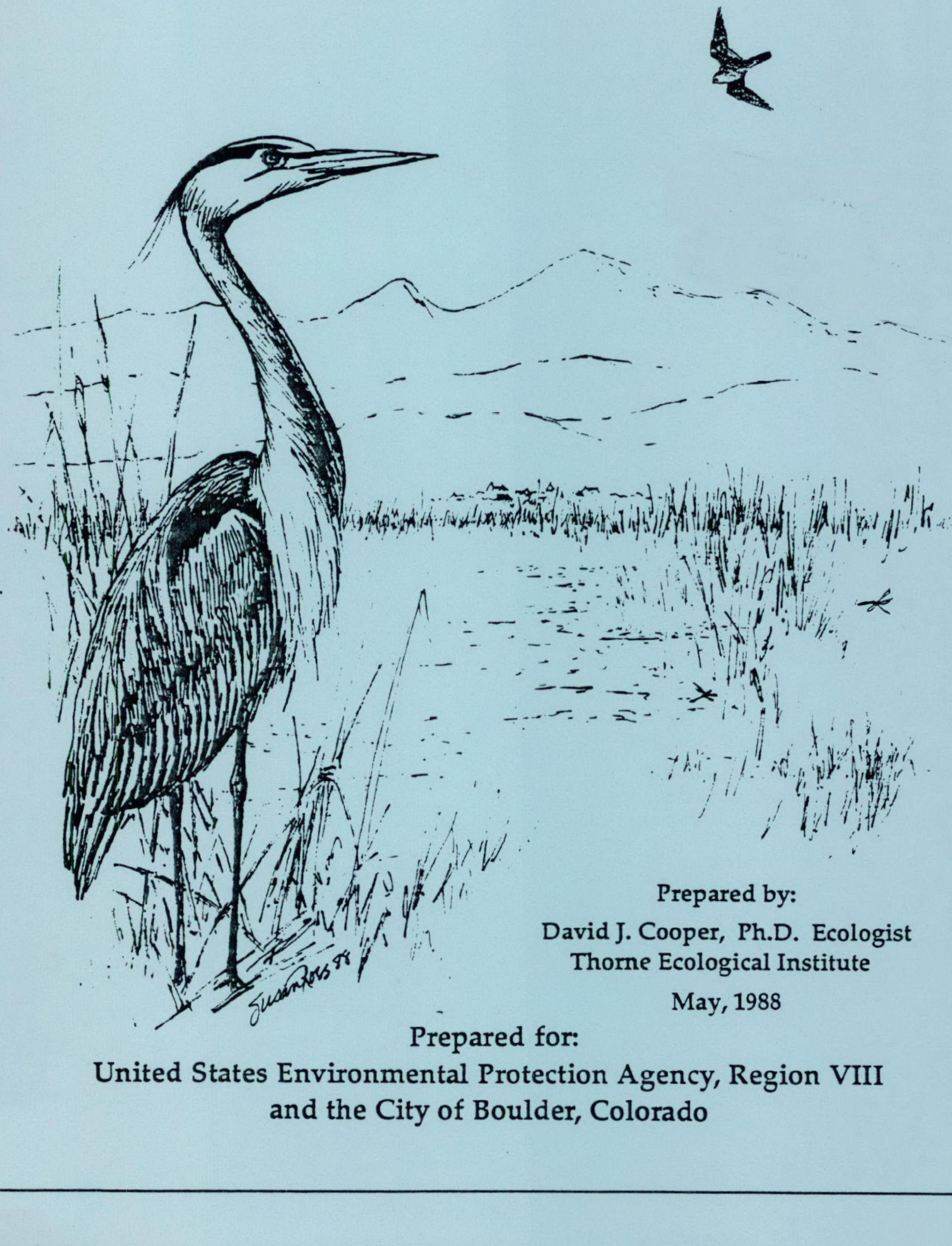
Advanced Identification of Wetlands in the City of Boulder Comprehensive Planning Area



Prepared by:
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May, 1988

Prepared for:
United States Environmental Protection Agency, Region VIII
and the City of Boulder, Colorado

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FOREWORD

This report is being published by the City of Boulder Planning Department as a means of disseminating the results of the advanced identification of wetlands in the City of Boulder Comprehensive Planning area. This project has been jointly funded by the City of Boulder and the U.S. Environmental Protection Agency. The aerial photographs and field data sheets referenced in the report are on file at the City of Boulder Planning Department in room 305 of the Park Central Building, 1739 Broadway, Boulder, Colorado. The Planning Department can be reached by phone at 441-3270. A summary map showing the general location of the wetlands discussed in this report is attached at the end of the report.

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ADVANCED IDENTIFICATION OF WETLANDS IN THE
CITY OF BOULDER COMPREHENSIVE PLANNING AREA

A. INTRODUCTION AND PURPOSE

Introduction

In the semiarid portions of the American West, water is a critical limiting factor for most ecosystems. Total average annual precipitation in most areas below 9,000 feet elevation is lower than total potential evapotranspiration and soils typically have a moisture deficit for a significant portion of the summer. Dominant vegetation types over vast areas are grassland, shrubland, pygmy forest and savannah. More lush vegetation occurs only in areas where the water balance is more favorable. This may occur on north-facing slopes in the foothills, along water courses or other sites where water is abundant near the ground surface. Sites receiving more water (through runoff, groundwater discharge etc.) than can percolate into soils, run off or be lost to evaporation will have saturated soils at some time during the year. If soil saturation occurs during the growing season, it becomes a leading factor structuring the ecosystem and controlling the types of plants that can occupy the site as well as the types of soils that will develop. These sites, having seasonally or permanently wet soils, support distinct types of ecosystems that occur only in these wetland sites.

The abundant water may allow the primary production to be significantly higher in wetlands than in surrounding uplands. Wetlands typically support trees, shrubs and coarse herbaceous species that do not occur in the uplands. Two of the most common wetland types are (1) riparian ecosystems adjacent to streams where overbank flow during flood events are common, and (2) areas where the water table is close to the ground surface. Any activity which introduces pollution to these sites would directly or indirectly introduce pollution into surface and ground waters because leaching or erosion of pollutants into streams or into groundwater flow systems would occur.

The Federal Water Pollution Control Act, as amended by the Clean Water Act, provides the mandate for the U.S. Environmental Protection Agency (EPA) to improve the conditions of streams and other "waters of the United States" (Hughes et al. 1986). The objective of both Acts "is to restore and maintain the chemical, physical and biological integrity of the Nation's waters". The Acts are aimed at restoring water quality and maintaining water in a condition that does not limit its attainable uses. The concept of attainable uses focuses upon uses that are possible if streams and water sources were in an undisturbed or natural condition. This includes water chemistry, the physical structure of aquatic habitats and the potential of the habitat-water system to support biota.

The term "waters of the United States", as defined by the Clean Water Act, is a very broad concept and is defined as:

a. "all waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;

b. all interstate waters including interstate wetlands;

c. all other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use degradation or destruction of which could affect interstate or foreign commerce...;

d. all impoundments of waters otherwise defined as waters of the United States under the definition;

e. tributaries of waters identified" (elsewhere in the regulations);

f. "wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs" (a-f) "of this section" (33 C.F.R. S328.3(a): 40 C.F.R. S230.3(s) 1986).

For purposes of this report, wetlands are defined as:

> "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" (33 C.F.R. Part 328.3(b); C.F.R. S230.3(t) 1986).

Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the United States. The goal of these regulations is to reduce the introduction of pollutants into our nation's waters and to preserve and restore the integrity of our nations waters.

Not only do wetlands play a key role in protecting the nation's waters, but recent syntheses of scientific data have improved our understanding of the broad range of wetland functions (Adamus and Stockwell 1983, Sather and Stuber 1984). Wetlands are now known to be critical in the function of:

(a) ground water recharge; (b) ground water discharge; (c) flood water retention/detention/storage; (d) shore-line anchoring; (e) sediment trapping; (f) nutrient retention; (g) food chain support; (h) fish and wildlife habitat; (i) active and passive human recreation. Not all wetlands provide all of these functions, and most provide only a few to a very high degree. All of these functions are valuable to human society and thus wetlands providing any of these functions to a high degree are very valuable to society.

Purpose

The purpose of this project was to identify, map, describe and evaluate the functions being performed by wetlands occurring within areas 1 and 2 of the City of Boulder Comprehensive Growth Planning Area. The data will be used by the U.S. Environmental Protection Agency in evaluating the applicability of the advanced identification process which has as its purpose the designation of wetlands which federal regulators feel are suitable or unsuitable for disposal of dredged and fill material. Advanced identification of key wetlands will help protect the water quality and other wetland functions of the region and provide local regulators and the regulated public with information to allow appropriate advanced planning and decision making. The advanced identification process is described in the Section 404 (b)(1) Guidelines or 40 C.F.R. Part 230.80. Evaluation of all wetlands in the study area will allow an objective evaluation and make it possible to identify wetlands with the highest functional values and also the most sensitive wetlands in the area.

B. METHODS

The study area includes all land within areas 1, 2a, and 2b of the City of Boulder Comprehensive Planning Growth Areas, as delineated on the map by the same name and dated January, 1986. Area 3 was not included within this study because these areas are protected as parks and open space or are not developable in the near future because they will not receive city utilities within a 15 year planning period. As areas change from area 3 to 2, an evaluation of wetlands in such areas will be required by the Planning Department.

A complete set of 1"=400' aerial photographs for this region were used as a preliminary guide for locating wetlands, as were the wetland maps for this region which are available from the U.S. Fish and Wildlife Service's National Wetlands Inventory. It quickly became apparent during this study that many wetlands do not appear on the National Wetlands Inventory (NWI) maps, nor are they apparent on the 1"=400' blueline aerials available through the City of Boulder and Boulder County. Wetlands having a high water table but which rarely have surface water were, for the most part, not identified by the National Wetlands Inventory and were not identifiable on the blueline aerials. This made it necessary to visit all open land within the study area. Even in the field many wetlands were not visible by casual observation from a single location, such as a road. Thus, each parcel had to be walked. This was especially true for flat sites and for wetland sites that were not dominated by cattails, willows or other rank plants. Wetlands dominated by sedges, rushes, three-square and forbs are not always easily identified at a distance on the ground.

Each wetland was numbered and that number appears on the field data sheet for that wetland (Appendix 3). Wetlands are identified by this same number on every aerial photo and map used in the study. The locations of all wetlands are identified on a single large scale (1:24,000) topographic map (map pocket). Each wetland is also located on both 1"=400′ and 1"=100′ aerial bluelines (Table 1).

In using this map system the following procedure is suggested. Locate the area of interest on the 1:24,000 scale map. If a wetland occurs in the area, use the wetland number shown on the map and Table 1 to determine the 1"=400′ and 1"=100′ aerials on which the wetland of interest is located and plotted. It will then be routine to find the area of interest in relation to the mapped wetlands. Note that many wetlands occur on more than one aerial at each scale. Table 1 lists all aerials on which each wetland occurs. Field data sheets for each wetland are in numerical order in Appendix 4 and provide a description of each wetland. A total of 73 maps and aerials are used in this work. One, 1:24,000 scale base map is used, thirteen 1"=400′ scale aerial photographs, and fifty nine 1"=100′ scale aerial photographs.

The purpose of this mapping was not to plot the exact wetland-upland boundary for regulatory purposes but to identify in a single field visit where wetlands exist. For regulatory purposes each wetland will have to be delineated more precisely. Other information collected at each wetland site were a general

TABLE 1. AERIAL PHOTOS FOR BOULDER WETLANDS

WETLAND	1"=400´	1"=400´	1"=100´	1"=100´	1"=100´
1	2076-232		2076-238		
2	2076-240	2076-232	2079-242	2076-238	2076-240
			2076-242		
3	2076-240	2076-232		2076-240	2079-240
4	2076-240		2079-246	2082-246	
5	2064-240	2064-232	2070-242	2070-240	
6	2064-240		2070-246	2070-244	2070-242
7	2064-240		2070-248	2070-246	
8	2064-240	2064-248	2070-248	2073-248	
9	2064-240	2064-232	2070-244	2070-246	
10	2076-232	2076-249	2079-240	2079-238	
11	2064-248		2073-248		
12	2064-248		2073-248		
13	2064-248		2070-248	2073-248	
14	2064-248		2067-252		
15	2064-248		2067-252		
16	2064-248		2070-252	2070-254	
17	2064-232		2073-236		
18	2064-232		2073-236	2073-234	
19	2064-232		2073-232	2073-234	
20	2064-232		2073-232	2073-234	2076-234
21	2064-248		2070-248		
22	2064-248		2073-256	2073-254	
23	2064-256		2067-258	2070-258	
24	2064-256		2070-260		
25	2064-224	2064-224	2073-230		
26	2064-224	2064-224	2073-228	2073-230	
27	2064-256		2070-262		
28	2064-256		2067-260	2067-262	2064-258
29	2064-256		2070-260		
30	2064-256		2070-254	2070-256	
31	2076-264		2082-270		
32	2076-272		2082-272		
33	2076-272		2082-272		
34	2076-264		2082-266	2085-264	2082-272
			2082-264		
35	2076-240		2076-244		
36	2076-264		2082-264		
37	2076-264		2082-268		
38	2076-264	2076-272	2082-268	2082-270	2085-272
39	2076-264		2082-270	2082-268	
40	2076-264		2079-266		
41	2076-264		2085-264	2082-266	2082-264
42	2064-248		2073-254		
43	2064-256		2067-260	2070-260	
44	2052-256		2061-262	2058-262	
45	2064-256		2064-258	2064-260	
46	2064-256		2064-260	2067-260	2067-258
47	2076-256	2076-264	2082-262	2079-262	2079-264
48	2076-256		2085-262	2082-262	

TABLE 1 (continued). AERIAL PHOTOS FOR BOULDER WETLANDS

WETLAND	1"=400´	1"=400´	1"=100´	1"=100´	1"=100´
49	2076-256		2085-262		
50	2076-248		2079-250	2079-248	2076-252
			2079-252		
51	2076-248		2079-248		
52	2076-248		2076-252	2076-250	2076-248
53	2076-248		2079-250	2079-248	
54	2076-240	2076-248	2079-246	2079-242	2079-248
			2079-244		
55			2073-258	2070-258	
56			2070-260	2073-260	
57	2064-256		2067-256		
58	2064-256		2067-256		
59			2073-248		
60			2076-244	2076-242	2079-244
			2079-242		

site description, notes on the soil substrate, hydroperiod (duration of flooding or soil saturation), notes on water level fluctuations, percentage of the area that is vegetated and unvegetated, notes on the source of water, wetland history (if known), current disturbance regime, and known outside threats.

The major community types occurring in each wetland area were described as well as the approximate percentage area of the wetland that each community occupied. Notes on the depth to water table and hydric characteristics of the soil were listed for each community. Soil colors, where listed, are for matrix chroma just below the A horizon and mottle colors where they occurred. Standard soil colors are provided from Munsell Soil Color Charts (Munsell Color, Baltimore, MD). A species list was made for each wetland, and the percent coverage for each species within each community was estimated.

A wetland plant species list (flora) for the study area was developed and is presented in Appendix 3. This list also presents the most current (August, 1987) indicator status of each plant species according to the National Wetlands Inventory. This indicator status is the best scientific judgement of a panel of experts on what percentage of the total number of individuals of each species in the central Great Plains region occur in wetlands. An indicator status for the Boulder Valley based on the results of this study is also given for each species. This information will be submitted to the National Wetlands Inventory of the U.S. Fish and Wildlife Service for consideration in future revisions of the National Wetlands Plant List.

The following functions were evaluated for each wetland:

ground water recharge, ground water discharge, flood storage, shoreline anchoring, sediment trapping, nutrient retention and removal (long and short term), food chain support (downstream and within basin), habitat (fish and wildlife), active recreation and passive recreation-heritage. Each of these functions was ranked on two different scales. The first scale ranks the intensity with which that function was or could be performed by that wetland in its current condition on a scale of 1-5. The different wetland communities within each wetland were not separately evaluated, but the entire wetland was given a single rating. A rating of 1 indicates that that function was not being performed and could not be performed by that particular wetland. For example, a Juncus (rush) dominated community that never has standing water would not and could not provide fish habitat. A ranking of 2 indicated that the function was performed to a low degree. A ranking of 3 indicated that the function was performed to a medium or average degree. A ranking of 4 indicated that the function was performed to a high degree. A ranking of 5 was given when a function was performed to an extremely high degree. For example, a pond built to detain flood waters on an intermittent stream located within an urban area would likely have a 5 ranking, if it was large enough to provide this function, for the flood storage function and probably also for sediment trapping.

The second ranking system is used to indicate the confidence in the ranking given with the 1-5 scale. This ranking system is based on a three letter scale "a", "b", "c". A rank of "c" was given if there was great uncertainty of the degree to which the function was being performed. A rating of "b" was given if the rating was relatively certain, and "a" was given if the rating was very certain. For example, in ranking the fish habitat function, if fish were observed than an "a" was given for this function. This rating does not indicate the quality of the fish habitat. The quality of the habitat for fish is ranked on the 1-5 scale. So if during this investigation a common species of minnow was found in an intermittent stream the rating for fish habitat function might be 2a. The 2 would denote a low functional value for fish habitat, and the "a" denotes certainty that the habitat does exist. If, however, the same intermittent stream did not have observable fish populations, the rank for the fish habitat function would be 2c.

Some functions are in conflict with each other. For example, trapping of fine seminent is often incompatible with ground water recharge and ground water discharge because the sediment makes the soil surface less permeable. Sediment trapping may also be incompatible with the flood storage and desynchronization function because sediment accumulation reduces the capacity of flood storage basins. Sediment trapping, however, is a virtual prerequisite for the nutrient retention and removal function, because nutrients many times are a component of sediments. Thus, each wetland must be evaluated for each function separately, and no single general rating for each wetland is attempted. However, some wetlands clearly perform more functions than others, and some wetlands clearly perform certain functions to a higher degree than other wetlands. This will be obvious on the data sheets for each wetland provided in Appendix 4 and in the discussion presented later in this report. For a complete description of each wetland function evaluated in this study see Appendix 1.

C. RESULTS

Sixty wetlands were identified in the study area. Each is identified on the three different scales of maps and aerial photographs provided, and each is described and its functions evaluated.

Evaluation of Boulder Wetlands

The 60 wetlands were evaluated as to whether or not they were existing in the landscape in presettlement times, and if not, what was their origin. The wetlands are divided into three categories: natural, created by agricultural practices (along ditches, irrigated fields) or gravel mining, and created by urban runoff. The acreage of wetlands that owe their origins to two factors, such as naturally occurring wetlands that are enlarged due to agricultural irrigation, have been divided and 1/2 entered into each appropriate category. Table 2 shows the results of this analysis.

These wetlands were further broken down into categories which describe their primary water source. These categories are: streams, ditches, reservoirs, high ground water or springs, natural ponds, and urban and industrial runoff. Seven wetlands appear to have two main sources of water. These wetlands are listed under both categories, and 1/2 of the wetland acreage is

TABLE 2. ORIGIN OF BOULDER WETLANDS

Origin	Total Number	Wetland Numbers	Acreage	% of Total Acreage
Natural	21	4, 5, 6, 7, 8, 9, 11, 13, 19, 21, 23, 24, 26, 44, 45, 46, 50, 54, 55, 56, 60	196.1	36
Agricultural and Mining	29	1, 2, 3, 10, 17, 18, 20, 22, 25, 27, 28, 29, 30, 31, 32, 34, 35, 38, 39, 41, 42, 43, 47, 48, 49, 51, 53, 57, 58	306.9	56
Urban	10	12, 14, 15, 16, 33, 36, 37, 40, 52, 59	44.4	8

added to each category. The results are shown in Table 3 and the acreage calculations for each wetland are summarized in Table 4. Table 5 summarizes the number of wetlands of different size occurring in the study area.

TABLE 3. PRINCIPAL WATER SOURCES FOR BOULDER WETLANDS

Water Source	Number of Wetlands	Wetland Numbers	Acreage	% of Total Acreage
Streams	16	5, 6, 7, 8, 9, 11, 13, 14, 15, 16, 23, 44, 46, 50, 54, 55	93.7	17.1
Ditches	19	1, 2, 3, 17, 24, 28, 30, 32, 38, 39, 42, 45, 47, 48, 49, 52, 53, 56, 60	138.5	25.3
Reservoirs	11	10, 20, 22, 27, 29, 31, 34, 41, 51, 57, 58	163.9	29.9
High Ground Water or Springs	14	2, 3, 9, 11, 18, 19, 21, 24, 25, 26, 31, 35, 43, 56, 60	118.5	21.7
Natural Pond	1	4	20.9	3.8
Urban/Industrial Runoff	6	12, 33, 36, 37, 40, 59	12.1	2.2

TABLE 4. ACREAGE, ORIGIN AND WATER SOURCES OF BOULDER WETLANDS

WETLAND NUMBER	ACREAGE	ORIGIN	SOURCE
1	2.3	A/M	D
2	46.2	A/M+N	D+G
3	4.2	A/M+N	D+G
4	20.9	N	P
5	3.1	N	S
6	1.4	N	S
7	0.7	N	S
8	3.4	N	S
9	11.5	N	S
10	73.3	A/M	R
11	16.1	N	G+S
12	0.8	U	U
13	0.5	N	S
14	0.1	U	S
15	0.1	U	S
16	1.9	U	S
17	8.6	A/M	D
18	4.9	A/M	G
19	1.8	N	G
20	17.1	A/M	R
21	0.4	N	G
22	2.5	A/M	R
23	10.2	N	S
24	8.5	N	G+D
25	1.8	A/M	G
26	15.9	N	G
27	6.9	A/M	R
28	4.8	A/M	D
29	6.5	A/M	R
30	1.2	A/M	D
31	5.2	A/M	G+R
32	6.3	A/M	D
33	2.1	U	U
34	19.9	A/M	R
35	4.2	A/M	G
36	2.2	U	U
37	4.9	U	U
38	4.1	A/M	D
39	4.8	A/M	D
40	1.7	U	U
41	30.2	A/M	R
42	2.2	A/M	D
43	12.8	A/M	G
44	3.2	N	S
45	4.5	N	D
46	5.5	N	S
47	4.9	A/M	D
48	3.1	A/M	D
49	4.8	A/M	D
50	34.6	U+N	S
51	1.2	A/M	R

TABLE 4. CONTINUED

52	12.9	U	D
53	7.9	A/M	D
54	4.5	N	S
55	4.9	N	S
56	26.5	A/M+N	D+G
57	1.9	A/M	R
58	1.8	A/M	R
59	0.4	U	U
60	46.5	A/M+N	D+G

Abbreviations used in Table 4.
A/M = Agriculture or Mining ; N = Naturally Occurring ;
U = Urban Runoff ; S = Stream ; D = Ditch ; R = Reservoir ;
G = Ground Water ; P = Natural Pond ; U = Urban/Industrial Runoff

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TABLE 5. BOULDER WETLANDS ACREAGE SUMMARY TABLE

Less than one acre	=	7 WETLANDS
One to ten acres	=	39 WETLANDS
Greater than ten acres	=	14 WETLANDS

This data describes the types of wetlands occurring in the Boulder valley very well. Most natural wetlands occur along natural stream systems in oxbows, along shores and in overflow areas. Many of these streams once had wide floodplains and meandered extensively. Abandoned or seldom used channels were vegetated, held water and usually did support wetlands. However, most of these backwater areas, particularly along Boulder Creek, have been filled and the wetlands lost. Only one natural pond (Sombrero Marsh, wetland number 4) occurs in the study area. The natural wetlands appear to support a number of plant species that are not found in the more recently created wetlands. For example, <u>Lobelia siphilitica</u> and <u>Agalinis tenuifolia</u> both of which are rare in the Boulder Valley were found in the remaining fragments of sloughs in the Boulder Creek, Bear Creek and South Boulder Creek system. In addition, species of <u>Bidens spp.</u>, <u>Leersia oryzoides</u> and other plant species are most common in the sandy channels of these drainages. Most of the area occupied by these species has been lost to urbanization. <u>Spiranthes diluvialis</u> which is found in some wetlands in City of Boulder Open Space in the South Boulder Creek drainage near U.S. 36, is extremely rare in the Rocky Mountain region. This species was found in wetland 21 in the study area (which did not include the Open Space lands designated as Area 3 of the Comprehensive Plan). Most of the mature cottonwood-willow stands in the Boulder Valley occur along the major natural drainages in the region, and these are prized wildlife habitat.

Almost two thirds of the wetlands in the study area apparently are totally or partially a result of man's activities, particularly agriculture and gravel mining. Twenty nine wetlands are associated with ditches, leaks from ditches, flood irrigated fields, reservoir margins and backwaters, and leaks from reservoirs (Table 2). Wetlands located along reservoir margins, ditch banks and natural streams support woody vegetation, while wetlands in other sites tend to have saturated soils for longer periods of time during the growing season and support herbaceous wetland communities. Some of the wetlands created by leaking reservoirs and ditches are among the largest and most biologically diverse wetlands in the study area. For example wetland number 34, located north and east of Twin Lakes in the Gunbarrel area appears to be supported primarily by leakage from the lakes and wetland number 49 supported by leaks from a large ditch, are both large and biologically diverse wetlands.

It may seem that because more than one half of the study area's wetlands have been produced by man's activities that more wetlands occur in the Boulder Valley now than prior to settlement, but this probably is not true. Presettlement wetlands were probably found along streams and rivers and in landscape depressions. All streams and rivers in the study area have been partially or totally channelized and their flows are now regulated. Agricultural and urban development has clustered along Boulder Creek throughout the Boulder Valley and most natural wetlands have been destroyed. Spring runoff water that once inundated floodplains at the mountain front and on the Great Plains is retained in mountain reservoirs for municipal use or diverted into ditches and canals for agricultural uses. Seeps from ditches and reservoirs, and extensive flood irrigation have created high water tables and wetlands in many parts of the Boulder Valley that in presettlement condition were dry uplands. Municipal water ends up in sewer lines and is transported to water treatment plants, and as street runoff. Urban wetlands are the result of the redistribution of street runoff, much of which has been diverted from streams.

Man's activities to divert water for municipal and agricultural uses has created completely different patterns of water distribution, resulting in wetlands in different locations, and of different type than occurred naturally in the Boulder Valley. Most likely the area of wetlands supported now is similar to that in pre-settlement conditions, however the types and functions of wetlands are probably very different. For example, presently many wetlands occur away from floodplains, and few occur along floodplains, whereas in presettlement condition, most likely the majority of wetlands occurred along floodplains. Important wetland functions that have been largely lost due to these changes include flood storage and desynchronization, native fish and wildlife habitat, water quality control (sediment and nutrient cycling), food chain support and shoreline anchoring. The types of functions that have increased due to these changes include increased habitat for waterfowl (created by open water reservoirs) and active recreation.

In attempting to understand the cumulative impacts of human development upon water and wetlands in the Boulder Valley, the redistribution of water for municipal and agricultural uses is important to understand. In addition, the profound effect of mountain reservoirs and irrigation canals in reducing seasonal variation in stream water volume and the elimination of regular flood events has eliminated an essential component of streamside wetland functioning. Sediment retention and nutrient cycling are dependant upon the flooding, as are many food chain and habitat characteristics. In addition, plant species such as plains cottonwood and peach-leaf willow depend upon flood scouring to create sand bars which are essential seed beds for germination and establishment of new populations. It is also essential to understand that at present these streams are not capable of supporting the types of wetland and riparian ecosystems that they once did, nor can the ecosystems be recreated by a tree planting program. What is lost is the ecosystem function, and this can only be restored by restoring the hydrology of presettlement Boulder Valley streams and creeks which includes some large flows and creek bed and bank scouring and high sustained flow in the spring and early summer as the high mountain snowpack melts.

The wetland maps created during this project were compared with the National Wetland Inventory (NWI) Maps produced by the U.S. Fish and Wildlife Service for eastern Colorado to see which Boulder wetlands they had identified from aerial photographs. The NWI wetland maps for the Boulder area were mapped from 1:80,000 black and white aerial photographs that had been flown in 1975. Mapping of eastern Colorado was also one of the first efforts at wetland mapping by the U.S. Fish and Wildlife Service. Thus, an attempt was made to determine what types of wetlands they had consistently identified, and what types they had consistently missed and these results are presented in Table 6.

This data indicates that the wetlands most accurately mapped by NWI were those with standing water (ponds and reservoirs, streams and ditches). Wetlands that can be detected only by

TABLE 6. BOULDER WETLANDS MAPPED IN THIS STUDY AND BY NWI

Type of Wetland	Number mapped this study	Number mapped by NWI
Stream sections	16	9
Ditches	19	7
Reservoirs and Ponds	12	11
High Water Table	14	6
Urban and Industrial	6	2

tonal changes due to differences in vegetation are not easy to identify. In particular, as mentioned earlier, wetlands supported by a high water table that rarely have standing water support vegetation that is similar is size and color in certain seasons to the upland grasslands. It makes these wetlands difficult to identify on aerial photographs. The overall accuracy of the the current NWI maps for the study area, makes them of limited value as a baseline evaluation of existing wetlands. This probably also applies to other areas of the Front Range mapped at the same time. In addition, the NWI maps identified many wetlands which do not currently exist. Whether this is due to misidentification by the NWI or whether recent drainage projects have destroyed wetlands is not known.

Evaluation Of Functions Performed By Boulder Wetlands

Table 7 summarizes the number of wetlands performing each function to a high degree (a ranking of 4 or 5). The results of this analysis indicate that flood storage is the function a large percentage of the wetlands most likely do perform. Other functions that are performed to a high degree include sediment trapping, short-term nutrient retention and wildlife habitat. This indicates that many wetlands occupy landscape depressions and receive water from streams or uplands and that this water can have a rather long residence time in the wetland. Many of the wetlands also have high biological productivity and are rather isolated from human disturbances.

Two functions do not appear to be performed by very many Boulder wetlands. These are active recreation and fish habitat. This is because most of the wetlands are not suitable for the types of active recreation activities covered by this function (canoeing, swimming etc.), most are not open to the public and few have perennial open water and other habitat features which can support healthy populations of native fish species.

Most other functions are performed to a high degree by less than 1/4th of the wetlands surveyed. Table 7 lists the Boulder wetlands that perform each function to a high degree. Table 8 lists the Boulder wetlands that perform three or more functions to a high degree. Table 9 lists the Boulder wetlands that do not perform any functions to a high degree. These tables will be valuable for the advanced identification process and will make it easier to determine the most valuable wetlands for each function and for multiple functions in the study area.

Wetlands that occur along irrigation ditches, farm ponds and that are fed by leaks from irrigation ditches are those performing the fewest functions to a high degree. Wetlands fed by surface waters from streams, adjacent to streams, very isolated from housing developments, or those surrounded by urban and/or industrial development are the wetlands that perform functions to the highest degree.

TABLE 7. SUMMARY TABLE SHOWING THE NUMBER AND PERCENTAGE OF BOULDER WETLANDS PERFORMING EACH FUNCTION TO A HIGH DEGREE

FUNCTION	NUMBER	PERCENTAGE
Ground Water Recharge	7	11.7
Ground Water Discharge	11	18.3
Flood Storage	29	48.3
Shoreline Anchoring	11	18.3
Sediment Trapping	19	31.7
Long Term Nutrient Retention	8	13.3
Short Term Nutrient Retention	19	31.7
Downstream Food Chain Support	8	13.3
Within Basin Food Chain Support	11	18.3
Fish Habitat	3	5.0
Wildlife Habitat	17	28.3
Active Recreation	2	3.3
Passive Recreation	8	13.3

It should be understood that the functions listed were evaluated based on methodology developed by the Adamus technique (Adamus and Sockwell 1983). While this technique has not been regionalized to local conditions in the western United States the method does provides an accurate framework for evaluating wetland functions. The ratings for each function are not based on quantitative data and a limited data set on these functions was available. This study was carried out knowing the limitations of the methodology. However, every wetland was evaluated with exactly the same methodology and perspective. In addition, the data base used to evaluate Boulder wetlands is derived from experience based on hundreds of wetlands studied in the Front Range area by the principal investigator. Thus, the functional ratings are a valid comparitive evaluation of the Boulder wetlands, but they neither provide absolutes, nor do they compare the Boulder wetlands to wetlands occurring in any other region.

TABLE 8. BOULDER WETLANDS PERFORMING FUNCTIONS TO A HIGH DEGREE

UNCTION	WETLAND NUMBERS
Ground Water Recharge	11, 13, 14, 35, 39, 41, 51
Ground Water Discharge	18, 19, 20, 24, 26, 34, 35, 43, 45, 49, 54
Flood Storage	2, 3, 4, 9, 11, 13, 14, 16, 17, 18, 20, 21, 26, 33, 35, 36, 37, 39, 40, 45, 47, 48, 49, 50, 52, 53, 54, 59, 60
Shoreline Anchoring	1, 5, 6, 7, 8, 15, 16, 23, 46, 50, 54
Sediment Trapping	3, 4, 7, 9, 11, 14, 15, 16, 21, 27, 33, 36, 39, 41, 47, 48, 50, 52, 54
Long Term Nutrient Retention	10, 16, 21, 35, 39, 49, 51, 54
Short Term Nutrient Retention	4, 12, 14, 16, 17, 19, 21, 26, 33, 34, 36, 39, 48, 49, 50, 51, 52, 56, 60
Downstream Food Chain Support	1, 5, 7, 8, 12, 13, 26, 39, 46, 54
Within Basin Food Chain Support	4, 7, 8, 12, 13, 26, 39, 46, 54, 56, 60
Fish Habitat	8, 39, 54
Wildlife Habitat	4, 8, 10, 12, 13, 25, 26, 39, 41, 46, 49, 50, 51, 54, 56, 60
Active Recreation	8, 10
Passive Recreation	4, 8, 13, 21, 26, 31, 39, 54

TABLE 9. BOULDER WETLANDS PERFORMING THREE OR MORE FUNCTIONS TO A HIGH DEGREE

1, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 21, 26, 33, 35, 36, 39, 41, 46, 48, 49, 50, 51, 52, 54, 56, 60

TABLE 10. BOULDER WETLANDS NOT PERFORMING ANY FUNCTIONS TO A HIGH DEGREE

22, 28, 29, 30, 32, 38, 42, 44, 55, 57, 58

To more critically evaluate any single wetland in the study area its boundaries must be more accurately delineated and data collected to quantify its functions. This data would be most valuable in determining what type of mitigation, if any, could replace the functions lost due to any filling activities.

Suggestions for Priority Wetlands

In determining which wetlands should be designated as priority wetlands several factors must be kept in mind. First, within the study area no pristine wetlands occur: all have been impacted by human activities. Second, many wetlands have been created by human activities through the redistribution of water on the landscape. Thus, wetland functions that once were performed may not be performed at present and functions that now are being performed may not have been performed in the past. Because human activities have changed so much of the physical landscape and the ecological processes that structure the biological characteristics of the study area, it is not reasonable to limit priority wetlands to those which are naturally occurring remnants of wetlands that occurred in presettlement times.

Based upon the functions that now are important to human society and to the other organisms that are part of the biological community of the study area, a number of wetlands are identified as being most important. Each is listed and discussed below and the order in which they are discussed is not in order of their quality.

* Sombrero Marsh (#4). This wetland is large, natural and provides a number of wetland functions. It is essential that this be a priority wetland.

* South Boulder Creek (#54). This section of the Creek is channelized, but supports very well-developed riparian vegetation and provides a number of functions.

* Four Mile Canyon Creek (#23 and #55). This section of the Creek is heavily over-grazed (#23) but supports riparian forest and with proper management has good potential to be a valuable wetland.

* IBM wetland (#33). This wetland provides an important water quality function treating runoff from the IBM plant.

* South Boulder Creek wetlands (#'s 25 + 26). These wetland areas are among the most diverse and complex in the study area. A number of habitats and communities are present and they appear to be largely natural and performing a number of functions.

* South Boulder Creek floodplain wetlands (#'s 2 + 3). These large wetland areas are the last remnants in good condition of what once were very extensive wetland complexes on this broad floodplain area. Considerable biological diversity occurs.

* Boulder Creek and adjacent wetlands (#'s 8 + 21). Boulder

Creek is the largest waterway in the study area and is channelized throughout its extent. It does support luxuriant, although decadent, riparian forests and provides a number of important wetland functions. Wetland number 21 is the last remnant of what was once a rich and diverse lowland floodplain ecosystem type. It supports a unique flora (for the study area), and once provided an important flood attenuation function. This ecosystem has all but been destroyed by human activities, and this wetland is not a great example of an undisturbed community. A similar, but species poor, community survives at wetland number 9, along Skunk Creek at the CU Research Park, but that wetland will soon be destroyed.

* Twin Lakes (#34 + 41). This pair of reservoirs and the associated wetlands on the north and eastern side are large, have considerable diversity and could provide some important functions. This wetland is chosen mainly for its large size.

* Bear Creek - Boulder Creek confluence wetland (#11). Located along Bear and Boulder Creeks this is one of the last remaining large wetlands in the Boulder Creek area and within the City limits proper. It contains extensive wetlands but is heavily impacted by cattle grazing. This wetland could provide a very important wetland in the middle of the city.

Suggestions for Management of Boulder Wetlands

Direct and indirect human use of wetlands can control the functions wetlands perform. For example, heavy livestock grazing can degrade the understory of a riparian forest so badly that instead of preventing bank erosion, the banks of the riparian forest are eroding. Wetlands that are heavily grazed might also be so saturated with nutrients from livestock excrement that the wetlands will not provide any water quality function for incoming surface waters. The suggestions provided here will help Boulder's wetlands perform high quality functions.

(1) Grazing management. Livestock should not be allowed to graze in riparian corridors and fences must be erected to exclude the animals.

(2) The City should consider the use of controlled releases from Barker and Gross Reservoirs to provide stream flows larger than presently occur to reinitiate the geological processes that cause sediment erosion and deposition in Boulder Creek and South Boulder Creek. Bare sediment is the required seed bed for cottonwood and peach-leaf willow trees. These two species form the majority of tree canopy vegetation in our riparian zones in the Boulder Valley and currently these species are not reproducing because appropriate seed bed is not regularly created. These are two most important trees for providing high recreation value as well as fish and wildlife habitat and the perpetuation of these species should be considered a high priority.

Controlled releases need not be of flood size or endanger property and lives, but they should be large enough to create some erosion and deposition in the channel and banks. The timing of the releases must be be when the trees are releasing their seeds. This stream management technique will need to be tried a few times to determine the proper flow volume to provide the needed seed beds. It need occur only once every few years and this could be years when there is ample snow melt water for filling reservoirs.

(3) At least one abandoned dump is located adjacent to a priority wetland, Sombrero Marsh. This dump is the property of the Boulder Valley School district and currently there is no information available describing whether or not toxic pollutants exist in the dump. The City should encourage the School District to identify possible toxic materials in their dumps and determine the extent of pollution that is escaping from the dump into Sombrero Marsh.

(4) Many streams in the Boulder Valley have eroded their channel so that the creek is much lower than the adjacent banks and floodplain. These streams do not support adjacent riparian vegetation and the value of these streamside habitats is very small compared to banks with diverse riparian vegetation. The City should consider some small projects to enhance stream sides. One area to consider such a project is along South Boulder Creek between South Boulder Road and Baseline Road. These projects should not be expensive, and some of the goals of these projects could be fulfilled if the controlled releases from upstream reservoir described in number 2 above were implemented.

(5) Develop storm water retention/detention facilities in new housing and commercial areas. Adequate storm water management in areas with largely impermeable surfaces will reduce peak flows into wetlands and help protect them from serious erosion.

(6) Develop wetland tertiary water treatment systems for

effluent from the municipal water treatment plant that is too high in nitrogen compounds. Carefully designed wetlands are widely used in many parts of the U.S. for wastewater treatment. The removal of nitrogen compounds from wastewater would enhance water quality downstream and increase the fish habitat function in many portions of Boulder Creek. In addition, these wetlands could be quite large and add significant acreage to the existing Boulder wetlands and could provide functions such as wildlife habitat, especially for water birds.

D. LITERATURE CITED

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APPENDIX 1 : DESCRIPTION OF WETLAND FUNCTIONS

The following is a description of each function listed above, and a description of how each function was evaluated in the field. Also included is a description of how the ranking system for that function was used in the field. These functions and the indicators of whether or not a function is currently or could potentially be performed by a wetland are from "A Method For Wetland Functional Analysis: Volumes I and II" by Paul Adamus and L. Stockwell, published by the Federal Highway Administration (Adamus and Stockwell 1983). This manual has recently been revised and updated and is published by the U.S. Army Corps of Engineers in draft form as the Wetland Evaluation Technique (WET) (Adamus et al. 1987). This latter document has been utilized only slightly because it appeared when this work was already in progress.

Ground Water Recharge. This function involves the movement of surface water or precipitation into the ground water flow system. This is a very difficult function to estimate without actual flow measurements. Physical characteristics of a wetland that appear to be good indicators that ground water recharge is occurring are: porous underlying strata, low sediment trapping efficiency, a dam occurring on the waterway at the wetland location, a densely vegetated basin, a constricted outlet, surface water inflow is greater than surface water outflow, the wetland occurs high in the basin and the wetland is irregularly shaped with high wetland edge to wetland area ratio. A dam site on alluvium would most likely perform this function and would be given a high rating. A moving stream in alluvium would likely have a medium chance of performing this function. A fast moving stream on clay substrate (which is relatively impermeable) would probably not perform this function or perform it very slightly. It would thus get a low ranking.

<u>Ground Water Discharge</u>. This function involves the movement of ground water into surface water (e.g. springs). It is very difficult to estimate whether or not this function is operating unless it is actually seen or measured. Factors which give an indication that this function may be performed include: unconstricted outlet, occurs low in the watershed (low hydrologic head), lithologically diverse (different bedrock types, some of which may be waterbearing), a dam upstream (which would be recharging the ground water just upstream), and the basin is not silty. Many wetlands occur due to ground water discharge. For example wetland number 19 is located on the side of a hill where a large spring occurs. Other examples of wetlands occurring where this function occurs are adjacent to a reservoir (such as wetland number 34 east and north of Twin Lakes in Gunbarrel). An example of a wetland where this function would probably be of low value is wetland number 4, Sombrero Marsh, (a seasonal pond-marsh on fine-textured substrate which is probably isolated from the underlying ground water).

<u>Flood Storage</u>. Flood storage is the process by which peak flows (from runoff, surface flow, ground water interflow and discharge and precipitation) enter a wetland basin and are delayed in their downslope journey. This function includes flood desynchronization. This latter process involves the simultaneous

storage of peak flows in numerous basins within a watershed and their subsequent gradual release in a non-simultaneous, staggered manner. Wetlands which are known to perform this function typically have some of the following characteristics: occur in a large watershed, are along an order 1 or 2 (very small) stream, the size of the wetland is greatly increased in flood times, the basin is large and deep, has a low gradient, sediments are unsaturated (not permanently saturated), has high above-ground and/or below-ground storage, has no outlet and has dense vegetation. A wetland that would most likely perform this function to a high degree would occupy a large and broad, low gradient basin (such as wetland numbers 40 and 9) or a small basin that has a dam on it (for example wetland numbers 52 and 50 in the South Boulder Creek drainage between Valmont Road and Arapahoe Avenue). Wetlands that most likely would not perform this function would be channelized stretches of streams (for example wetland number 5, and 6 along Bear Creek) and the numerous irrigation ditches and canals in the study area.

Shoreline Anchoring. Shoreline anchoring is the stabilization of soil at the water's edge or in shallow water by plant species with fibrous roots and may include long-term accretion of sediment and/or peat. Wetlands that perform this function occur along open water (lakes and streams). Rating this function is done under the assumption that vegetation density and vegetation type and wetland width are important predictors. Wetlands dominated by woody vegetation located along streams in which the stream bottom is largely covered by fibrous roots surely provide this function to a high degree (for example wetland number 54 along South Boulder Creek where the entire channel bottom in many areas is covered with fine and medium sized tree roots. Wetlands that would not perform this function are those that do not have open water.

Sediment Trapping. Sediment trapping is the process by which inorganic particulate matter of any size is retained and deposited within a wetland or its basin. This function may be performed for short-term or long-term. Wetlands which perform this function typically have the following characteristics: no outlet, surface water input exceeds surface water output, dense vegetation, and gently sloping wetland edges. They also have deposits of mud or organics which indicate deposition. Wetlands that perform this function to a high degree occur behind a dam (such as wetland number 16), or occur in a detention pond in urban areas (for example wetland number 14 along Goose Creek at 30th and Mapleton Street). Flood irrigated fields with dense vegetation (such as wetland numbers 2 and 3) probably also perform this function.

Nutrient Retention and Removal. Nutrient retention is the storing of nutrients within the substrate and vegetation of wetlands. Nutrient removal is the purging of nitrogen nutrients by conversion to gas (denitrification) while nutrient retention may involve trapping of runoff-borne nutrients in wetlands before they are carried downstream or to underlying aquifers. Nutrient storage in wetlands may be for long-term (greater than 5 years) or short-term (30 days to 5 years). The most critical nutrients for retention in aquatic ecosystems and removal are nitrogen and phosphorus compounds, although other nutrients may also be important.

Wetlands that perform the nutrient retention or removal function for long-term typically have the following characteristics; high sediment trapping function, organic matter accumulation, no outlet, flooded permanently or semi-permanently (this creates reducing soil conditions which support active populations of denitrification bacteria and also minimizes the oxidation of organics which facilitates peat accumulation). An example of a wetland with long-term nutrient retention functions would be one with highly productive vegetation and highly organic soils that are permanently saturated (for example wetland number 2 which is flood irrigated and grazed pasture land. Other examples would be where sediment retention is high, because many nutrients are received adsorbed to sediments, for example wetland number 16. Many wetlands located in urban and industrial areas would perform this function.

Wetlands that perform this function for short-term typically have the following characteristics: high net biological productivity, sediment retention, non-acid soils, and/or occur in watersheds that are highly developed including urban, industrial, and/or agricultural land uses with eroding soils and/or where fertilizer is applied. An example of a wetland that performs this function for the short-term is one with extremely productive vegetation and permanently saturated soils. Most densely vegetated cattail (Typha) stands would meet this criterion (for example, wetland number 33 located at IBM's facilities). A wetland that would not perform this function would have a very sparse vegetation, little sediment retention, and a steep slope which would keep sediment moving (for example wetland number 6 along Bear Creek which is channelized and has little edge vegetation, or wetland number 37 in Gunbarrel which is largely an alkali flat with little plant production).

Food Chain Support. Food chain support is the direct or indirect use of nutrients, in any form, by animals inhabiting aquatic environments. Food chain support may occur within that wetland basin or downstream. Wetlands that perform downstream food chain support typically have the following characteristics; an outlet, non-acidic waters, not sandy substrate, not permanently flooded, a dense and diverse vegetation with high sustained productivity, not stagnant or with severe scouring, not hypersaline, good flushing flows, and vegetation overhanging the water. An example of a wetland that would provide high quality downstream food chain support would be number 54, South Boulder Creek. Wetlands that perform within-basin food chain support typically have the following characteristics; not stagnant water, highly productive vegetation, irregularly shaped wetland with no outlet, without being entirely shallow and warm water in the summer, and has good mixing of the water. An example of a wetland that would have high within- basin food chain support value would have high diversity of plants and animals.

Habitat. Habitat includes those physical and chemical factors which affect the metabolism, attachment, and predator avoidance of the adult or larval forms of fish, and the food and cover needs of wildlife in the place where they reside. These factors determine the suitability of a given site for an animal species. For this study, habitat was evaluated for fish and for wildlife (birds and mammals) separately. Wetland physical and chemical characteristics that are good for one species is not necessarily good for another species, thus there are few indicators of good habitat for animals in general.

Wetlands that provide good fish habitat typically have the following characteristics; some open water which is not shallow, not acidic, not turbid, no barriers to migration, no oxygen stagnation, no artificial fluctuations, not oligotrophic, not flashy, cool water temperatures with some shade. An example of a wetland that provides these characteristics is wetland number 38 which has cool flowing water, shade, and is not turbid or flashy. Wetlands which do not have open water are all examples of wetlands that do not provide the fish habitat function.

Wetlands that provide good wildlife habitat typically have some of the following characteristics; good edge ratio, islands, high plant diversity, some (but not excessive) alkalinity, sinuous and irregular basin, the basin and wetland are not small, gentle gradient, no artificial water level fluctuations, not moss dominated, pH exceedes 6.0, some open water, not urban or deep water, not channelized or farmed, undisturbed by man, and has good food sources. An example of a wetland that would probably provide high quality wildlife habitat would support a diverse and productive vegetation, have some open water, be fairly undisturbed and provide some isolation from man's activities (such as wetland number 4, Sombrero Marsh).

Active Recreation. Active recreation refers to recreational activities which are water-dependant and can occur either in an incidental or obligatory manner in wetlands. This includes the following activities: swimming, boating, canoeing, kayaking and sailing. Hunting is not water-dependant and is not considered here. Wetlands that provide this function typically have the following characteristics; direct evidence of actual use for a certain activity, convenient public access, mostly unvegetated, some sand, little debris, slow standing water, channels and boat launch facilities, permanently flooded basin, no algal blooms and not weedy. A wetland that would provide these characteristics in the study area would typically be a reservoir (such as Twin Lakes in Gunbarrel, wetland number 41), although certain streams large enough to support boating also would support this function. Most wetlands in the study area however, do not support this function to a high degree because there is limited public access, little or no open water and many large water bodies, such as Boulder Reservoir, are already in public ownership as Parks land and management focuses on active recreation.

<u>Passive Recreation and Heritage Value</u>. This function includes use of wetlands for aesthetic enjoyment, nature study, picnicking, education, scientific research, open space, preservation of rare species, maintenance of the gene pool, protection of archaeologically or geologically unique features, maintenance of historic sites and numerous other activities. Wetlands that perform this function typically have the following characteristics; rare plants, landscape diversity, unity of landscape elements, are a natural area, scarcity of this type of

wetland, freedom from eyesores. Some of the remaining fragments of the Boulder Creek oxbow complex near Foothills Highway (wetland number 21) support rare plants, but do not provide any of the other characteristics of this function. Some of the larger wetland complexes such as Sombrero Marsh (wetland number 4) support many of the features that are characteristic of this function. Many wetlands in the study area do not provide this function to a high degree at present.

APPENDIX 2 : WETLAND COMMUNITIES OF THE BOULDER VALLEY

A perplexing variety of combinations of plant species presents itself to anyone investigating wetlands in the Boulder Valley. Species sort out along gentle and almost imperceptible gradients of depth to water table and drainage, alkalinity, water aeration, disturbance regime (including grazing and artificial water level manipulations) and other environmental factors and typically occupy distinct, and well-defined portions of these gradients. At first glance the vegetation complex at each wetland is difficult to subdivide into communities or ecosystem types. However, with experience it can be seen that a large number of distinct communities occur again and again across the landscape, repeatedly in similar ecological situations.

The primary objective of this study was to map and describe the functions of wetlands in the Boulder Valley. However, a sidelight was to begin to develop a framework for describing the types of wetland communities that occur along the Colorado Front Range. This includes the regions from Pueblo to Fort Collins. From my work on wetlands in this region over the past several years I feel that it is possible and practical to develop a classification of wetland types for this region. However, it should be recognized that this region presents a fantastic array of species and a tremendous variety of different habitats and so the number of different and repeated community types that will be found here will be quite large. It should also be recognized that an understanding of vegetation science is necessary to develop and employ such a classification of ecosystems or communities. Communities are abstract units that are a synthesis of many different stands which have similar floristic composition and occur in sites with similar environmental characteristics. It should not be expected that each stand (example) of a certain community will be identical to other stands. It should also be remembered that many stands will be fragments of a particular community due to disturbance eliminating certain species. Also, mixtures of communities can and do occur where the environmental gradients are gentle.

The following discussion presents a preliminary classification of the wetland vegetation of the Boulder Valley. The 27 communities described here all occur in the study area, however the discussion is based not only on data from Boulder but from hundreds of other wetland communities I have investigated in the region. It will take several more years before a more complete characterization of Front Range wetlands can be produced. Three general types of wetlands occur in the Boulder Valley, using the terminology I have discussed more completely elsewhere (Cooper 1986): communities in permanent shallow water; communities with seasonal or permanent high water tables but without permanent standing water; and communities adjacent to running water. Within each of these categories there are several subcategories based on dominant vegetation form, eg. forested, shrub etc. The system further subdivides communities based on substrate (water, mineral or organic soils) and water chemistry (minerotropic vs. ombotrophic for organic substrates, and fresh vs. saline for mineral substrates). This classification leads to a number of rather distinct ecosystem types, for example, marshes and fens. Both of these ecosystem types have a high water table, do not have permanent standing water and are dominated by herbaceous plants. Fens have organic (peaty) soils while marshes have mineral soils. Several different marsh and fen community types, dominated by different plant species occur due to different conditions created by elevation, temperature, water quality etc.

I. Communities in Permanent Shallow Standing Water

A. Dominated by Floating Plants.

1. _Chara_ sp. community. This community was found in Sombrero Marsh, in alkaline standing water water. It occupies semi-permanently flooded areas. This appears to be the only species occupying this site.

B. Dominated by Rooted Submergent Plants.

2. _Persicaria amphibia_ community. This community occupies water from 1-3 feet in depth, and typically occurs along the fringes of reservoirs. It was found at both Baseline Reservoir and Hayden Lake. The water regime of these water bodies is artificially controlled and in late summer these sites may be dry.

3. _Myriophyllum exalbescens_ community. This community was found only in standing water of wetland number 51 in eastern Boulder. It is most likely found in nutrient rich water.

4. _Potamogeton pectinatus - P. foliosus - Elodea canadensis_ community. This community is composed of one or more species of thin leaved submergent plants and occurs in sites that are permanently flooded and may have slow moving water. The

plants probably can not stand dessication and hence are not emergent. This community occurs in slowly moving deep water (wetland number 25, 13) of streams, large canals, and in some places can be rather weedy, filling canals with plants.

C. Dominated by Rooted Emergent Plants.

5. _Typha latifolia_ - _Lemna minor_. This community is common in potholes with shallow standing water (less than 12 inches). _Lemna_ is a floating aquatic plant that proliferates in high nutrient, slightly alkaline to neutral pH waters. The _Typha_ typically forms an overstory.

6. _Potamogeton gramineus_ - _Sagittaria cuneata_ - _S. latifolia_ - _Alisma plantago-aquatica_ - _Ceratophyllum demersum_ community. This community occupies shallow water (6-24 inches) of ponds and reservoirs and is very common. The community rarely has more than two species present and it seems to be interchangable which species occur.

II. Communities with High Water Table, but Without Permanent Standing Water

A. Herbaceous wetlands with organic soils and mineral rich water supplies (fens).

7. _Carex nebraskensis_ community. This community is very characteristic of open, flats with very shallow (1-6 inches) standing water in the early summer and a water table at or very near the soil surface during the entire growing season. The community is dominated by this one species of sedge, although _Carex lanuginosa, C. hystricina, Juncus balticus_ and other species may also occur. This community may accumulate true peat, like high altitude or northern fens. For the most part the peat

is thin (less than 10 inches) but does indicate long-term nutrient storage.

8. Typha latifolia - T. angustifolia - Scirpus lacustris - S. acutus community. This community is typically dominated by one or two of the species listed above. It forms dense and productive stands, where healthy, and usually leads to the formation of soils rich in organics. This is probably the most common community in the Front Range. Species diversity is usually low due to shading and possibly allelopathic effects (the inhibition of one organism by another via the release of chemicals into the environment). This community may provide many water quality functions that are important in urban, agricultural and industrial areas, including sediment retention, nutrient retention, ground water recharge and flood attenuation.

B. Herbaceous wetlands with mineral soils and fresh water.

9. Scirpus americanus community. This community is very common on loamy to clayey soils with neutral to high pH. It rarely occurs on soils with pH greater than 7.7. This community is common as a fringe around the Typha-Scirpus community (#8 listed above) that occupies wetter sites. The water table is rarely above the soil surface, but always is close to the surface. This community may occupy large areas (wetland numbers 11, 24, 34) where ground water discharge occurs. This community is not easily distinguished and identified as wetland from a distance or from aerial photographs. However, Scirpus americanus is a true and abundant obligate wetland plant species in our region and it occurs only in wetlands.

10. Juncus balticus community. This species dominates communities that occupy seasonally wet meadows. These areas typically have a long grazing history, and this species reportedly is an "increaser", being unpalatable to cattle. The stands may have a variety of associated species.

11. Eleocharis macrostachya - Juncus spp. community. Communities dominated by Eleocharis are found where there is usually some standing water early in the growing season, but they are drier later in the summer. A number of Juncus species may occur, including J. balticus, J. interior, J. dudleyi and J. longistylis. These stands are usually small and are found in complexes with stands dominated by Typha, Scirpus and other wetland plant species.

12. Agrostis gigantea community. Redtop dominates communities found in irrigated hay meadows. It usually is the dominant plant species but occurs with Phleum pratense, Dactylis glomerata, Festuca pratensis and other tall grasses which are all native to Eurasia and have been widely introduced into pastures in our area. A number of forbs including Trifolium spp. are typically found as well.

13. Poa pratensis - Trifolium pratense community. This community occurs in irrigated or naturally wet pastures that are either intensively grazed or mowed. These areas are usually marginally wetlands because the soils are usually transitional between hydric and non-hydric, the plant community is typically dominated by species that are ranked as facultative or facultative upland by the National Wetlands Inventory. However, the soils are usually saturated long enough during the growing

season to call them wetlands.

14. _Spartina pectinata_ community. _Spartina_ typically thoroughly dominates this community, although it is common to find a number of other common species as well. Prairie cordgrass is typically found at springs, on the margins of sloughs and in some areas may form an organic soil. The stands are usually very productive. This community probably was very common along river floodplains, on the edges of ox-bows and sloughs and in floodplain margins in presettlement times. This community now, however is very restricted in its occurrence.

15. _Phalaris arundinacea - Circium arvense_ community. This community typically occurs in disturbed wetland sites where the water table has been artificially lowered by diverting a stream, streams downcutting into their floodplain or other reasons. These species are weedy in nature and are very rapid and powerful colonizers of damp, highly organic substrates.

16. _Persicaria lapathifolia - Persicaria maculata_ - grass community. This community occurs in wet spots in irrigated hay meadows dominated by the _Agrostis gigantea_, or other grass-dominated community. It is very easily identified due to the broad leaf nature of the smartweeds (_Persicaria_).

C. Herbaceous wetlands with mineral soils and alkaline water source.

17. _Scirpus paludosus_ community. This is an alkaline marsh community that occurs in shallow seasonally standing water, or where a high water table, near the soil surface occurs. Soils always are alkaline and there is usually very low species diveristy. It is also a very uncommon community, and in the

Boulder Valley the only large stand is at Sombrero Marsh.

18. Puccinellia distans - Spergularia media community. This community is characteristic of extremely alkaline wetlands that have a seasonally or permanently high water table. It usually occurs as an ecotone between Scirpus americanus or Scirpus paludosus and upland communities. The capillary rise of alkaline water through heavy soils results in a net accumulation of solutes at the soil surface. Few species can germinate and become established in this environment. This is most likely the most salt tolerant wetland community occurring in our area.

19. Distichlis spicata - Iva axillaris community. This community occurs in slightly drier sites than those occupied by the Puccinellia distans - Spergularia media community. Some stands are not regulatory wetlands. They are characterized by Distichlis and may not have other species present, except Hordeum jubatum which is ubiquitous.

20. Juncus compressus communities. This species dominates communities that are not as alkaline as the latter two communities, but that are none-the-less alkaline. They typically fringe wetland communities dominated by Scirpus americanus, but are rather uncommon in the area.

21. Atriplex spp. communities. A community found on seasonally wet sites on the edges of reservoirs where there is a distinct summer drawdown is typically characterized by species of Atriplex. The species present are usually annuals, weedy and tolerate of highly alkaline soils and water.

III. Communities Adjacent to Running Water

A. Herbaceous wetlands.

22. Glyceria maxima - Anemone canadensis community. This community occurs along ditches, small streams and slough where there is usually some moving water during portions of the growing season. The communities may be quite species rich and lush. Anemone may form a complete ground cover as it does in parts of wetlands number 1, 42, and 6 in this study. A taller overstory with grasses and other species usually also occurs.

23. Leersia oryzoides - Bidens cernua community. This community occupies ditches and sloughs along the major drainage systems in the area. It is lush and species rich and supports many species that are rare in the Boulder valley, including: Lobelia siphilitica and Agalinus tenuiflora. It probably represents a community type and flora that was abundant along the sloughs of Boulder Creek in presettlement condition. This type is nearly lost from the Valley.

24. Impatiens capensis - Stellaria graminea community. This distinctive community is found along irrigation ditches of the South Boulder Creek system. It is distinctive because it lines the ditches with lush and flowery plants. Both of these species are not native.

25. Nasturtium officionale - Bacopa rotundifolia - Berula erecta community. This community is limited to springs and rapidly moving water that is well-oxygenated. This community is very distinctive and indicative of these conditions. These species usually choke the channel with lush foliage and probably have enormous nutrient absorption capacity, thus providing a

major water quality function.

B. Shrub wetlands.

26. Salix exigua community. The sandbar willow community is distinctive and the primary shrub-dominated community found along river wetland systems in the study area. The stems of this willow are reddish-purple and very flexible. Their flexibility allows them to colonize stream channels and floodplains and bend flat onto the soil surface during flooding. Thus they are not eroded, do not accumulate much debris, yet stabilize the channel and floodplains. This community provides vital shoreline anchoring and sediment trapping functions. It also provides food chain support and habitat functions because of its use by insects, birds, deer and other animals.

C. Forested Wetlands.

27. Populus sargentii - Salix anygdaloides - Bromopsis inermis community. This community is dominant along the major streams and irrigation canals in the study area. It is the only forested wetland community in the study area. It may have not only plains cottonwood and peach leaf willow, but also supports Fraxinus pennsylvanica, Acer negundo, Alnus tenuifolia, Gleditsia tricanthos, Ulmus americana and other trees and large shrubs. It this provides major wildlife habitat, food chain, shoreline anchoring, nutrient retention and removal functions. It also provides shade in streams that creates good fish habitat. These forested waterways also are among the most important passive recreation sites in the area and many are preserved for that function.

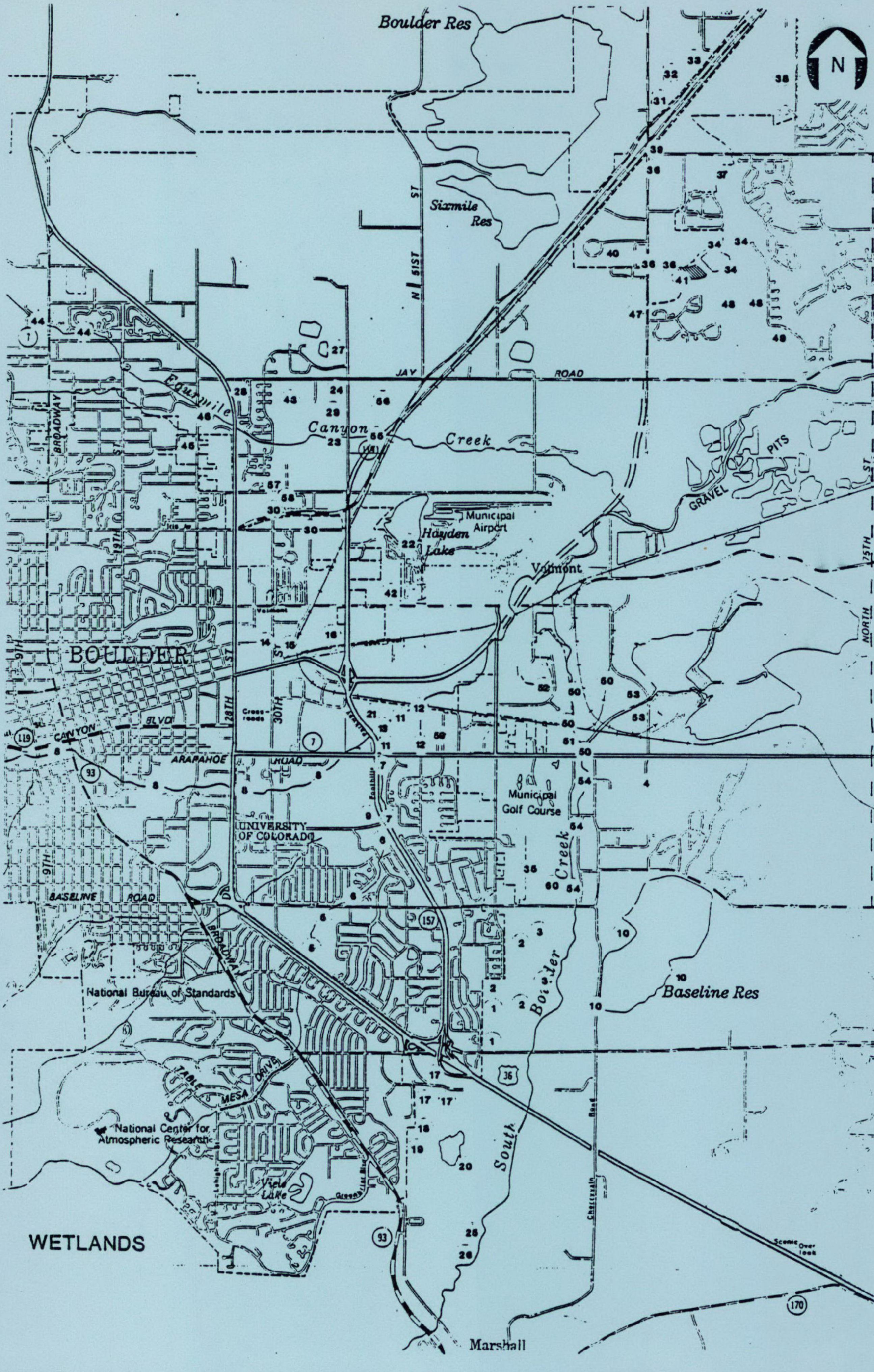
APPENDIX 3. PLANT SPECIES OCCURRING IN BOULDER WETLANDS AND THEIR STATUS ACCORDING TO THE NATIONAL WETLANDS INVENTORY AND THEIR STATUS IN THE STUDY AREA

Scientific Name	Common Name	NWI Rank	Boulder
Acer negundo	box elder	fac	facu
Agalinus tenuifolia	agalinus	facw	facw+/obl
Agropyron repens	quack grass	fac	fac
Agropyron smithii	western wheatgrass	facu	facu-
Agrostis gigantea	redtop	facw	facw
Alisma plantago-aquatica	plantain	obl	obl
Alnus tenuifolia	narrow-leaf alder	no	facw
Alopecurus aequalis	foxtail	obl	obl
Ambrosia artemisiifolia	ragweed	facu	facu
Anemone canadensis	anemone	facw	facw
Apocynum sibiricum	dogbank	fac	facu
Arctium minus	burdock	upl	facu
Asclepias incarnata	marsh milkweed	obl	obl
Aster ericoides	aster	facu	facu-
Aster falcatus	aster	fac	facu-
Aster hesperius	aster	obl	facw+/obl
Aster laevis	aster	upl	facu
Bacopa rotundifolia	water-hyssop	obl	obl
Berula erecta	berula	obl	obl
Bidens cernua	nodding bur-marigold	obl	obl
Bidens frondosa	beggars tick	facw	obl
Bromopsis inermis	smooth brome	upl	upl
Calamagrostis canadensis	canada reed grass	obl	obl
Carex brevior	sedge	fac	fac
Carex hystricina	sedge	obl	obl
Carex lanuginosa	sedge	obl	obl
Carex nebraskensis	sedge	obl	obl
Carex praegracilis	sedge	facw	facw
Ceratophyllum demersum	hornwort	obl	obl
Cichorium intybus	chicory	upl	upl
Cirsium arvense	canada thistle	facu	fac
Cyperus inflexus	galingale	obl	obl
Dactylis glomerata	orchard grass	facu	facu
Dipsacus sylvestris	teasle		fac
Distichlis spicata	saltgrass	facw	fac
Echinochloa crus-galli	barnyard grass	facw	fac
Eleagnus angustifolia	russian olive	fac	fac-
Eleocharis coloradoensis	spike rush	obl	obl
Eleocharis macrostachya	spike rush	obl	obl
Elodea canadensis	elodea	obl	obl
Elymus canadensis	canada wildrye	facu	facu
Epilobium adenocaulon	willow-herb	obl	obl
Epilobium leptophyllum	willow-herb	facw+	facw/obl
Festuca pratensis	meadow fescue	fac	fac
Fraxinus pensylvanicus	green ash	facw	fac
Gleditsia tricanthos	honey locust	fac	facu
Glyceria maxima	manna grass	obl	obl
Helenium autumnale	helenium	facw	facw

Helianthus nuttalli	nuttals sunflower	fac	fac-
Hordeum jubatum	foxtail barley	facw	facw-
Impatiens capensis	impatiens	facw	facw
Iris missouriensis	iris	obl	facw+
Iva axillaris ?	marsh elder	fac	fac
Juncus alpinus	rush	obl	obl
Juncus arcticus	rush	obl	facw
Juncus articulatus	rush	obl	obl
Juncus bufonis	rush	obl	obl
Juncus compressus	rush	no	obl
Juncus dudleyi	rush	fac	facw
Juncus gerardii	rush	no	obl
Juncus interior	rush	fac	fac/facw
Juncus longistylis	rush	facw	facw
Juncus nodosus	rush	obl	obl
Juncus saximontanus	rush	facw	facw
Juncus tracyi	rush	no	facw/obl
Juncus torreyi	rush	facw	facw/obl
Leersia oryzoides	rice cutgrass	obl	obl
Lemna minor	duckweed	obl	obl
Lobelia siphilitica	lobelia	obl	obl
Lolium perenne	ryegrass	facu	facu
Lycopus americanus	water horehound	obl	obl
Lycopus asper	water horehound	obl	obl
Lotus tenuis	lotus	upl	facu
Medicago sativa	alfalfa	upl	facu
Melilotus officionalis	sweet clover	facu	facu
Mentha arvense	mint	facw	facw+
Monarda fistulosa	pink bergamot	facu-	facu-
Muhlenbergia asperifolia	alkali muhly	facw	facw
Myriophyllum exalbescens	water milfoil	obl	obl
Nasturtium officionale	water-cress	obl	obl
Oenothera coronopifolia	evening primrose	upl	facu-
Oligoneuron rigidum	stiff goldenrod	facu	facu-
Panicum virgatum	switchgrass	fac	fac/facu
Pastinacea sativa	parsnip	upl	upl
Persicaria amphibia	smartweed	obl	obl
Persicaria coccinea	smartweed	obl	obl
Persicaria hydropiper	smartweed	obl	obl
Persicaria lapathifolia	smartweed	obl	obl
Persicaria maculata	smartweed	obl	obl
Persicaria pensylvanica	smartweed	facw+	facw+
Phalaris arundinacea	reed canary grass	facw+	facw+/obl
Phleum pratense	timothy	facu	fac/facu
Plantago lanceolata	english plantain	fac	fac
Plantago major	common plantain	fac	fac
Poa compressa	canada bluegrass	facu	facu
Poa pratensis	kentucky bluegrass	facu	fac
Polypogon monosepliensis	rabbits foot grass	obl	obl
Populus sargentii	plains cottonwood	fac	fac
Populus Xacuminata	cottonwood	fac	fac
Potemogeton foliosus	pondweed	obl	obl
Potamogeton gramineus	pondweed	obl	obl
Potamogeton pectinatus	pondweed	obl	obl
Prunus americanus	american plum	upl	upl

Puccinellia airoides	alkali grass	obl	obl
Puccinellia distans	alkali grass	obl	obl
Ranunculus cymbalaria	shore buttercup	obl	obl
Ranunculus macounii	buttercup	obl	obl
Ribes aureum	golden current	facw	facw
Rorippa palustris	cress	obl	obl
Rumex crispus	dock	facw	facw
Rumex salicifolius	willow dock	obl	facw/obl
Sagittaria cuneata	arrowroot	obl	obl
Sagittaria latifolia	arrowroot	obl	obl
Salix amygdaloides	peach leaf willow	facw	facw
Salix exigua	sandbar willow	obl	facw/obl
Scirpus acutus	softstem bulrush	obl	obl
Scirpus americanus	three square	obl	obl
Scirpus lacustris	hardstem bulrush	obl	obl
Scirpus paludosus	alkali bulrush	obl	obl
Scirpus pallidus	bulrush	obl	obl
Scirpus microcarpus	bulrush	obl	obl
Sisyrinchium montanum	blue eyed grass	fac	fac
Solidago gigantea	golden rod	facw	facw
Sonchus oleraceus	cow thistle	facu	facu
Sorgastrum avenaceum	yellow indian grass	facu	facu
Spartina pectinata	prairie cordgrass	facw	facw/obl
Spergularia media	sand spurry	no	facw
Spiranthes diluvialis	orchid	no	obl
Sporobolus airoides	alkali sacaton	fac	fac
Sporobolus asper	big dropseed	facu	facu
Stachys palustris	hedge nettle	obl	obl
Stellaria graminea	chickweed	no	facw
Thermopsis divaricarpa	golden banner	upl	upl
Thlaspi arvensis	pennycrest	upl	facu-
Trifolium pratense	red clover	facu	facu
Trifolium repens	white clover	facu	facu
Typha angustifolia	narrow leaf cattail	obl	obl
Typha latifolia	broad leaf cattail	obl	obl
Ulmus americanus	american elm	fac	facu
Verbena hastata	blue vervain	facw	facw/obl
Veronica anagallis-aquatica	speedwell	obl	obl

Abbreviations:
upl : less than 1% of this species´ occurrence is in wetlands
facu : 1-33% of this species´ occurrence is in wetlands
fac : 33-66% of this species´ occurrence is in wetlands
facw : 66-99% of this species´ occurrence is in wetlands
obl : greater than 99% of this species´ occurrence is in wetlands
no : not listed on the National Wetlands Inventory wetlands plant list for Region 5, the Central Great Plains
\+ : on the higher end of the range
\- : on the lower end of the range
? : I am unsure what ranking this species should receive
/ : this species could be either of the two ranks, but I am unsure which rank is more accurate at present


Boulder Res
N
Sixmile Res
N 51ST ST
JAY ROAD
Canyon Creek
GRAVEL PITS
Municipal Airport
Hayden Lake
Valmont
BOULDER
BROADWAY
9TH
19TH ST
28TH ST
30TH ST
NORTH 75TH ST.
CANYON BLVD
ARAPAHOE ROAD
Municipal Golf Course
UNIVERSITY OF COLORADO
South Boulder Creek
BASELINE ROAD
Baseline Res
National Bureau of Standards
TABLE MESA DRIVE
National Center for Atmospheric Research
Viele Lake
Marshall
Scenic Over look

WETLANDS