine System.

Subsystems. The Riverine System is divided into four subsystems: the Tidal, the Lower Perennial, the Upper Perennial, and the Intermittent. Each is defined in terms of water permanence, gradient, water velocity, substrate, and the extent of floodplain development. The subsystems have characteristic flora and fauna (see Illies and Botosaneau 1963; Hynes 1970; Reid and Wood 1976). All four subsystems are not necessarily present in all rivers, and the order of occurrence may be other than that given below.

Tidal—The gradient is low and water velocity fluctuates under tidal influence. The streambed is mainly mud with occasional patches of sand. Oxygen deficits may sometimes occur and the fauna is similar to that in the Lower Perennial Subsystem. The floodplain is typically well developed.

Lower Perennial—The gradient is low and water velocity is slow. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur, the fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.

Upper Perennial—The gradient is high and velocity of the water fast. There is no tidal influence and some water flows throughout the year. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation. The fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared with that of the Lower Perennial Subsystem, and there is very little floodplain development.

Intermittent.—In this subsystem, the channel contains nontidal flowing water for only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Streambed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent).

Lacustrine System

Definition. The Lacustrine System (Fig. 5) includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 ha (20 acres). Similar wetland and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 2 m (6.6 feet) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5‰.

Limits. The Lacustrine System is bounded by upland or by wetland dominated by trees, shrubs, per-

Table 2. *Salinity modifiers used in this classification system.*

Coastal modifiers[a]	Inland modifiers[b]	Salinity (parts per thousand)	Approximate specific conductance (µMhos at 25 °C)
Hyperhaline	Hypersaline	>40	>60,000
Euhaline	Eusaline	30.0-40	45,000-60,000
Mixohaline (brackish)	Mixosaline[c]	0.5-30	800-45,000
Polyhaline	Polysaline	18.0-30	30,000-45,000
Mesohaline	Mesosaline	5.0-18	8,000-30,000
Oligohaline	Oligosaline	0.5-5	800- 8,000
Fresh	Fresh	< 0.5	<800

[a]Coastal modifiers are used in the Marine and Estuarine systems.
[b]Inland modifiers are used in the Riverine, Lacustrine, and Palustrine systems.
[c]The term Brackish should not be used for inland wetlands or deepwater habitats.

sistent emergents, emergent mosses, or lichens. Lacustrine systems formed by damming a river channel are bounded by a contour approximating the normal spillway elevation or normal pool elevation, except where Palustrine wetlands extend lakeward of that boundary. Where a river enters a lake, the extension of the Lacustrine shoreline forms the Riverine-Lacustrine boundary.

Description. The Lacustrine System includes permanently flooded lakes and reservoirs (e.g., Lake Superior), intermittent lakes (e.g., playa lakes), and tidal lakes with ocean-derived salinities below 0.5‰ (e.g., Grand Lake, Louisiana). Typically, there are extensive areas of deep water and there is considerable wave action. Islands of Palustrine wetland may lie within the boundaries of the Lacustrine System.

Subsystems.

Limnetic.—All deepwater habitats within the Lacustrine System; many small Lacustrine systems have no Limnetic Subsystem.

Littoral.—All wetland habitats in the Lacustrine System. Extends from the shoreward boundary of the system to a depth of 2 m (6.6 feet) below low water or to the maximum extent of nonpersistent emergents, if these grow at depths greater than 2 m.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent).

Palustrine System

Definition. The Palustrine System (Fig. 6) includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5‰. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2 m at low water; and (4) salinity due to ocean-derived salts less than 0.5‰.

Limits. The Palustrine System is bounded by upland or by any of the other four systems.

Description. The Palustrine System was developed to group the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie, which are found throughout the United States. It also includes the small, shallow, permanent or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; in isolated catchments; or on slopes. They may also occur as islands in lakes or rivers. The erosive forces of wind and water are of minor importance except during severe floods.

The emergent vegetation adjacent to rivers and lakes is often referred to as "the shore zone" or the "zone of emergent vegetation" (Reid and Wood 1976), and is generally considered separately from the river itself. As an example, Hynes (1970:85) wrote in reference to riverine habitats, "We will not here consider the long list of emergent plants which may occur along the banks out of the current, as they do not belong, strictly speaking, to the running water habitat." There are often great similarities between wetlands lying adjacent to lakes or rivers and isolated wetlands of the same class in basins without open water.

Subsystems. None.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Unconsolidated Shore, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland, and Forested Wetland.

Classes, Subclasses, and Dominance Types

The CLASS is the highest taxonomic unit below the subsystem level. It describes the general appearance of the habitat in terms of either the dominant life form

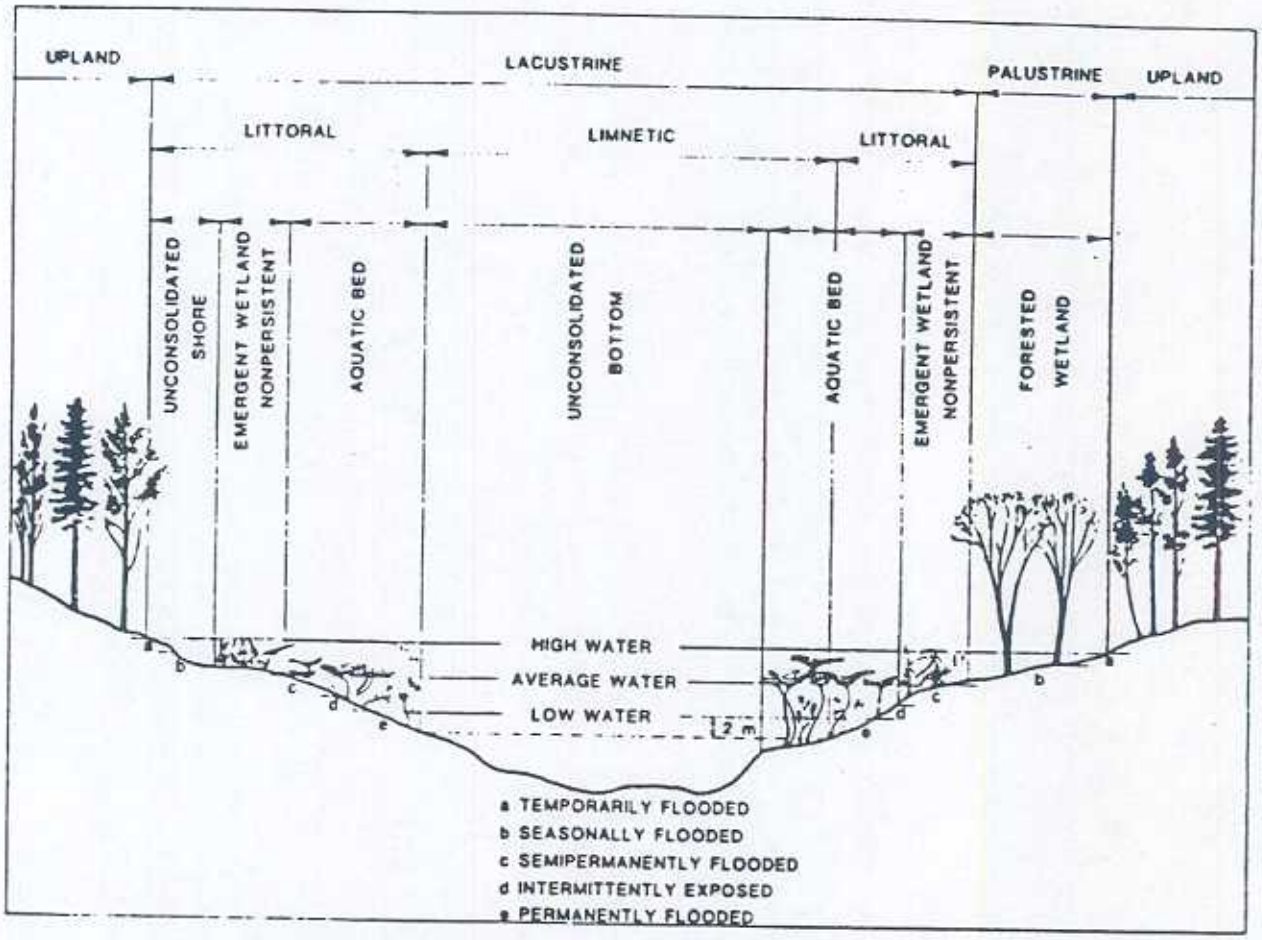

Fig. 5. Distinguishing features and examples of habitats in the Lacustrine System.

of the vegetation or the physiography and composition of the substrate—features that can be recognized without the aid of detailed environmental measurements. Vegetation is used at two different levels in the classification. The life forms—trees, shrubs, emergents, emergent mosses, and lichens—are used to define classes because they are relatively easy to distinguish, do not change distribution rapidly, and have traditionally been used as criteria for classification of wetlands.[a] Other forms of vegetation, such as submerged or floating-leaved rooted vascular plants, free-floating vascular plants, submergent mosses, and algae, though frequently more difficult to detect, are used to define the class Aquatic Bed. Pioneer species that briefly invade wetlands when conditions are favorable are treated at the subclass level because they are transient and often not true wetland species.

Use of life forms at the class level has two major advantages: (1) extensive biological knowledge is not required to distinguish between various life forms, and (2) it has been established that various life forms are easily recognizable on a great variety of remote sensing products (e.g., Radforth 1962; Anderson et al. 1976). If vegetation (except pioneer species) covers 30% or more of the substrate, we distinguish classes on the basis of the life form of the plants that constitute the uppermost layer of vegetation and that possess an areal coverage 30% or greater. For example, an area with 50% areal coverage of trees over a shrub layer with a 60% areal coverage would be classified as Forested Wetland; an area with 20% areal coverage of trees over the same (60%) shrub layer would be classified as Scrub-Shrub Wetland. When trees or shrubs alone cover less than 30% of an area but in combination cover 30% or more, the wetland is

[a]Our initial attempts to use familiar terms such as marsh, swamp, bog, and meadow at the class level were unsuccessful primarily because of wide discrepancies in the use of these terms in various regions of the United States. In an effort to resolve that difficulty, we based the classes on the fundamental components (life form, water regime, substrate type, water chemistry) that give rise to such terms. We believe that this approach will greatly reduce the misunderstandings and confusion that result from the use of the familiar terms.

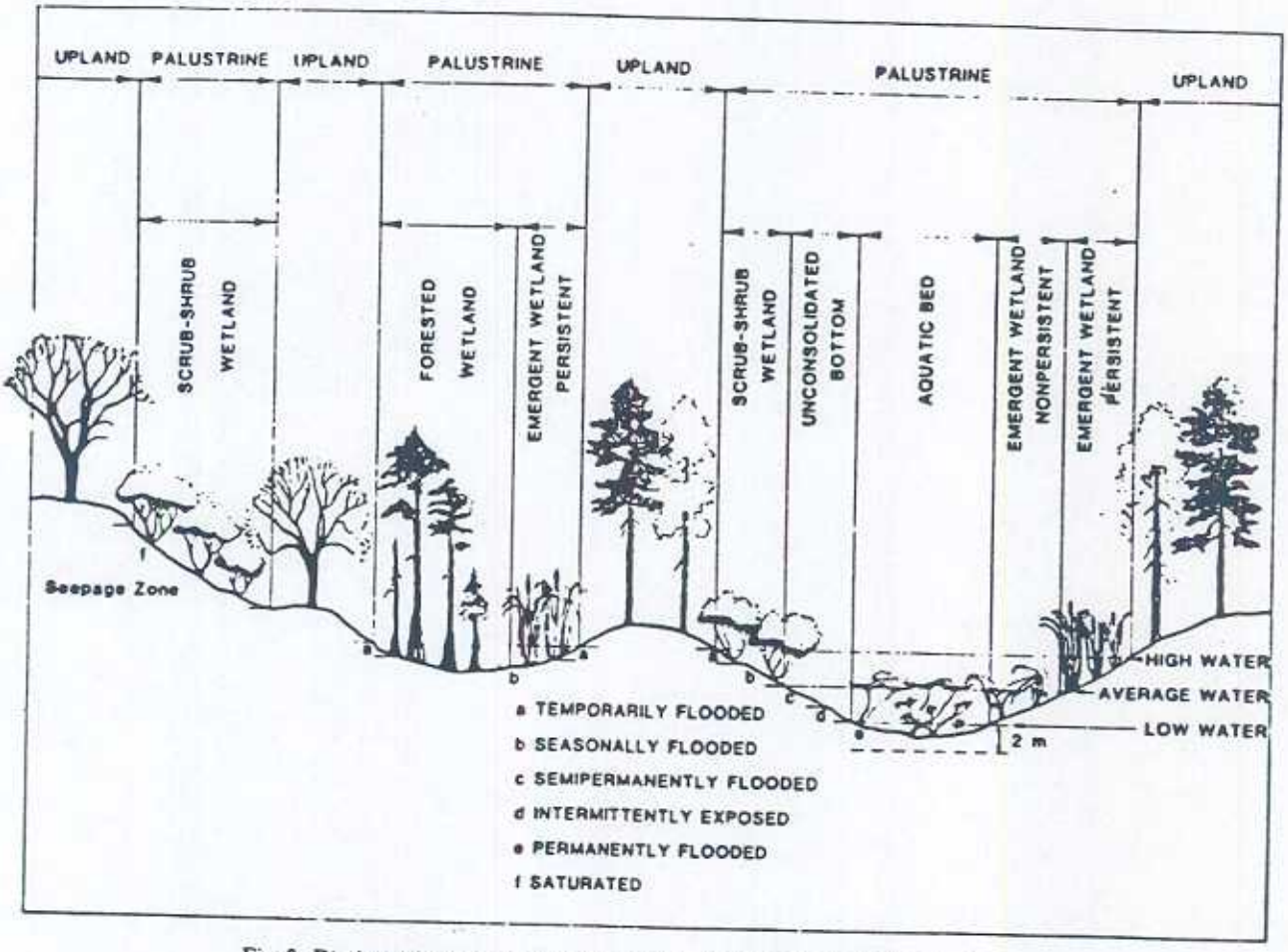

Fig. 6. Distinguishing features and examples of habitats in the Palustrine System.

assigned to the class Scrub-Shrub. When trees and shrubs cover less than 30% of the area but the total cover of vegetation (except pioneer species) is 30% or greater, the wetland is assigned to the appropriate class for the predominant life form below the shrub layer. Finer differences in life forms are recognized at the SUBCLASS level. For example, Forested Wetland is divided into the subclasses Broad-leaved Deciduous, Needle-leaved Deciduous, Broad-leaved Evergreen, Needle-leaved Evergreen, and Dead. Subclasses are named on the basis of the predominant life form.

If vegetation covers less than 30% of the substrate, the physiography and composition of the substrate are the principal characteristics used to distinguish classes. The nature of the substrate reflects regional and local variations in geology and the influence of wind, waves, and currents on erosion and deposition of substrate materials. Bottoms, Shores, and Streambeds are separated on the basis of duration of inundation. In the Riverine, Lacustrine, and Palustrine systems, Bottoms are submerged all or most of the time, whereas Streambeds and Shores are exposed all or most of the time. In the Marine and Estuarine systems, Bottoms are subtidal whereas Streambeds and Shores are intertidal. Bottoms, Shores, and Streambeds are further divided at the class level on the basis of the important characteristic of rock versus unconsolidated substrate. Subclasses are based on finer distinctions in substrate material unless, as with Streambeds and Shores, the substrate is covered by, or shaded by, an aerial coverage of pioneering vascular plants (often nonhydrophytes) of 30% or more; the subclass is then simply vegetated. Further detail as to the type of vegetation must be obtained at the level of dominance type. Reefs are a unique class in which the substrate itself is composed primarily of living and dead animals. Subclasses of Reefs are designated on the basis of the type of organism that formed the reef.

The DOMINANCE TYPE is the taxonomic category subordinate to subclass. Dominance types are determined on the basis of dominant plant species (e.g., Jeglum et al. 1974), dominant sedentary or sessile animal species (e.g., Thorson 1957), or dominant plant and animal species (e.g., Stephenson and Stephenson 1972). A dominant plant species has traditionally meant one that has control over the community (Weaver and Clements 1938:91), and this plant is also usually the predominant species (Cain and Castro

1959:29). When the subclass is based on life form, we name the dominance type for the dominant species or combination of species (codominants) in the same layer of vegetation used to determine the subclass.[4] For example, a Needle-leaved Evergreen Forested Wetland with 70% areal cover of black spruce and 30% areal cover of tamarack (*Larix laricina*) would be designated as a *Picea mariana* Dominance Type. When the relative abundance of codominant species is nearly equal, the dominance type consists of a combination of species names. For example, an Emergent Wetland with about equal areal cover of common cattail (*Typha latifolia*) and hardstem bulrush (*Scirpus acutus*) would be designated as *Typha latifolia-Scirpus acutus* Dominance Type.

When the subclass is based on substrate material, the dominance type is named for the predominant plant or sedentary or sessile macroinvertebrate species, without regard for life form. In the Marine and Estuarine systems, sponges, alcyonarians, mollusks, crustaceans, worms, ascidians, and echinoderms may all be part of the community represented by the *Macoma balthica* Dominance Type. Sometimes it is necessary to designate two or more codominant species as a dominance type. Thorson (1957) recommended guidelines and suggested definitions for establishing community types and dominants on level bottoms.

Unconsolidated Bottom

Definition. The class Unconsolidated Bottom includes all wetland and deepwater habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%. Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semipermanently flooded.

Description. Unconsolidated Bottoms are characterized by the lack of large stable surfaces for plant and animal attachment. They are usually found in areas with lower energy than Rock Bottoms, and may be very unstable. Exposure to wave and current action, temperature, salinity, and light penetration determine the composition and distribution of organisms.

Most macroalgae attach to the substrate by means of basal hold-fast cells or discs; in sand and mud, however, algae penetrate the substrate and higher plants can successfully root if wave action and currents are not too strong. Most animals in unconsolidated sediments live within the substrate, e.g., *Macoma* and the amphipod *Melita*. Some, such as the polychaete worm *Chaetopterus*, maintain permanent burrows, and others may live on the surface, especially in coarse-grained sediments.

In the Marine and Estuarine systems, Unconsolidated Bottom communities are relatively stable. They vary from the Arctic to the tropics, depending largely on temperature, and from the open ocean to the upper end of the estuary, depending on salinity. Thorson (1957) summarized and described characteristic types of level bottom communities in detail.

In the Riverine System, the substrate type is largely determined by current velocity, and plants and animals exhibit a high degree of morphologic and behavioral adaptation to flowing water. Certain species are confined to specific substrates and some are at least more abundant in one type of substrate than in others. According to Hynes (1970:208), "The larger the stones, and hence the more complex the substratum, the more diverse is the invertebrate fauna." In Lacustrine and Palustrine systems, there is usually a high correlation, within a given water body, between the nature of the substrate and the number of species and individuals. For example, in the profundal bottom of eutrophic lakes where light is absent, oxygen content is low, and carbon dioxide concentration is high, the sediments are ooze-like organic materials and species diversity is low. Each substrate type typically supports a relatively distinct community of organisms (Reid and Wood 1976:262).

Emergent Wetland

Definition. The Emergent Wetland class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed.

Description. In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central United States, violent climatic fluctuations cause them to revert to an open water phase in some years (Stewart and Kantrud 1972). Emergent Wetlands are found throughout the United States and occur in all systems except the Marine. Emergent Wetlands are known by many names, including marsh, meadow, fen, prairie pothole, and slough. Areas that are dominated by pioneer plants that become established during periods of low water are not Emergent Wetlands and should be classified as Vegetated Unconsolidated Shores or Vegetated Streambeds.

Subclasses and Dominance Types.

Persistent.—Persistent Emergent Wetlands are dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the Estuarine and Palustrine systems.

Persistent Emergent Wetlands dominated by saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), big cordgrass (*S. cynosuroides*), needlerush (*Juncus roemerianus*), narrow-leaved cattail (*Typha angustifolia*), and southern wild rice (*Zizaniopsis miliacea*) are major components of the Estuarine Systems of the Atlantic and Gulf coasts of the United States. On the Pacific Coast, common pickleweed (*Salicornia virginica*), sea blite (*Suaeda californica*), arrow grass (*Triglochin maritima*), and California cordgrass (*Spartina foliosa*) are common dominants.

Palustrine Persistent Emergent Wetlands contain a vast array of grasslike plants such as cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), saw grass (*Cladium jamaicense*), sedges (*Carex* spp.); and true grasses such as reed (*Phragmites communis*), manna grasses (*Glyceria* spp.), slough grass (*Beckmannia syzigachne*), and whitetop (*Scolochloa festucacea*). There is also a variety of broad-leaved persistent emergents such as purple loosestrife (*Lythrum salicaria*), dock (*Rumex mexicanus*), waterwillow (*Decodon verticillatus*), and many species of smartweeds (*Polygonum*).

Nonpersistent.—Wetlands in this subclass are dominated by plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious sign of emergent vegetation. For example, wild rice (*Zizania aquatica*) does not become apparent in the North Central States until midsummer and fall, when it may form dense emergent stands. Nonpersistent emergents also include species such as arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), and arrowheads (*Sagittaria* spp.). Movement of ice in Estuarine, Riverine, and Lacustrine systems often removes all traces of emergent vegetation during the winter. Where this occurs, the area should be classified as Nonpersistent Emergent Wetland.

Scrub-Shrub Wetland

Definition. The class Scrub-Shrub Wetland includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. All water regimes except subtidal are included.

Description. Scrub-Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities. They occur only in the Estuarine and Palustrine systems, but are one of the most widespread classes in the United States (Shaw and Fredine 1956). Scrub-Shrub Wetlands are known by many names, such as shrub swamp (Shaw and Fredine 1956), shrub carr (Curtis 1959), bog (Heinselman 1970), and pocosin (Kologiski 1977). For practical reasons we have also included forests composed of young trees less than 6 m tall.

Modifiers

To fully describe wetlands and deepwater habitats, one must apply certain modifiers at the class level and at lower levels in the classification hierarchy. The modifiers described below were adapted from existing classifications or were developed specifically for this system.

Special Modifiers

Many wetlands and deepwater habitats are man-made, and natural ones have been modified to some degree by the activities of man or beavers. Since the nature of these modifications often greatly influences the character of such habitats, special modifying terms have been included here to emphasize their importance. The following modifiers should be used singly or in combination wherever they apply to wetlands and deepwater habitats.

Farmed

The soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become reestablished if farming is discontinued.

Diked

Created or modified by a man-made barrier or dike designed to obstruct the inflow of water.

Relationship to Other Wetland Classifications

There are numerous wetland classifications in use in the United States. Here we relate this system to three published classifications that have gained widespread acceptance. It is not possible to equate these systems directly for several reasons: (1) The criteria selected for establishing categories differ; (2) some of the classifications are not applied consistently in different parts of the country; and (3) the elements classified are not the same in various classifications.

The most widely used classification system in the United States is that of Martin et al. (1953) which was republished in U. S. Fish and Wildlife Service *Circular 39* (Shaw and Fredine 1956). The wetland types are based on criteria such as water depth and permanence, water chemistry, life form of vegetation, and dominant plant species. In Table 4 we compare some of the major components of our system with the type descriptions listed in *Circular 39*.

In response to the need for more detailed wetland classification in the glaciated Northeast, Golet and Larson (1974) refined the freshwater wetland types of *Circular 39* by writing more detailed descriptions and subdividing classes on the basis of finer differences in plant life forms. Golet and Larson's classes are roughly equivalent to Types 1-8 of *Circular 39*, except that they restricted Type 1 to river floodplains. The Golet and Larson system does not recognize the coastal (tidal) fresh wetlands of *Circular 39* (Types 12-14) as a separate category, but classifies these areas in the same manner as nontidal wetlands. In addition to devising 24 subclasses, they also created 5 size categories, 6 site types giving a wetland's hydrologic and topographic location; 8 cover types (modified from Stewart and Kantrud 1971) expressing the distribution and relative proportions of cover and water; 3 vegetative interspersion types; and 6 surrounding habitat types. Since this system is based on the classes of Martin et al. (1953), Table 4 may also be used to compare the Golet and Larson system with the one described here. Although our system does not include size categories and site types, this information will be available from the results of the new inventory of wetlands and deepwater habitats of the United States.

Table 4. *Comparison of wetland types described in U. S. Fish and Wildlife Service* Circular 39 *with some of the major components of this classification system.*

Circular 39 type, and references for examples of typical vegetation	Classification of wetlands and deepwater habitats: Classes	Water regimes	Water chemistry
Type 1—Seasonally flooded basins or flats Wet meadow (Dix and Smeins 1967; Stewart and Kantrud 1972) Bottomland hardwoods (Braun 1950) Shallow-freshwater swamps (Penfound 1952)	Emergent Wetland Forested Wetland	Temporarily Flooded Intermittently Flooded	Fresh Mixosaline
Type 2—Inland fresh meadows Fen (Heinselman 1963) Fen, northern sedge meadow (Curtis 1959)	Emergent Wetland	Saturated	Fresh Mixosaline
Type 3—Inland shallow fresh marshes Shallow marsh (Stewart and Kantrud 1972; Golet and Larson 1974)	Emergent Wetland	Semipermanently Flooded Seasonally Flooded	Fresh Mixosaline
Type 4—Inland deep fresh marshes Deep marsh (Stewart and Kantrud 1972; Golet and Larson 1974)	Emergent Wetland Aquatic Bed	Permanently Flooded Intermittently Exposed Semipermanently Flooded	Fresh Mixosaline
Type 5—Inland open fresh water Open water (Golet and Larson 1974) Submerged aquatic (Curtis 1959)	Aquatic Bed Unconsolidated Bottom	Permanently Flooded Intermittently Exposed	Fresh Mixosaline
Type 6—Shrub swamps Shrub swamp (Golet and Larson 1974) Shrub-carr, alder thicket (Curtis 1959)	Scrub-Shrub Wetland	All nontidal regimes except Permanently Flooded	Fresh
Type 7—Wooded swamps Wooded swamp (Golet and Larson 1974) Swamps (Penfound 1952; Heinselman 1963)	Forested Wetland	All nontidal regimes except Permanently Flooded	Fresh
Type 8—Bogs Bog (Dansereau and Segadas-vianna 1952; Heinselman 1963) Pocosin (Penfound 1952; Kologiski 1977)	Scrub-Shrub Wetland Forested Wetland Moss-Lichen Wetland	Saturated	Fresh (acid only)
Type 9—Inland saline flats Intermittent alkali zone (Stewart and Kantrud 1972)	Unconsolidated Shore	Seasonally Flooded Intermittently Flooded Temporarily Flooded	Eusaline Hypersaline
Type 10—Inland saline marshes Inland salt marshes (Ungar 1974)	Emergent Wetland	Seasonally Flooded Semipermanently Flooded	Eusaline
Type 11—Inland open saline water Inland saline lake community (Ungar 1974)	Unconsolidated Bottom	Permanently Flooded Intermittently Flooded	Eusaline
Type 12—Coastal shallow fresh marshes Marsh (Anderson et al. 1968) Estuarine bay marshes, estuarine river marshes (Stewart 1962) Fresh and intermediate marshes (Chabreck 1972)	Emergent Wetland	Regularly Flooded Irregularly Flooded Semipermanently Flooded-Tidal	Mixohaline Fresh

APPENDIX B

Circular 39 Wetland Classification System Definitions of Type 1-11 Wetlands

A. Wetlands

1. Seasonally Flooded Basins or Flats

The soil is covered with water or is water logged during variable seasonal periods, but usually is well drained during much of the growing season. This type is found both in upland depressions and in overflow bottom lands; along river courses, flooding occurs in late fall, winter, or spring. In the uplands, basins or flats may be filled with water during periods of heavy rains or melting snow. Vegetation varies greatly according to the season and the duration of flooding. Where the water has receeded early in the growing season, smartweeds, wild millet, fall panicum, tealgrass, and weeds, such as marsh elder, ragweed, and cockleburs are likely to occur. Shallow basins that are submerged only very temporarily usually develop little or no wetland vegetation.

2. Inland Fresh Meadows

The soil is without standing water during most of growing season but is waterlogged within at least a few inches of the surface. Vegetation includes grasses, sedges, rushes, and various broadleaf plants. Representative plants are carex, brushes, redtop, reedgrasses, managrasses, prairie cordgrass, and mints. Meadows may fill shallow lake depressions, sloughs or farmland sags, or these meadows may border shallow marshes on the landward side. Wild hay is often cut from such areas.

3. Inland Shallow Fresh Marshes

The soil is usually waterlogged during the growing season. Often, it is covered by as much as six inches or more of water. Vegetation includes grasses, bullrushes, spikerushes, or other various marsh plants such as cattails, arrowheads, and smartweeds. These marshes may nearly fill shallow lake basins or sloughs or they may border deep marshes on the landward side. They are also common as seep areas on irrigated lands.

4. Inland Deep Fresh Marshes

The soil is covered with six inches to three feet or more of water during the growing season. Vegetation includes cattails, bullrushes, reeds, spikerrushes, and wildrice. In open areas, pondweeds, naiads, coontail, watermilfoils, waterweeds, duckweeds, waterlilies or spatterdocks may occur. These deep marshes may almost fill shallow lake basins, potholes, limestone sinks and sloughs or they may border open water in such depressions.

5. Inland Open Fresh Water

Shallow ponds and reservoirs are included in this type. Water is usually less than 10 feet deep and is fringed by a border of emergent vegetation. Vegetation mainly at water depths of less than six feet include pondweeds, naiads, wild celery, coontail, watermilfoils, muskgrasses, waterlillies, and spatterdocks.

6. Shrub Swamps

The soil is usually waterlogged during the growing season and is often covered with as much as six inches of water. Vegetation includes alders and willows.

7&8. Not found in Utah.

9. Inland Saline Flats

The soil is without standing water except after periods of heavy precipitation but it is waterlogged within at least a few inches of the surface during the growing season. Vegetation often sparse or patchy, consists of salt tollerant plants such as seablite, saltgrass, Nevada bullrush, saltbush, and burrowweed.

10. Inland Saline Marshes

The soil is usually waterlogged during the growing season and is often covered with as much as two or three feet of water. This type occurs mostly in shallow lake basins. Vegetation is mainly alkali or hardstem bullrushes often widgongrass or sego pondweed in the openings.

11. Inland Open Saline Water

These more permanent areas of shallow saline water are often closely associated with types 9 and 10. Depth of the water is variable. Vegetation, mainly at water depths of less than six feet, includes pondweeds and widgongrass.