ANALYSIS OF IRRIGATION AND NATURAL RESOURCES ON THE AXELSON/JOHNSON MANAGEMENT AREA

Prepared For:

The City of Boulder
Open Space Department

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ERO
RESOURCES CORPORATION

SUMMARY OF FINDINGS AND CONCLUSIONS

Agriculture

- Of the 892 acres within the Axelson Johnson Management Area, a range of 480 to 550 acres have been historically irrigated in one season. In 1993, 516 acres of the Management Area were irrigated. Overall, 567 acres are considered irrigable.

- The available water supply for the Management Area (owned and leased water rights) is 1,391 acre-feet, enough water to sufficiently irrigate about 500 acres of grass/alfalfa hay fields. Currently, deficit irrigation is occurring on all or some fields and only about 445 acres can be sufficiently irrigated with existing system conditions.

- The lessee appears to be using the full water right allotment.

- Agriculture appears to be a viable enterprise for the Management Area for the foreseeable future. A variety of practical and economic considerations limit potential agricultural alternatives to grass hay, alfalfa hay, grazing and small grains.

- Total net income to the lessee with the current cropping patterns and irrigation system is estimated at $72,244 under intensive management. Improvements to the cropping and irrigation system could increase the estimated net annual income by about $16,000, some of which could be captured by OSD through higher lease revenues.

- Total annual costs to OSD for the Management Area are estimated at $512,000. These costs will decline as properties are paid off.

- The lease rate for the Management Area appears to be low.

- The economic template established in this report can be used by OSD for further consideration of alternatives on this and other properties. However, new variables and assumptions should be clearly defined.

Natural Resources and Recreation

- Except for use from adjoining residences, the Management Area is a relatively unknown and unused portion of the City of Boulder's Open Space portfolio from the perspective of public access and recreation.

- There is increasing pressure by the public for access to and use of the Management Area.

- The Management Area has recently supported a substantial prairie dog population and was part of a larger complex of surrounding lands that supported prairie dogs. A recent plague epizootic has reduced prairie dog numbers within the Management Area.

- The Management Area supports a wide diversity of wildlife and is rich in predators.

- Extensive wetlands occur in the southern half of the Axelson property, many of which are probably supported, at least in part, by the extensive and somewhat inefficient irrigation system.

Recommendations

- Make physical improvements to the irrigation system for better utilization and control of water, including the installation of measuring devices at select locations. More efficient use of water means better yields and less labor, but may also affect wetland areas.

- Continue implementation of the grass/alfalfa mix program. This alternative makes the most sense economically.

- Re-evaluate the lease structure and rate. OSD should be able to recapture expenses for capital improvements and property management.

- Integrate and formalize public access and trails around the agricultural area. Fewer areas than historically irrigated are recommended. This will open up more land that can be dedicated to recreation and wildlife habitat, though retirement of irrigated land may require revegetation, weed control and other maintenance expenses.

- Further evaluate irrigation system improvements proposed for implementation to determine potential adverse effects to natural resources. An evaluation of downstream water users should be completed for integration into the system improvement impacts report.

- Mitigate unavoidable adverse impacts to important wildlife habitat associated with irrigation system improvements.

- Encourage public access around the perimeter of and minimize the numerous private access points to the Management Area.

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ANALYSIS OF IRRIGATION AND NATURAL RESOURCES ON THE AXELSON/JOHNSON MANAGEMENT AREA

INTRODUCTION

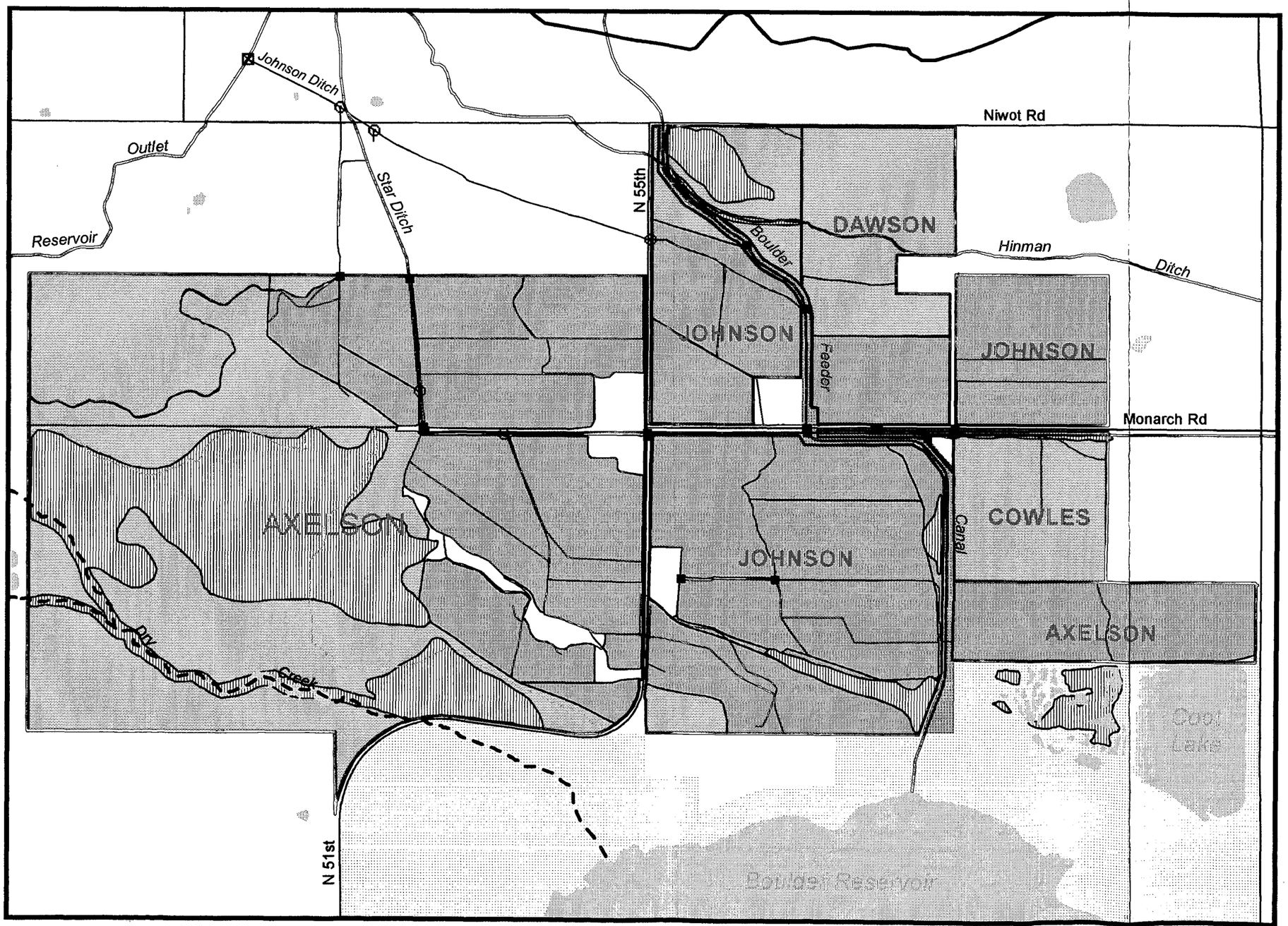
The City of Boulder Open Space Department (OSD) manages several tracts of city open space north and west of Boulder Reservoir. The lands are collectively known as the Axelson/Johnson Management Area (Management Area) and include significant acreage under irrigation (Figure 1). Other current land uses include prairie dog preserves, rangeland, wildlife habitat and passive recreation at moderate but increasing use.

OSD has expressed a desire to manage this area as a single cohesive unit. Conceptually, this area and several others to the west (e.g., Beech and Boulder Valley Ranch) might be characterized as a larger management unit consisting primarily of irrigated agriculture and rangeland, with integrated recreation and wildlife habitat uses. Urban and suburban developments have progressed into this area and there is increasing pressure to provide additional access to open space. The challenge facing OSD is to properly manage this area with contrasting land uses while minimizing management and use conflicts.

This report presents the findings and recommendations from a reconnaissance investigation of the Management Area. The purpose of the investigation was to evaluate the current land use and resources of the Management Area. Particular emphasis was placed on irrigated agriculture in the context of long-term lease agreements. Sections of the report are devoted to current natural and agricultural resources, analysis of the irrigation system, economic viability, public access, specific issues of concern, and suggested alternatives for management. This work represents a joint effort between the consultant and OSD staff assigned to this project.

Figure 1. 1994 land uses, Axelson/Johnson Management Area.

Figure 1. 1994 Land Use, Axelson/Johnson Management Area



Irrigation Structures
- concrete diversion
- headgate/weir
- pipe/culvert
- O.S. Boundary
- Road

Hydrology
- Creek
- Intermittent Creek
- Ditch
- Lateral
- Lateral - discontinued use
- Lake
- Wetland

Fields
- rangeland
- irrigated

- City Parks
- Other Public Land

N
W E
S

500 0 500 1000 Feet

Map produced by M. Smith and the City of Boulder Open Space G.I.S. Lab, April 28, 1995. Graphical representation only, not for legal purposes.

WATER AND AGRICULTURAL RESOURCES ASSESSMENT

One of the primary concerns of OSD is the utilization and protection of its water rights on the Management Area. This section describes the present condition of the irrigation delivery system, management decisions in producing crops, and a description of the status of OSD's water rights attached to the Management Area. An assessment of irrigated agriculture in terms of economic viability is contained in the next section.

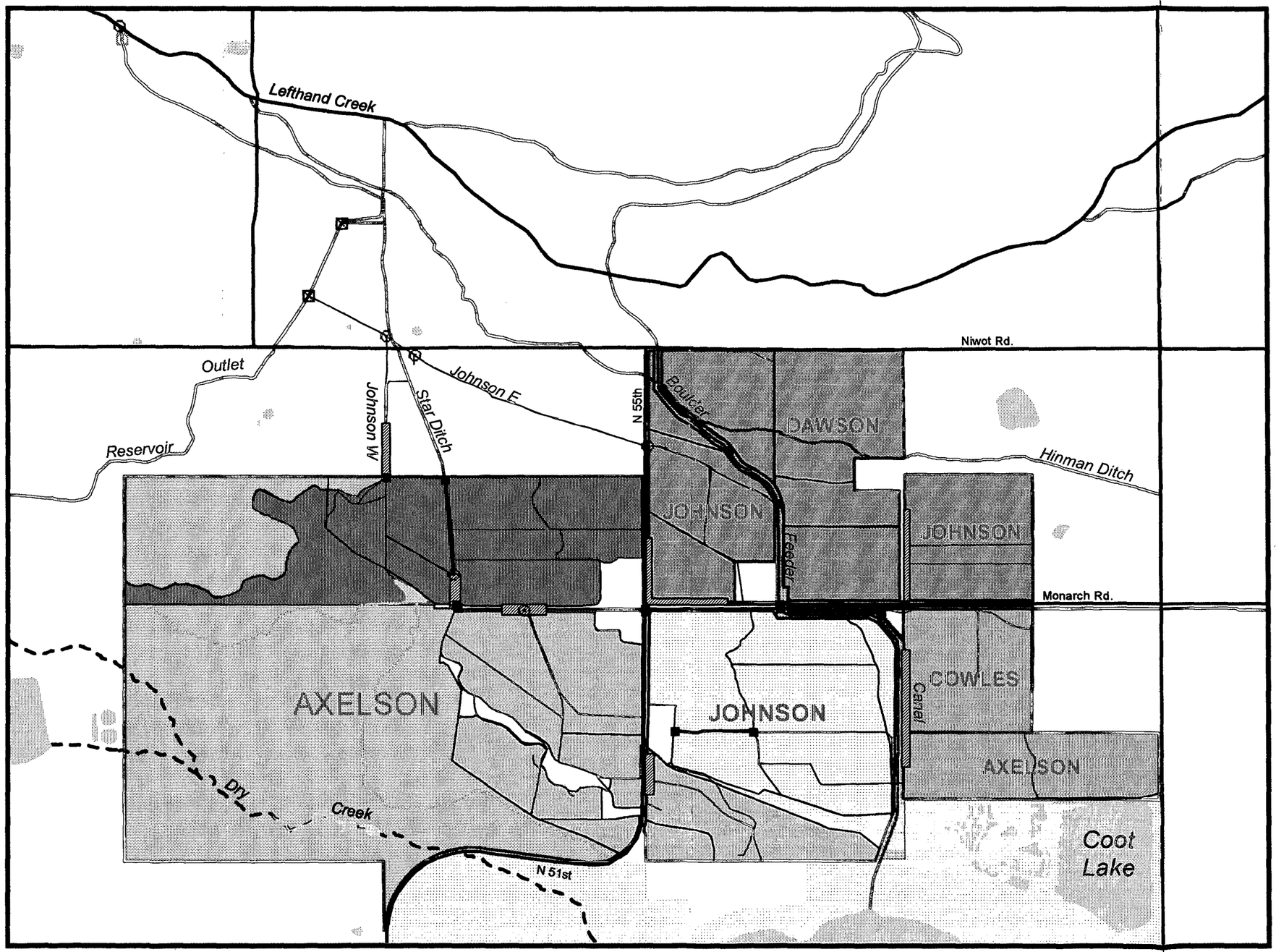
Irrigation System

Two ditches serve the Management Area: the Johnson Ditch and the Star Ditch. Each ditch system is comprised of several primary laterals that serve discrete areas of the Management Area. Of the 892 acres within the Management Area, anywhere from 480 to 550 acres have been irrigated in recent years. The water supply originates in Left Hand Creek where flows are diverted to fill Left Hand Valley Reservoir. The Reservoir Outlet or Feeder Canal supplies water for diversion by both the Star and Johnson ditches, although the Star can also divert directly from the creek. Field application of water is accomplished by flood irrigation with some control by corrugations. Furrows are used when corn is grown. The irrigation system is shown in Figure 2, while the field layout and service area by ditch lateral are shown in Figure 3.

The Johnson Ditch can only divert from the Reservoir Outlet Canal. The lessee typically diverts a full ditch capacity (6 cfs). Water is diverted at a concrete structure that has a 2-foot weir along the Johnson Ditch for measuring flows. Other than this structure, there are no measuring devices on the system. About 900 feet down ditch, the Johnson splits into two main laterals. Both laterals are earthen, unlined ditches. The split is accomplished within a concrete division box with a single-flap gate. This gate simply allows a percentage of the flow to go in either lateral; if the flow into the west lateral is Q percent, then the flow into the east lateral must be 100 minus Q percent.

Figure 2. Irrigation system, fields and facilities, Axelson/Johnson Management Area.

Figure 2. Irrigation System, Fields and Facilities - Axelson/Johnson Management Area



Irrigation Structures
- concrete diversion
- headgate/weir
- pipe/culvert
- weir
- Areas of high seepage losses
- O.S. Boundary
- Road
- Lake

Hydrology
- Creek
- Intermittent Creek
- Ditch
- Lateral
- Lateral - discontinued use
- Star ditch, 1st lateral
- Star ditch, 2nd lateral
- Star Ditch, 3rd lateral
- Johnson ditch, East lateral
- Johnson ditch, West lateral
- Not Irrigable

- City Parks
- Other Public Land

N
W E
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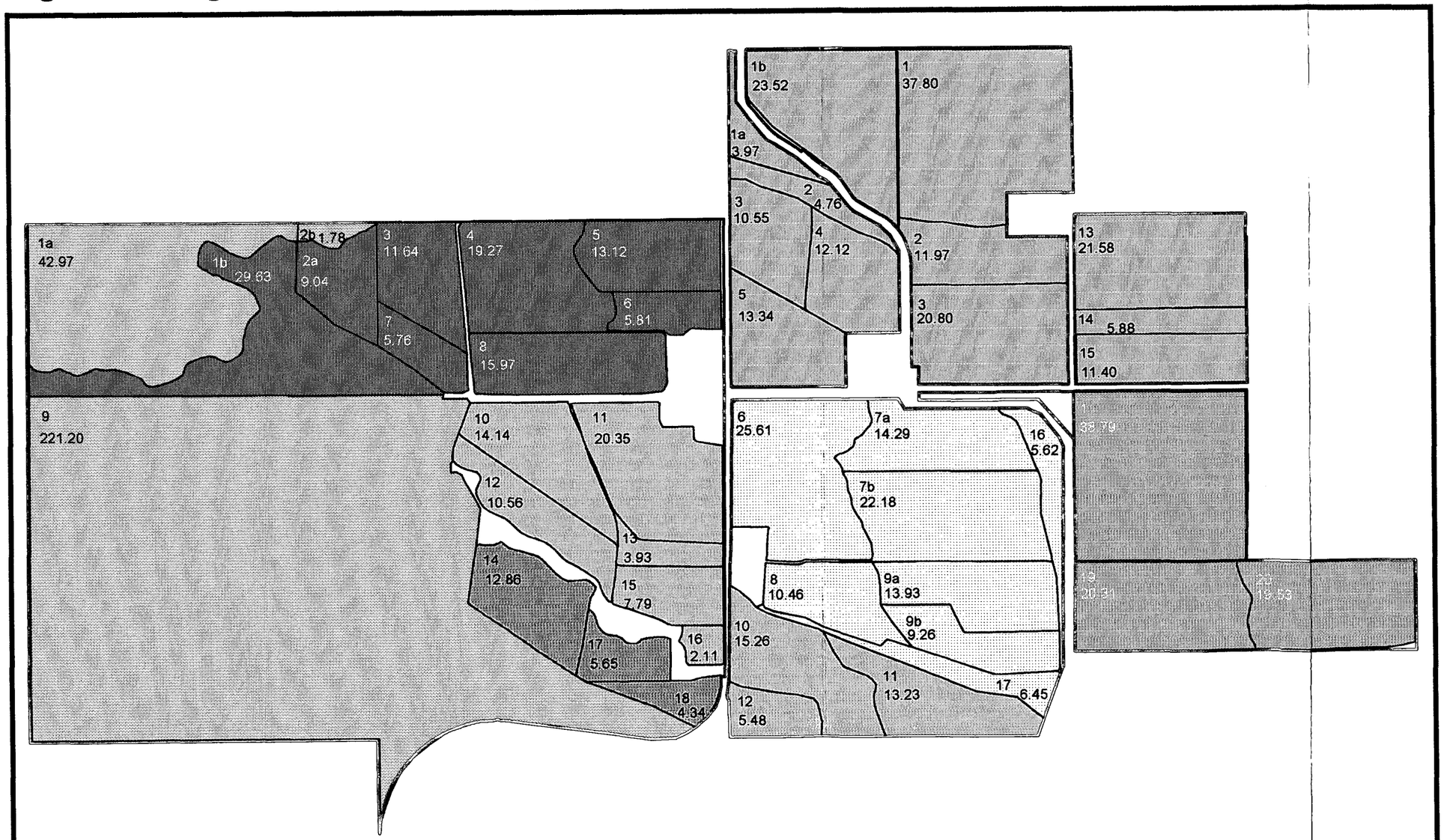
500 0 500 1000 Feet

Map produced by M. Smith and the City of Boulder Open Space G.I.S. Lab, April 28, 1995. Graphical representation only, not for legal purposes.

Figure 3. Irrigation service areas by ditch and field acreage, Axelson/Johnson Management Area.

Figure 3. Irrigation Service Area by Ditch and Field Acreage - Axelson/Johnson Management Area



Map produced by M. Smith and the City of Boulder Open Space G.I.S. Lab, April 27, 1995. Graphical representation only, not for legal purposes.

The west lateral can serve about 110 irrigable acres within the Axelson property. The west lateral splits twice and is piped over the Star Ditch at one point. At each of these junctions, seepage losses are high due to multiple damming and/or earth moving that must be done to direct the flow of water. Coincidently, erosion at these points is a problem. Heavy losses due to seepage and phreatophytes are incurred along the portion of the lateral that follows the Star Ditch; the flow is fast along field #4, but slows considerably along field #8 due to these losses (see Figures 2 and 3). Another lateral terminates at a pond that is used for stockwatering. Axelson field #9 is traversed by two ditches no longer in use. The soils in this area are best suited to unirrigated range.

The east lateral crosses under 55th Street and can provide water for irrigation of about 178 acres within the Johnson and Dawson properties. A concrete division box splits the flow in three directions. The north branch serves acreage at the north end of the Johnson and Dawson properties, but water control is difficult here because of low hydraulic head and ditch seepage. The middle branch bisects the Johnson property and is piped over the Boulder Feeder Canal. Transmission losses along this lateral are not significant. The south lateral irrigates land on both Johnson properties, but loses a significant amount of water along the way. The greatest losses begin 800 feet below the division box and end close to the Johnson residence. The ditch in this section cuts into gravelly subsoils and the effects of high seepage are indicated by heavy sedge growth in the adjacent field. The lateral continues east past the Dawson property and, if any water is left, can irrigate 39 acres. Transmission losses along the way are severe; the lessee estimates that only one-sixth of the flow originally diverted will reach these fields.

The Star Ditch can divert water either from the Reservoir Outlet Canal or directly from Left Hand Creek. According to the lessee, water is diverted about 90 percent of the time from the canal; diversions from the creek are generally limited to the early spring and late fall. There is no diversion structure in the creek; diversions are accomplished by piling sand bags in the creek to move water into the ditch. A weir just down ditch

from this point measures the flow. Water moves down the unlined earth ditch about one mile before it reaches the irrigation service area. The diversion point from the feeder ditch is located about 850 feet northeast of the Johnson Ditch take-out point. Water is diverted into the Star Ditch utilizing a concrete structure with a 2-foot weir. The Star has three primary laterals within the Management Area, as well as serving numerous downstream users including IBM property. The lessee typically diverts a full ditch capacity (9 cfs).

The first lateral splits off the Star within the Johnson Ditch service area, and serves about 116 acres on the Axelson and Johnson properties. The take-off point is another concrete box with a single-flap gate. In the vicinity of this diversion, there are numerous supply laterals and parallel field ditches. Losses due to seepage and phreatophytes are high, and ditch water moves slowly. This lateral splits again about 400 feet below the box, and yet again about 800 feet further east. Water is applied to fields by damming field ditches or moving earth across the laterals. Water loss and erosion are significant at each of these junctions. Numerous waste ditches collect runoff and transport it back into the primary lateral after it crosses beneath 55th Street. This tail water is reused on the last field served by the first Star lateral (field #11). The end of this lateral terminates in field #12 but visually carries little water because of transmission losses and topographic problems.

The second lateral of the Star ditch splits off about 1,000 feet down ditch from the first lateral. It delivers water to 108 acres on the Johnson property. Once the lateral crosses beneath 55th Street, it splits into two branches. Transmission losses are not as great on this lateral as the first, and the irrigated fields are much larger as well. Any waste water collected is dumped into the Boulder Feeder Canal. There are generally few problems on this lateral.

The third lateral splits away from the Star Ditch about 3,500 feet east of the second lateral, and 50 feet east of the division box for the IBM Ditch. Just below the concrete division box, this lateral splits again. The south ditch delivers water to the Axelson and Cowles properties, about 79 acres. However, ditch losses are severe (about 50 percent) along this route due to seepage through the gravelly subsoil. Tailwater, if present, can be collected and returned to the Boulder Feeder Canal.

Cropping System

The Management Area consists of about 892 acres, of which 567 acres are considered irrigable. Irrigable acreage is defined here as the amount of land that has no restrictions to crop growth due to soils or topography and occurs under the existing irrigation system. Of the remaining 325 acres, 289 acres have shallow soils, slopes too steep to irrigate, or occur above existing ditches. Some of these lands have been irrigated in the past or are currently wetlands. The remaining 36 acres include buildings, roads and irrigation facilities.

Crop production is best suited to irrigated grass/alfalfa hay because of surface cobbles on many of the soils within the property. The historical rotation of crops has consisted of alfalfa, grass hay, field corn and small grains, with some acreage in irrigated pasture. Generally soils not rated as suitable for irrigation are put into pasture. Reintroduction of native grasses on irrigated land has yet to be shown as a viable alternative to the present cropping system.

The suitability of individual Management Area fields is presented in Appendix A. The ratings consider soil depth, texture, slope and chemical characteristics; irrigation system constraints in delivering water to the field; and productivity of the soil. This rating should help OSD in deciding how to manage land for irrigation.

Management

The lessee currently irrigates alfalfa once before each of three cuts, grass hay twice before each of two cuts, and corn four times before harvest. Except at the time of cutting, there are very few times that irrigation headgates are shut; the lessee is generally always irrigating somewhere on the property between May 1 and mid-September.

A rotation preferred by the lessee is 10 years in grass/alfalfa mixture followed by small grains, corn or both. Row crops such as corn are least favorable due to greater management requirements (i.e., fertilizer, pesticides, herbicides and tillage) and the cobbly soils. Inorganic fertilizers are applied based on recommendations from soil tests. Herbicides may be applied to control weeds when corn is grown. Pesticides may be used on alfalfa to control alfalfa weevils before the first cutting each year. Generally the lessee can do without insect controls on corn unless there is a large population of spider mites or corn borer beetles.

Water Rights

The following information on OSD's water rights appurtenant to the Management Area was extracted from the report "Axelson/Johnson Management Area Water Supply Study" (February 1995) prepared by Elizabeth Payton of Hydrosphere. The reader is referred to the water supply report for details concerning water right specifics not covered in this report.

OSD owns 879 shares of Left Hand Ditch Company (LHDC) water rights, which are currently used for irrigation in the Management Area. Seasonally, OSD rents an additional 374 shares of LHDC water from City of Boulder Utilities Department (Utilities). This is not a long-term agreement, but a year-to-year contract. The yield per share has decreased over the years mainly due to tighter water administration. Yield is defined as total water delivered divided by the number of shares, and includes "free" water, storage and creek flow. The current yield (1990-1994 average) is 1.11 acre-

feet/share. This brings the present available water supply for the Management Area to 1,391 acre-feet. The OSD shares alone provide only 976 acre-feet.

There are a variety of administration and operation issues that may impact the water supply from year to year. These include water right exchanges, Colorado-Big Thompson (CBT) water as a supplemental supply, "free" water in the creek and replacement water (in agreement with the Northern Colorado Water Conservancy District). The effect of any of these arrangements on the amount of water available to LHDC shareholders, including OSD, is contingent on both Front Range and central Rockies annual water supplies and market forces.

All LHDC shares must be used within the service area historical boundaries. The water right service area includes all of the Management Area and the user is allowed to move the water around the area as long as it is put to beneficial use. This allows flexibility on deciding how much or which fields to irrigate within the Management Area. The lessee reports that he uses close to the water right allotment and believes he gets all that the right allows. This is supported by annual LHDC water account tabulations. He indicated that the ditch headgates are generally wide open through the period May 1 to September 15, except for periods of harvest. Weirs in place at the turnouts for the Star and Johnson ditches may or may not be in proper condition for water measurement. Regardless, no measurement data appears to have been collected in the past. The amount of water ordered by the lessees (and listed on the LHDC water account) is the only approximation of total diversions.

As discussed earlier, two ditches deliver LHDC water to the management Area. The Star Ditch is incorporated and collects assessment for maintenance and insurance. Boulder has 4.83 shares in the Star Ditch Company. The Johnson Ditch is unincorporated and traditionally has been maintained cooperatively by the users.

Available Water Supply

A variety of water supply scenarios were developed to compare crop water requirements to water delivery. Four combinations of cropping patterns and irrigation system efficiencies were evaluated, and all scenarios assume a continued rental of Utilities water. As shown in Table 1, under the present system and crop pattern, more water is required to irrigate all 511 acres with a full supply than is presently available (1,391 acre-feet). This indicates that deficit irrigation is occurring on all or some fields. If the delivery system is improved to deliver an adequate water supply to all fields, then the historical pattern of crops (at least in 1993) could be fully irrigated. Under the grass/ alfalfa monoculture, all lands proposed for irrigation (590 acres) will be under-irrigated even if the system is improved. This indicates that less acreage should be irrigated to achieve maximum potential yields with the water supply available. Based on these calculations, the maximum number of acres that should be irrigated, under an improved system, current water supply and the grass/alfalfa mix, is 503 acres. Coincidentally, this scenario is also the most economically attractive to the lessee, as discussed in the next section of this report. The reduction in irrigated acreage also provides OSD with other land use opportunities. All four water supply scenarios are detailed in Appendix B.

The diversion requirement is defined here as the amount of water diverted per acre to meet crop water demands and includes transmission losses. The current water duty (or average diversion requirement) is estimated to be 3.91 af/ac (see Scenario 1, Appendix A). Under grass/alfalfa, the water duty increases to 3.98 af/ac. If reasonable improvements are made to increase system efficiency, the expected water duties drop to 2.67 and 2.71, respectively, a savings of 32 percent. Reasonable improvements may include lining certain ditch segments or bypassing ditch sections with high losses (e.g., pipelines). Another alternative would be to curtail irrigation of fields beyond the seepage areas, such as the Dawson fields and Johnson fields 13, 14 and 15. Simply avoiding these areas will improve overall efficiency 20 percent.

Table 1. Management Area water requirements.

Cropping Pattern (acres)	Gross Irrigation Requirement (acre-feet)	
	Current System	Improved System
1993 crop (511)	1,996	1,363
Grass/alfalfa mix (590)	2,350	1,598

Key Issues

The primary issues related to agriculture and irrigation include the following:

1. Low Conveyance Efficiency. Based on lessee comments, losses due to seepage in gravelly substrata are significant along the east lateral of the Johnson Ditch, the tail end of the Star Ditch, and along the Star Ditch near the first lateral diversion point (Figure 2). Even with a full supply diverted, it is currently impossible to deliver more than one-third of it to the Dawson and east Johnson properties. Willows along the Star Ditch and parallel laterals on the Axelson property also contribute to irrigation water losses.

2. Inefficient Irrigation. Water is raised from ditches and applied to fields by earth or portable dams. This is a very labor-intensive technique. Corrugations in many fields help direct the flow across fields. The time between irrigations on a given field may be four weeks or more, and there is usually seepage losses and erosion at each lateral junction.

3. Lack of Control Structures. The only "permanent" structures are the concrete weirs at the headgates for each ditch system, and the concrete division boxes at each primary lateral take-off point. Distribution of water to secondary and tertiary laterals is accomplished by building earthen dams. There are no measuring structures (i.e., flumes or weirs) along the system other than at the points of diversion.

4. Problematic Soils. As noted above, many sections of the ditch systems cross gravelly, cobbly soils. In these reaches, water loss is high. There are about 400 acres of irrigated fields that are restrictive to certain crops (i.e., corn, other row crops) because of rocks and are best suited to grass/alfalfa hay or pasture. According to the Boulder County soil survey, shallow soils dominate most of Axelson fields 9, 14, 17 and 18, and for practical purposes are considered non-irrigable and best suited to native pasture. No salinity or sodicity was noted in any of the irrigated areas.

5. Drainage. The negative aspects of seepage were discussed above. A benefit of this, however, is the maintenance of wetland areas along one ditch corridor and in the south central part of the Axelson property. Most surface water runs back into waste ditches for reuse or disposal. Internal drainage is excellent because of the gravelly substratum in the irrigated soils. The amount and quality of drainage water was not evaluated since this study was conducted after irrigation had ceased.

6. Biosolids. Treated effluent can be used on the property but there is a concern of runoff and/or deep percolation returning to Boulder Reservoir.

7. Irrigable Acreage. Rangeland currently inhabited by prairie dogs could be converted to irrigated fields but will require land leveling and revegetation. Redesignation of the Cowles property from a prairie dog preserve unit to irrigated cropland has been recently instituted. Though 567 acres are irrigable, the maximum number of acres that should be irrigated with the current water supply is 503.

8. Potential for Alternative Cropping Systems. Attempts to establish warm season native grasses on irrigated land have been unsuccessful. Row crops require a higher level of management, and is not a preferred option by the lessee. A custom grass/alfalfa mix shows promise and has been recently instituted on selected acreage. Other alternative crops, such as organically-grown vegetables for local farmers' markets, have

not been examined but may be best limited to a few acres because of inadequate soils and increased management.

9. Limited Available Water Supply. Water rights held by OSD for the Management Area currently yield only 976 acre-feet. Continued rental of 374 shares from Utilities adds another 415 acre-feet, bringing the total available supply to 1,391 acre-feet. This is sufficient to fully irrigate 503 acres of grass/alfalfa hay fields with an improved irrigation system that alleviates major seepage problems. Under the existing system, only 445 acres can be sufficiently irrigated. Furthermore, should the Utilities portion of the water supply become unavailable, less acreage would receive an adequate water supply — about 317 acres under the proposed grass/alfalfa monoculture. Conversely, OSD may want to consider purchasing additional water to irrigate the maximum amount of irrigable land (with a full supply of water).

10. Exercise of Water Rights. OSD appears to be diverting its full legal share of water and is not in jeopardy of losing all or any portion of its right. This opinion is consistent with that of LHDC officials. The Water Commissioner, however, suggested that the entire LHDC system would eventually come under scrutiny. His particular concerns include changes in points of diversion and irrigated areas under the various carrier ditches such as the Star and Johnson. A profile on downstream water users on the Star Ditch system, including a description of water usage, cooperation with OSD and outstanding shares, should probably be completed.

ECONOMIC ANALYSIS

Economics are important to planning and decision making for the Management Area. Issues include the future viability of irrigated agriculture, the feasibility of capital improvements, and the relative economics of alternative land uses. In this case, standard economic analysis of land use and investment alternatives must be tempered by consideration of non-economic factors. For example, OSD's charter to preserve

agriculture may warrant subsidization of crop and livestock production. Conversely, emphasizing other public policy goals such as enhancement of wildlife habitat or recreation opportunities may warrant limiting agricultural production even if the economic return from crops or livestock is greater than these alternative land uses. The following economic analysis is directed at providing information to evaluate various options and to identify issues that may require further study.

Agricultural Viability

Continued crop and livestock production on the Management Area is one of the alternative land uses to be considered. Within this alternative, a variety of options exist including different cropping patterns and various mixes of grazed and cropped acreage. A number of practical and economic considerations limit the number of potential agricultural alternatives. The prevalence of sloping, cobbly, clayey soils precludes some crops altogether and favors pasture or hay production. Surrounding urbanization and marginal native grass production eliminates the potential long-term integration of this property into a large enough unit to support a livestock-focused ranching or intensive feeding operation. Thus, continued livestock grazing is assumed to be a marginal "sideline" enterprise on the property which does not contribute significantly to continued agricultural viability, although grazing contributes benefits such as economic diversification, weed control and cleanup of crop residue. Dryland crop production is not considered to be viable given the limited size of the area that can be farmed over the long run on and near the Management Area.

Although a few alternative or specialized crops such as sweet corn could conceivably be grown on the property, they are ignored in this analysis since standard economic practice counsels against reliance on specialty crops without careful, detailed evaluation of markets, management requirements and production costs.

In order to evaluate the viability of agriculture under various alternatives, estimated annual net income to a lessee (prior to lease payment) from crop and livestock production has been estimated on a per acre basis for crops judged to be reasonable given current practice in the area, lessee preferences, and existing information. The crop budgets are presented in Appendix C and summarized in Table 2. For the purposes of this analysis, the net annual income from grazing native rangeland is assumed to be $2/acre. The budgets also include aftermath grazing valued at $8/acre. **It must be emphasized that the crop budgets reflect full yields under optimum water supply, intensive management and vigorous crop stands, not the yields under historical practices.**

Table 2. Estimated annual net income per acre for agricultural activities.

Activity	Annual Net Income (1993 $/acre)
Grass Hay	$193
Alfalfa	$235
Corn	$54
Small Grains	$86
Grazing (Native Range)	$2

Based on the above net income estimates, various scenarios of agricultural production on the Management Area can be examined. The primary alternative presented below is based on conversion of all cropland to grass hay and grazing on the rest of the property. For comparison purposes, a cropping pattern based on general historical practice in the area is also evaluated. Although not displayed below, a third alternative of intensive alfalfa production was considered. It has a slightly lower net income than the grass hay alternative. In Table 3, cropped acreage is limited by water availability based on the existing irrigation system. The economic impact of irrigation system improvements is presented in the next section.

Table 3. Management Area annual net income under various cropping patterns, existing irrigation system.

Alternative	Acres	Net Income* ($/acre)	Total Income ($/acre)	Lease Cost ($)	Total Net Income ($)
1. Primary					
Grass Hay	445	$193	$85,885		
Grazing	447	$2	$894		
			$86,779	$9,300	$77,479
2. Historical					
Alfalfa Hay (40%)	174	$235	$40,890		
Grass Hay (40%)	174	$193	$33,582		
Corn (10%)	44	$54	$2,376		
Small Grains (10%)	44	$86	$3,784		
Grazing	456	$2	$ 912		
			$81,544	$9,300	$72,244

*Prior to lease payments.

The total annual net income estimates of $72,244 to $77,479 provide an indication of the continued viability of agriculture on the Management Area with no major changes to the irrigation system. Even though the net income may be optimistic and will vary from year to year as a result of market prices, input costs and weather conditions, agriculture appears to be a viable enterprise on the Management Area for the foreseeable future.

The relatively high net income estimates reflect the absence of water and property tax costs and the relatively low lease rates on this land. However, lease rates should increase under the existing lease structure as new perennial crop acreage is established and becomes productive.

Feasibility of Capital Improvements

The primary capital improvements being considered are irrigation system investments to reduce canal or lateral seepage and to improve or add water control structures. These improvements would increase the amount of water that can be delivered to fields,

thereby increasing any number of acres that can be irrigated with a full water supply. However, it should be noted that total acreage irrigated with a full water supply, with or without improvements (445 to 503 acres), is less than all of the acreage that is irrigable or that has been historically irrigated at one time or another. Thus, some of the historically irrigated land could be managed for a different mix of land uses. Table 4 presents the estimated net income for the same cropping scenarios as Table 3 after the irrigation system improvements are in place.

Table 4. Management Area annual net income under various cropping patterns, improved irrigation system.

Alternative	Acres	Net Income* ($/acre)	Total Income ($/acre)	Lease Cost ($)	Total Net Income ($)
1. Primary					
Grass Hay	503	$193	$97,079		
Grazing	389	$2	$778		
			$97,857	$9,300	$88,557
2. Historical					
Alfalfa Hay (40%)	191	$235	$44,885		
Grass Hay (40%)	191	$193	$36,863		
Corn (10%)	48	$54	$2,592		
Small Grains (10%)	48	$86	$4,128		
Grazing	414	$2	$828		
			$89,296	$9,300	$79,996

*Prior to lease payments.

Comparison of Tables 3 and 4 shows that net income is estimated to increase by $11,078 and $7,752 for Alternatives 1 and 2, respectively. Switching from historical agricultural practices (Table 3, Alt. 2) to an improved irrigated grass hay system (Table 4, Alt. 1) could increase income by about $16,000. Boulder should be able to capture some of the increased income to the lessee through higher lease revenues in the future.

The cost of irrigation system improvements is needed in order to provide a more complete economic analysis. At present, those costs have not been developed (and will not be developed by ERO for this study). When those costs are provided, they can be converted to an annual value by amortization over the life of the improvement. For example, a $10,000 investment amortized over 15 years at an interest rate of 8 percent is $1,740/year. This amount can be compared to the estimated increase in annual lease revenue to evaluate whether the improvement will pay for itself or will have to be subsidized.

City Costs

The annual costs of the Management Area to the City provide perspective for the evaluation of alternatives with and without lease revenue. Currently, the costs are estimated to be about $513,000/year as shown in Table 5. These costs do not include the general "overhead" costs of OSD, which are assumed to be independent of this particular Management Area. Excluding land costs, the annual amount is about $32,100/year.

Table 5. Annual Boulder costs for Management Area.

Item	Cost ($/year)
Land Purchased[1]	$480,600
Water[2]	$14,100
Direct Planning and Management[3]	$15,000
Miscellaneous (contract services, etc.)	$3,000
Total	$512,700

[1]Will drop to about $430,000/year after 1995 when the Cowles property will be paid for. After 2002, other properties begin to be paid off as well.

[2]$6,733 (879 shares of Left Hand Ditch water at $7.66/share), $405 (4.83 shares in Star Ditch Company) and $7,000 (500 af of Left Hand Ditch water [374 shares] rented from Utilities at $14/af).

[3]Estimated at $15,000/yr of staff time, transportation costs, etc.

Other Alternatives

Economic considerations for several land use and leasing alternatives are briefly described below.

- Longer Leases — Multi-year leases would be expected to yield slightly lower annual revenue than the short-term leases used at present. The lower revenue would be at least partially offset by the value of certainty to the City and reduced costs for lease negotiations.

- Leasing Water — This alternative has not been thoroughly evaluated at the present time since a number of alternatives and issues would need to be considered. For example, complications include lease term (short- or long-term), lease type (conventional or dry-year option), water rights constraints, transaction costs, and erosion/weed control costs. However, for general perspective, Colorado-Big Thompson (CBT) water has recently been rented or leased at the rate of $9/af/yr from the Left Hand Ditch Company. At the rate of $9/af/yr for the 879 shares that OSD owns, water on the property would generate $8,784/year (Note: City is paying $14/af).

- Recreation — This alternative is also complex. Agricultural and recreational use of the property are not mutually exclusive although the presence of one may affect the value of the other. The benefits of recreation are also difficult to quantify accurately or completely.

- Natural Uses — An economic assessment of the value of returning the area to a natural state is almost impossible although attempts are occasionally made at such estimates. At this point, the economic considerations for converting the property to a natural area are best limited to evaluation of foregone lease revenues, potential water lease revenue, and any change in planning, oversight or management efforts by OSD staff.

- Less Intensive Farming — The economic analysis presented above is based on relatively intensive management of the area in the future. It may be desirable to manage the property less intensively in the future. For example, water quality or wildlife considerations may lead to a policy decision to reduce the amount of fertilizer and pesticide used in farming the property. Although input costs would be lower, yields would be reduced and the overall effect would be lower farm net income and lower lease revenue.

The economic analysis in this report can serve as a template for OSD staff to use for further consideration of alternatives on this property or other open space areas. In

addition, this analysis can be readily modified to reflect current prices or actual lessee data. Several notes of caution are in order in any economic analysis:

- The type of economic calculations involved here are best used for planning purposes to compare among alternatives for relative net benefits or costs. Due to the many variables that change from year to year or from farmer to farmer, general farm budgets should not be used to predict actual net income on a particular farm or set specific lease rates.

- To the extent possible, prices, yields and other variables in the analysis should be based on a composite of sources since any one data set may reflect unique conditions or assumptions. The exception to this rule is when extensive records are available for a specific location or enterprise.

- Economic analysis of future alternatives inevitably involves assumptions. It is important to specify and describe the basis of those assumptions.

Key Issues

The primary issues related to economic viability of irrigated agriculture on the Management Area include the following:

1. Cropping Patterns. The grass/alfalfa hay monoculture planned by OSD and the lessee has a slight economical edge over the historical crop pattern. Under a full water supply, net income is about 7 percent higher for grass/alfalfa hay; with an improved irrigation, it's about 10 percent higher. However, lack of crop diversification also entails higher risks relative to crop prices or pest infestations.

2. Extent of Irrigation. Sufficient water is not currently available to meet full crop water requirements on all irrigable acreage on the property with or without system improvements. If the current supply is used to fully irrigate only the best lands, the benefits may include highest economic returns, conversion of some acres to alternative land uses, and a reduced need for system improvements. The alternative of acquiring more water depends on the water market and whether or not there is available ditch capacity.

3. Irrigation System Improvements. Evaluation of the feasibility of irrigation system modifications requires information on the costs of specific improvements and potential increases in lease revenue.

4. Lease Rates. The lease rate obtained by OSD seems to be inordinately low. Normally, lease revenue should cover the direct costs (in this case, water, direct expenses and a portion of the management costs) and provide a reasonable return on the land. An analysis of local farmland lease rates and OSD bidding procedures seems warranted.

NATURAL RESOURCES AND RECREATION ASSESSMENT

The size of the Management Area (over 800 acres), its linkage with over 4,000 acres of additional City Open Space, City Park lands and County Open Space in the northwestern portion of Boulder, and its mix of irrigated crop lands, hay meadows, rangeland, large wetlands and prairie dog communities, combine to make the Management Area a natural resource and agricultural area of local significance. The Management Area was probably once an important component in a highly diverse natural system composed of a matrix of prairie uplands and wetlands. Future planning should consider the present and historical context within which the Management Area occurs.

Although the focus of this study is the improved management of agricultural water resources for the Management Area, a secondary and important goal of the study is to address natural resources and recreation within the context of irrigation and agricultural improvements for the Management Area. The natural resource and recreation elements of this analysis are viewed from the perspective of integration with the agricultural improvement component for comprehensive planning of the Management Area.

Public Access and Recreation

At this time, the Management Area is a relatively unknown and unused portion of the City of Boulder's Open Space portfolio. There will be increasing pressure by the public for access to, and use of, the Management Area. The pressure for public access will likely come from several different points including:

- The Lake Valley residential development to the west;
- The development of the north Boulder community to the southwest;
- Boulder Reservoir to the southeast, which is a major regional draw for public recreation;
- The popular and heavily used Boulder Valley Ranch (BVR) open space parcel to the southwest; and
- Equestrian access from the east.

The greatest concerns and issues regarding access and recreational use of the Management Area are:

- Potential conflicts between agricultural activities and recreational uses;
- Conflicts among dogs, livestock, recreational users and wildlife;
- Fragmentation of habitat by trails within the Management Area;
- Wildlife disturbance and habitat degradation due to access, agricultural and recreational use; and
- Crop damage due to off-trail recreational use.

The following suggestions have been made regarding recreation/access issues for the management area:

- Encourage use around the perimeter of the Management Area (e.g., use trail easement along western perimeter and develop trails around the northern and southeastern perimeters linking the Eagle Trailhead with Monarch Road).
- Discourage internal access to much of the Management Area.

- Minimize numerous private access points to the Management Area (e.g., Lake Valley Estates).

Wildlife

The management area has historically supported a substantial prairie dog population (a recent plague epizootic has reduced prairie dog numbers). These prairie dog towns have been a component of a much larger complex including towns on BVR and on city-owned lands around Boulder Reservoir. This complex has been known for the density of wintering raptors it supports, specifically red-tailed hawks, ferruginous hawks, golden eagles and bald eagles. A great deal of biodiversity is associated with this complex beyond the wintering birds of prey. Badger, coyote, fox and, up until very recently, burrowing owls have lived in the prairie dog towns. One of the challenges of developing a plan for the Management Area will be to balance the importance and sensitivity of this important wildlife habitat with public access and agricultural use.

Certain wildlife uses of the area are dependent upon the present irrigation system. The numerous ditches within the Management Area serve as both wildlife habitat and movement corridors for coyote, fox and other medium and small mammals. Segments of the irrigation ditches support dense stands of willows that are used by wildlife for cover and nesting. Additionally, vegetation along the irrigation ditches is frequently the only uncut and non-grazed vegetation (except for some of the wetland areas) within the Management Area. Meadows supported by direct irrigation or runoff water provide favorable habitat for small mammals, insects and ground-nesting birds. Irrigation improvements, such as lining ditch segments that have heavy seepage or enclosing ditch segments in pipe, can separate existing wetlands and other habitats, particularly shrubs, from the water sources that support them, thus degrading, reducing or eliminating these wildlife habitats.

Upland Vegetation

There is little remaining native upland vegetation within the Management Area, with the exception of the Dry Creek valley, which supports 50 to 75 acres of native grassland. The potential for restoring current agricultural communities to native upland plant communities is considered limited due to poor site conditions (e.g., eroded soils, substantial weed infestation and other poor site conditions). Weed infestations are common within portions of the Management Area that are not routinely managed for weed control (e.g., ditches, roadways, areas between ditches and cropped fields, and prairie dog areas).

Wetlands

The hydrology of and occurrence of wetlands in the Management Area and vicinity is very interesting. Most of the water movement in this area is underground; there is no major drainageway between Left Hand Creek north of the Management Area to Fourmile Canyon Creek, about 5 miles south of the Management Area. When this ground water hits the underlying Pierre shale, it discharges to the surface. This regional pattern of ground water movement likely has substantial effects upon the nature, location and discharge of several of the ditches in the Management Area, as well as the distribution of wetlands. There is also a surface water component. In 1937, before the dams were built, Boulder Reservoir was a large marsh at the convergence of numerous heavily vegetated tributary drainages of slow moving water. Much of the water that historically flowed over the landscape in this area has been trapped in ditches and put to "beneficial" use. Some water seeps from the ditch systems or comes from irrigation return flows that support wetlands on the hillsides. The third contribution to wetland hydrology is effluent from two hydrothermal wells, which are located in the north half of the northeast quarter of Section 34. There may be undesirable salts and other chemicals associated with this water flow.

A relatively large wetland area occurs north of Dry Creek within the Axelson property, while smaller wetland areas occur in the eastern portions of the Management Area. The Dry Creek/Markel wetland easement, a mitigation site, occurs in the Dry Creek drainage. The wetlands are supported by a variety of hydrologic sources including high water tables, seeps and irrigation return flows. These wetland areas represent the largest and most diverse native plant communities within the Management Area and are important to wildlife. Wetlands are areas of enhanced primary productivity because of the availability of water. This primary productivity probably supports an enhanced community of herbivores, which in turn support higher levels of predators.

Irrigation improvements as well as recreational development may impact wetland resources. The lining or enclosing of irrigation ditch segments that have high seepage losses (Figure 2) may cause adverse impacts to small local wetlands dependent on seepage from the ditches, but is unlikely to cause significant impacts to the large wetlands along Dry Creek and north of Dry Creek. Wetland areas likely to be adversely impacted by lining or enclosing the ditch segments that have high seepage losses (Figure 2) include:

- The dense stand of willows along the Star Ditch east of the pond.
- The wetland area (unmapped) on the Johnson property northeast of the intersection of North 55th Road East and Monarch Road.
- Potentially, the mapped wetlands (Figure 1) in the southeastern portion of the Johnson property west of the Boulder Feed Canal and the wetlands above Coot Lake could receive less irrigation seepage; however, effects would likely be minimal due to irrigation tailwaters that feed these wetlands.

If the amount of acreage that is currently irrigated is reduced, the reductions could affect individual wetlands depending on which fields are no longer irrigated. Irrigation system improvements are not expected to degrade the large wetlands in the southern portion of the Axelson property as these wetlands appear to be supported, in large part, by the percolation of irrigation waters to the north and east that discharge into the

shallow Samsil-Shingle soils north of Dry Creek. The total amount of irrigation water applied to the Management Area is expected to remain the same and, therefore, the amount of water reaching these wetlands should also remain relatively the same with any proposed irrigation improvements.

Key Issues

At this time, OSD is in the process of developing its priorities for managing the natural resources, recreation and public access issues associated with long-term management of the Management Area. The following key issues related to natural resources, recreation and public access need to be addressed:

1. Are there significant potential conflicts among passive recreation, natural resources and agricultural activities in the Management Area?

2. How could revisions to the Management Area's irrigation distribution system affect natural resources (e.g., wetlands and wildlife habitat)?

3. Will improvements to the Management Area's irrigation system provide opportunities and/or constraints for the future management of other resources (e.g., weeds, access, wildlife habitat and prairie dogs)?

4. How compatible are public access and recreation with ongoing agricultural activities and management of wildlife habitat?

5. How will surrounding land development and uses affect agricultural operations, wildlife and wildlife habitat and the overall quality of the management area?

6. Can public access be effectively limited to perimeter trails and the Boulder Feeder Canal?

7. Can signage discourage off-trail use?

8. What opportunities exist to improve natural resources (e.g., wet meadows, wetlands, Dry Creek).

9. If improvements to the irrigation system result in excess water, how should this water be used?

10. If improvements to the irrigation system and cropping pattern result in less land being irrigated, how should the land retired from irrigation be managed?

11. How can mechanical weed control be planned so that habitat values of standing vegetation in wetlands can be balanced with integrated peat management goals?

CONCLUSIONS AND RECOMMENDATIONS

The major focus of this study has been on the irrigated agriculture component of the Management Area. Natural resources, wildlife habitat and recreation issues, however, are no less important and the management of these resources and issues will need to be integrated into future management plans for the Management Area. The issues surrounding the irrigation system, including water rights, are the focal point at this time in the preliminary development of management in the Management Area. Thus, the conclusions and recommendations herein reflect this concern and perspective.

Conclusions

1. The Management Area offers sufficient amenities and facilities, such as water, land and an irrigation system, to support a continued viable agricultural operation.

2. Of the 892 acres comprising the Management Area, 567 acres are considered irrigable. Based on this study, anywhere from 445 to 567 acres can be irrigated and

result in a profitable enterprise. The trade off between irrigating less or more acreage is higher or lower yield per acre, respectively.

3. The current available water supply limits the amount of land that can be sufficiently irrigated (i.e., supply enough water to meet crop consumptive use requirements for full yield). OSD's shares of LHDC water yield 976 acre-feet. Rental of 374 shares of Utilities water adds another 415 acre-feet, bringing the total available supply to 1,391 acre-feet. This is enough to meet the irrigation water requirements for about 500 acres of grass/alfalfa hay.

4. The grass/alfalfa hay monoculture developed by OSD and the lessee, and already established on several fields, is the most promising agricultural scenario. It provides the greatest net income, requires less management than other crops, and is best suited to the soils of the Management Area.

5. Given the urban pressures, OSD goals, market forces, and natural resources of the Management Area, no other agricultural alternatives seem viable. This rules out any significant development of livestock production (i.e., dairies, feedlots, etc.), dryland agriculture or specialty crops.

6. The irrigation system needs improvements in order to supply adequate water to crops in a timely fashion. There are high seepage losses in some sections, a lack of control and/or measurement structures, and the application of water is labor-intensive. System improvements will help encourage more favorable long-term lease agreements.

7. Under any of the water use scenarios discussed in this report, OSD appears to be properly exercising its full right to LHDC water, and is not under the threat of forfeiting all or part of its water rights.

8. The Management Area makes significant contributions to the complex of wildlife habitat associated with the northwestern open space and park lands to which it is adjacent. These contributions need to be preserved and integrated into the future plans for the Management Area.

9. Native plant communities within the Management Area are primarily restricted to wetland areas, most of which depend to some degree on irrigation water seepage and percolation.

10. There will likely be increasing pressure for public access to the Management Area as development in the surrounding rural area increases. Access to the Management Area, and particularly unauthorized access points, will likely pose future management problems.

11. Adverse impacts associated with irrigation system improvements will vary by improvement and location, and impacts should be local and minimal.

Recommendations

1. Make physical improvements to the irrigation system for better utilization and control of water. Concrete division boxes at lateral junctions and lining of specific ditch sections (or replacement with pipeline) will drastically reduce seepage losses. Realignment of the delivery system in some areas (e.g., the Johnson ditch in the vicinity of the Johnson and Dawson properties) is also suggested. Recommended locations for division boxes are known to OSD staff (Duane Myers). Measuring devices at these junctions also should be installed. The result of these improvements will be more water available for irrigation and, thus, more acreage that can receive a full supply of water. Conversely, reduction of seepage losses may diminish the supply of water supporting localized wetland areas. The cost of capital improvements, whether minor or major, can and should be recaptured through increased lease rates.

2. Optimize the amount of irrigated land. This involves several factors:

a. Cropping pattern. The proposed grass/alfalfa monoculture should be established as planned. The lands selected for this program should be dedicated as permanent irrigated fields. Under a full supply of water, and with an improved irrigation system, about 500 acres can be irrigated to achieve full yields. Though this is less acreage than has been recently irrigated, expected yields should be nearly double of that in the past. All fields were rated in terms of suitability for irrigation, as shown in Appendix C. Retirement of selected fields by OSD should consider this rating.

b. Water supply. More acreage, up to about 567 acres, can be irrigated if the water supply is increased. OSD could acquire additional LHDC shares (or rent more shares), but this is limited by the size of the conveyance system (if there are no improvements to increase delivery capacity). Improvements to the irrigation system, noted above, will increase the water yield per acre.

c. On-farm water application. Fewer acres to irrigate with a more sufficient quantity of water means a shorter duration between irrigations: An estimated 7 to 10 days versus 14 to 28 days in the past. Continued use of corrugations on all fields to control water movement is recommended.

d. Economic viability. An analysis of various crop enterprise budgets was performed and the grass/alfalfa mix provides the best economic return. A relatively small amount of acreage can be devoted to specialty crops if desired. Grazing on native pasture should not be considered a major component of the economic agricultural unit.

3. Integrate and formalize public access around the agricultural area. With fewer acres irrigated than historically practiced, more opportunities emerge for management of rangeland for wildlife and recreation. Public access points and a trail system can be developed once farmlands are dedicated to that use.

4. **Re-evaluate the lease rate.** An increase in the lease rate should be based on capital improvements, establishment of new crops (grass/alfalfa mix), OSD management (if extraordinary) and market value.

5. **Further evaluate irrigation system improvements that are proposed for implementation to determine possible adverse effects to natural resources.** For example, if fewer acres will be irrigated, determine if removal of irrigation from a field is likely to affect nearby wetlands.

6. **Evaluate downstream water users.** Any improvements or changes in the current irrigation system should consider impacts or effects to downstream uses on the Star Ditch. As such, OSD should investigate these users.

7. **Consider future natural resource management in the retirement of agricultural lands.** If system improvements involve a reduction in the acres of the Management Area currently irrigated, then an evaluation of the natural resources that the property provides or could provide need to be considered for future management plans.

8. **Unavoidable adverse impacts to important wildlife habitat (e.g., wetlands and shrub habitats associated with irrigation system improvements) should be compensated.** The pond discussed below holds some potential for such compensation.

9. **The pond located in the central portion of the Axelson property should be evaluated for its potential to be "enhanced" for wildlife.** This may include plantings, greater control of water levels, and establishment of a shallow marsh area.

10. **Encourage public access around the perimeter of the Management Area.** Use the trail easement along the western perimeter and develop trails around the northern and southeastern perimeters linking the Eagle Trailhead with Monarch Road.

11. Minimize numerous private access points to the Management Area. Lake Valley Estates and other access points and social trails should be controlled or eliminated.

Appendix A: Field Suitability for Irrigation

Irrigable acreage is defined here as the amount of land that is currently under existing ditches, has no restrictions to crop growth due to soils, and does not involve another land use of importance to OSD (i.e., wetlands, other natural areas). The assignment of field suitability for irrigation can help OSD in the selection of fields for retirement from irrigation, based on decisions made later for management of the property.

All fields in the Management Area were rated in terms of suitability for irrigation. The criteria include soil quality, productivity (potential yields) and consideration of the existing irrigation system (i.e., proximity to point of diversion, conveyance efficiency to field). Table 1 below explains the criteria and factor rating for soils.

Table 1. Soil suitability.

Soil Quality[1]		Productivity[2]				Total Rating
Map Unit	Rating	Alfalfa (t/ac)	Corn (bu/ac)	Sm. Grains (bu/ac)	Rating	
HeC	2	3.5	55	65	1	3
KuD	1	4	70	55	2	3
LoB	unsuitable — salinity, alkalinity					—
NnB	5	6	120	90	5	10
NuB	5	5.5	120	90	5	10
RnB	3	4	90	85	3	6
RnD	1	4	70	70	2	3
SeE	unsuitable — shallow soils					—
Te	unsuitable — shallow soils, slope					—
VaB	5	4.5	100	90	4	9
VaC	3	4	75	75	2	5
VcC	1	—	—	—	1[3]	2

[1]Based on Natural Resource Conservation Service (SCS) survey of Boulder County, and considers limiting physical and chemical properties as well as slope.

[2]Based on soil survey and considers potential yield for crops grown in the Management Area.

[3]Suitable for pasture.

A weighted average rating was determined for each field based on the combination of soil map units occurring within the field. For example, Axelson field #8 is about 90 percent VaB and 10 percent VcC. The weighted average rating for soils for this field is 8.3 ([.9 x 9] + [.1 x 2]). The irrigation system factor was added to this to produce a final value.

Irrigation System Factor	
Efficiency	Rating
.85+	5
.50 to .84	3
< .50	1

Total values from 10 to 14 indicated high potential irrigated land. Fields with values of 8 to 9.9 were rated as moderate. Moderately low potential croplands had a value of 7 to 7.9. A value of 1 to 6.9 suggested low cropland potential. Those fields not rated are considered unsuitable due to slope, excessive soil salinity or shallow soils. The table below describes the acreage in each class, while Table 2 indicates the individual rating and acreage by field.

Irrigation Suitability Class	Acreage	Number of Fields
High	234.6	14
Moderate	131.6	7
Moderately Low	144.7	14
Low	56.4	5
Unsuitable	288.9	6
Total	856.2	46

Table 2. Irrigation suitability of fields.

Ditch	Property	Field	Area	Suitability for Irrigation
Johnson West	Axelson	1A	43.0	—
		1B	29.6	ML
		2A	9.0	H
		2B	1.8	—
		3	11.6	H
		4	19.3	M
		5	13.1	ML
		6	5.8	ML
		7	5.8	H
		8	16.0	H
		9	221.2	—
Total Johnson West			376.2	110.2
Johnson East	Johnson	1A	23.5	H
		1B	4.0	ML
		2	4.8	ML
		3	10.6	ML
		4	12.1	ML
		5	13.3	L
		13	21.6	H
		14	5.9	L
		15	11.4	L
	Dawson	1	37.8	M
		2	12.0	H
		3	20.8	ML
Total Johnson East			177.8	177.8
Total Johnson			554.0	288.0

Ditch	Property	Field	Area	Suitability for Irrigation
Star 1st	Axelson	10	14.1	M
		11	20.4	H
		12	10.6	L
		13	3.9	ML
		14	12.9	—
		15	7.8	ML
		16	2.1	ML
		17	5.7	—
		18	4.3	—
	Johnson	10	15.2	L
		11	13.2	H
		12	5.5	M
Total Star 2nd			115.7	92.8
Star 2nd	Johnson	6	25.6	H
		7A	14.3	ML
		7B	22.2	H
		8	10.5	M
		9A	13.9	H
		9B	9.3	ML
		16	5.6	M
		17	6.5	ML
Total Star 2nd			107.9	107.9
Star 3rd	Cowles	1	38.8	M
	Axelson	19	20.3	H
		20	19.5	H
Total Star 3rd			78.6	78.6
Total Star			302.2	279.3
TOTAL MANAGEMENT AREA			856.2	567.3

Appendix B: Water Supply Scenarios

The scenarios were prepared by Elizabeth Payton of Hydrosphere in conjunction with ERO Resources. Since there is no water delivery or system efficiency data, several assumptions were used to produce these tables:

- 1993 was a representative year with respect to diversion and cropping pattern. 1993 was chosen because most of the data needed to calibrate the diversion requirement calculations were available and coincided with the year that the aerial photos were taken.

- Annual irrigation requirements are not limited by diversion rates. This assumption is a reflection of the fact that the LHDC limits diversions by volume, not rate.

- A typical irrigation run has a 10-day duration. The maximum monthly diversion requirement, based on delivering the peak month's requirement in 10 days, is presented in the accompanying tables. The totals per ditch are less meaningful than the totals per field or lateral, since there can be multiple runs per month.

- Excluding segments where exceptional losses are indicated, the annual average conveyance efficiency for typical earthen ditches and laterals is 85 percent, as reported in the SCS's Colorado Irrigation Guide (CIG). Individual monthly values may be quite different. ERO and the lessee have indicated considerable losses in specific segments of the laterals; lower conveyance efficiencies, based on the lessee's experience and field observation, are used for fields that are affected by those losses.

- Application efficiencies are 50 percent for irrigated pasture and 60 percent for all other crops, estimated from the CIG for contour flooding and corrugations, respectively, on slopes of 1 to 2 percent.

- Average net consumptive use (CU) values are used. Dry-year CU values could be as much as 20 percent higher.

- Monthly net consumptive use values for each crop type are taken directly from the Longmont values in the CIG, with two exceptions: the CU values for alfalfa are increased and extended (i.e., a longer irrigation season) and the winter wheat CU values are reduced (i.e., a shorter irrigation season) to reflect that the lessee irrigates these crops under slightly different schedules than the CIG indicates.

- Total water requirements are based on full delivery of the net CU requirement of each field. In fact, because of inefficiencies in the system, it is likely that deficit irrigation was taking place in some fields, such that each crop did not receive its full CU requirement.

- Tailwater recovery from application is limited to a few fields at the lower end of the management system. The lessee states that he is often able to recover much more water than this assumption indicates, though timing and cropping patterns are key to the efficient reuse of water applied to upper fields. In this analysis, tailwater recovery is represented as a conveyance gain rather than loss.

Scenario 1		92.8	corn
1993		115.3	alfalfa
		87.4	pasture
		103.3	grass hay
Fields subdivided		72.4	grass/alfalfa
3/6/95		69.8	winter wheat

DITCH	PROPERTY	FIELD	AREA	CROP	ANNUAL CU FEET	ANNUAL CU ACRE FEET	MAX MONTH CU INCHES	MAX MONTH CU ACRE FEET	CUMULATIVE CONVEYANCE EFFICIENCY	APPLICATION EFFICIENCY	ANNUAL DIVERSION RQMT ACRE FEET	MAX MONTH DIVERSION RQMT CFS
Johnson West	Axelson	1A	43.0	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		1B	29.6	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		2A	9.0	alfalfa	1.93	17.39	6.51	4.88	0.85	0.60	34.10	0.48
		2B	1.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		3	11.6	alfalfa	1.93	22.42	6.51	6.29	0.85	0.60	43.95	0.62
		4	19.3	alfalfa	1.93	37.30	6.51	10.47	0.85	0.60	73.13	1.04
		5	13.1	alfalfa	1.93	25.32	6.51	7.11	0.85	0.60	49.64	0.70
		6	5.8	alfalfa	1.93	11.21	6.51	3.15	0.85	0.60	21.98	0.31
		7	5.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		8	16.0	grass hay	1.38	22.03	5.32	7.09	0.75	0.50	58.74	0.95
		9	221.2	none	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
Total JW			**74.8**			**135.66**		**38.99**			**281.54**	**4.11**
Johnson East	Johnson	1A	23.5	pasture	1.38	32.35	5.32	10.42	0.85	0.50	76.12	1.24
		1B	4.0	pasture	1.38	5.51	5.32	1.77	0.85	0.50	12.96	0.21
		2	4.8	grass hay	1.38	6.61	5.32	2.13	0.85	0.50	15.55	0.25
		3	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.85	0.60	29.77	0.47
		4	12.1	winter wheat	0.29	3.56	2.94	2.96	0.85	0.60	6.98	0.29
		5	13.3	alfalfa	1.93	25.70	6.51	7.22	0.50	0.60	85.67	1.21
		13	21.6	corn	1.07	23.16	6.16	11.09	0.10	0.60	385.97	9.32
		14	5.9	alfalfa	1.93	11.40	6.51	3.20	0.50	0.60	38.01	0.54
		15	11.4	grass/alfalfa	1.43	16.33	5.44	5.17	0.50	0.60	54.43	0.87
	Dawson	1	37.8	pasture	1.38	52.04	5.32	16.76	0.85	0.50	122.44	1.99
		2	12.0	grass hay	1.38	16.52	5.32	5.32	0.85	0.50	38.87	0.63
		3	20.8	grass hay	1.38	28.63	5.32	9.22	0.50	0.50	114.54	1.86
Total JE			**177.8**			**237.0**		**80.1**			**981.3**	**18.9**
Total Johnson			**252.6**			**372.6**		**119.1**			**1262.8**	**23.0**
Star 1st	Axelson	10	14.1	alfalfa	1.93	27.25	6.51	7.65	0.50	0.60	90.83	1.29
		11	20.4	corn	1.07	21.87	6.16	10.47	0.50	0.60	72.90	1.76
		12	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.50	0.60	50.61	0.81
		13	3.9	grass/alfalfa	1.43	5.59	5.44	1.77	1.25	0.60	7.45	0.12
		14	12.9	grass/alfalfa	1.43	18.48	5.44	5.85	0.67	0.60	45.96	0.73
		15	7.8	grass/alfalfa	1.43	11.17	5.44	3.54	1.25	0.60	14.90	0.24
		16	2.1	winter wheat	0.29	0.62	2.94	0.51	1.25	0.60	0.82	0.03
		17	5.7	pasture	1.38	7.85	5.32	2.53	0.67	0.50	23.42	0.38
		18	4.3	pasture	1.38	5.92	5.32	1.91	1.00	0.50	11.84	0.19
	Johnson	10	15.2	grass/alfalfa	1.43	21.77	5.44	6.89	0.50	0.60	72.57	1.16
		11	13.2	grass hay	1.38	18.17	5.32	5.85	1.25	0.50	29.08	0.47
		12	5.5	none	0.00	0.00	0.00	0.00	0.50	1.00	0.00	0.00
Total Star 1st			**110.2**			**153.9**		**61.8**			**420.4**	**7.2**
Star 2nd	Johnson	6	25.6	winter wheat	0.29	7.53	2.94	6.27	0.85	0.60	14.77	0.62
		7A	14.3	grass hay	1.38	19.69	5.32	6.34	0.85	0.50	46.32	0.75
		7B	22.2	grass hay	1.38	30.56	5.32	9.84	0.85	0.50	71.91	1.17
		8	10.5	winter wheat	0.29	3.09	2.94	2.57	0.85	0.60	6.06	0.25
		9A	13.9	alfalfa	1.93	26.86	6.51	7.54	0.85	0.60	52.67	0.75
		9B	9.3	alfalfa	1.93	17.97	6.51	5.05	0.85	0.60	35.24	0.50
		16	5.6	pasture	1.38	7.71	5.32	2.48	1000.00	0.50	0.02	0.00
		17	6.5	pasture	1.38	8.95	5.32	2.88	1000.00	0.50	0.02	0.00
Total Star 2nd			**107.9**			**122.36**		**42.98**			**227.00**	**4.04**
Star 3rd	Cowles	1	38.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
	Axelson	19	20.3	corn	1.07	21.76	6.16	10.42	0.50	0.60	72.55	1.75
		20	19.5	winter wheat	0.29	5.74	2.94	4.78	0.75	0.60	12.75	0.54
Total Star 3rd			**39.8**			**27.5**		**15.2**			**85.3**	**2.3**
Total Star			**257.9**			**303.7**		**109.9**			**732.7**	**13.5**
Total Mgmt Area			**510.5**			**676.4**		**229.0**			**1995.5**	**36.5**

ERO RESOURCES CORPORATION

Scenario 2			*82.3*	*corn*									
1993			*115.3*	*alfalfa*									
			87.4	*pasture*									
			103.3	*grass hay*									
Fields subdivided			*72.4*	*grass/alfalfa*									
3/6/95			*69.8*	*winter wheat*									
					ANNUAL	ANNUAL	MAX MONTH	MAX MONTH	CUMULATIVE		ANNUAL	MAX MONTH
					CU	CU	CU	CU	CONVEYANCE	APPLICATION	DIVERSION RQMT	DIVERSION RQMT
DITCH	PROPERTY	FIELD	AREA	CROP	FEET	ACRE FEET	INCHES	ACRE FEET	EFFICIENCY	EFFICIENCY	ACRE FEET	CFS
Johnson West	Axelson	1A	43.0	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		1B	29.6	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		2A	9.0	*alfalfa*	1.93	17.39	6.51	4.88	0.85	0.60	34.10	0.48
		2B	1.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		3	11.6	alfalfa	1.93	22.42	6.51	6.29	0.85	0.60	43.95	0.62
		4	19.3	alfalfa	1.93	37.30	6.51	10.47	0.85	0.60	73.13	1.04
		5	13.1	*alfalfa*	1.93	25.32	6.51	7.11	0.85	0.60	49.64	0.70
		6	5.8	alfalfa	1.93	11.21	6.51	3.15	0.85	0.60	21.98	0.31
		7	5.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		8	16.0	grass hay	1.38	22.03	5.32	7.09	0.85	0.50	51.83	0.84
		9	221.2	*none*	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
Total JW			**74.8**			**135.66**		**38.99**			**274.63**	**3.99**
Johnson East	Johnson	1A	23.5	pasture	1.38	32.35	5.32	10.42	0.85	0.50	76.12	1.24
		1B	4.0	pasture	1.38	5.51	5.32	1.77	0.85	0.50	12.96	0.21
		2	4.8	grass hay	1.38	6.61	5.32	2.13	0.85	0.50	15.55	0.25
		3	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.85	0.60	29.77	0.47
		4	12.1	winter wheat	0.29	3.56	2.94	2.96	0.85	0.60	6.98	0.29
		5	13.3	alfalfa	1.93	25.70	6.51	7.22	0.85	0.60	50.40	0.71
		13	21.6	corn	1.07	23.16	6.16	11.09	0.85	0.60	45.41	1.10
		14	5.9	alfalfa	1.93	11.40	6.51	3.20	0.85	0.60	22.36	0.32
		15	11.4	grass/alfalfa	1.43	16.33	5.44	5.17	0.85	0.60	32.02	0.51
	Dawson	1	37.8	pasture	1.38	52.04	5.32	16.76	0.85	0.50	122.44	1.99
		2	12.0	grass hay	1.38	16.52	5.32	5.32	0.85	0.50	38.87	0.63
		3	20.8	grass hay	1.38	28.63	5.32	9.22	0.85	0.50	67.38	1.09
Total JE			**177.8**			**237.0**		**80.1**			**520.2**	**8.8**
Total Johnson			**252.6**			**372.6**		**119.1**			**794.9**	**12.8**
Star 1st	Axelson	10	14.1	alfalfa	1.93	27.25	6.51	7.65	0.85	0.60	53.43	0.76
		11	20.4	corn	1.07	21.87	6.16	10.47	0.85	0.60	42.89	1.04
		12	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.85	0.60	29.77	0.47
		13	3.9	grass/alfalfa	1.43	5.59	5.44	1.77	1.25	0.60	7.45	0.12
		14	12.9	grass/alfalfa	1.43	18.48	5.44	5.85	0.85	0.60	36.23	0.58
		15	7.8	grass/alfalfa	1.43	11.17	5.44	3.54	1.25	0.60	14.90	0.24
		16	2.1	winter wheat	0.29	0.62	2.94	0.51	1.25	0.60	0.82	0.03
		17	5.7	pasture	1.38	7.85	5.32	2.53	0.85	0.50	18.46	0.30
		18	4.3	pasture	1.38	5.92	5.32	1.91	1.00	0.50	11.84	0.19
	Johnson	10	15.2	grass/alfalfa	1.43	21.77	5.44	6.89	0.85	0.60	42.69	0.68
		11	13.2	grass hay	1.38	18.17	5.32	5.85	1.25	0.50	29.08	0.47
		12	5.5	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
Total Star 1st			**110.2**			**153.9**		**51.8**			**287.5**	**4.9**
Star 2nd	Johnson	6	25.6	winter wheat	0.29	7.53	2.94	6.27	0.85	0.60	14.77	0.62
		7A	14.3	grass hay	1.38	19.69	5.32	6.34	0.85	0.50	46.32	0.75
		7B	22.2	grass hay	1.38	30.56	5.32	9.84	0.85	0.50	71.91	1.17
		8	10.5	winter wheat	0.29	3.09	2.94	2.57	0.85	0.60	6.06	0.25
		9A	13.9	alfalfa	1.93	26.86	6.51	7.54	0.85	0.60	52.67	0.75
		9B	9.3	alfalfa	1.93	17.97	6.51	5.05	0.85	0.60	35.24	0.50
		16	5.6	pasture	1.38	7.71	5.32	2.48	1000.00	0.50	0.02	0.00
		17	6.5	pasture	1.38	8.95	5.32	2.88	1000.00	0.50	0.02	0.00
Total Star 2nd			**107.9**			**122.36**		**42.98**			**227.00**	**4.04**
Star 3rd	Cowles	1	38.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
	Axelson	19	20.3	corn	1.07	21.76	6.16	10.42	0.85	0.60	42.67	1.03
		20	19.5	winter wheat	0.29	5.74	2.94	4.78	0.85	0.60	11.25	0.47
Total Star 3rd			**39.8**			**27.5**		**15.2**			**53.9**	**1.5**
Total Star			**257.9**			**303.7**		**109.9**			**568.5**	**10.4**
Total Mgmt Area			**510.5**			**676.4**		**229.0**			**1363.3**	**23.2**

ERO RESOURCES CORPORATION

Scenario 3		0.0	corn									
Future		0.0	alfalfa									
		0.0	pasture									
		0.0	grass hay									
Fields subdivided		590.2	grass/alfalfa									
3/7/95		0.0	winter wheat		ANNUAL	ANNUAL	MAX MONTH	MAX MONTH	CUMULATIVE		ANNUAL	MAX MONTH
					CU	CU	CU	CU	CONVEYANCE	APPLICATION	DIVERSION RQMT	DIVERSION RQMT
DITCH	PROPERTY	FIELD	AREA	CROP	FEET	ACRE FEET	INCHES	ACRE FEET	EFFICIENCY	EFFICIENCY	ACRE FEET	CFS
Johnson West	Axelson	1A	43.0	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		1B	29.6	grass/alfalfa	1.43	42.39	5.44	13.42	0.85	0.60	83.13	1.33
		2A	9.0	grass/alfalfa	1.43	12.89	5.44	4.08	0.85	0.60	25.28	0.40
		2B	1.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		3	11.6	grass/alfalfa	1.43	16.61	5.44	5.26	0.85	0.60	32.58	0.52
		4	19.3	grass/alfalfa	1.43	27.64	5.44	8.75	0.85	0.60	54.20	0.86
		5	13.1	grass/alfalfa	1.43	18.76	5.44	5.94	0.85	0.60	36.79	0.59
		6	5.8	grass/alfalfa	1.43	8.31	5.44	2.63	0.85	0.60	16.29	0.26
		7	5.8	grass/alfalfa	1.43	8.31	5.44	2.63	0.85	0.60	16.29	0.26
		8	16.0	grass/alfalfa	1.43	22.92	5.44	7.25	0.75	0.60	50.92	0.81
		9	221.2	none	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
Total JW			**110.2**			**157.83**		**49.95**			**315.47**	**5.03**
Johnson East	Johnson	1A	23.5	grass/alfalfa	1.43	33.66	5.44	10.65	0.85	0.60	66.00	1.05
		1B	4.0	grass/alfalfa	1.43	5.73	5.44	1.81	0.85	0.60	11.23	0.18
		2	4.8	grass/alfalfa	1.43	6.87	5.44	2.18	0.85	0.60	13.48	0.22
		3	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.85	0.60	29.77	0.47
		4	12.1	grass/alfalfa	1.43	17.33	5.44	5.48	0.85	0.60	33.98	0.54
		5	13.3	grass/alfalfa	1.43	19.05	5.44	6.03	0.50	0.60	63.50	1.01
		13	21.6	grass/alfalfa	1.43	30.94	5.44	9.79	0.10	0.60	515.61	8.23
		14	5.9	grass/alfalfa	1.43	8.45	5.44	2.67	0.50	0.60	28.17	0.45
		15	11.4	grass/alfalfa	1.43	16.33	5.44	5.17	0.50	0.60	54.43	0.87
	Dawson	1	37.8	grass/alfalfa	1.43	54.14	5.44	17.13	0.85	0.60	106.16	1.69
		2	12.0	grass/alfalfa	1.43	17.19	5.44	5.44	0.85	0.60	33.70	0.54
		3	20.8	grass/alfalfa	1.43	29.79	5.44	9.43	0.50	0.60	99.30	1.58
Total JE			**177.8**			**264.7**		**80.6**			**1055.3**	**16.8**
Total Johnson			**288.0**			**412.5**		**130.5**			**1370.8**	**21.9**
Star 1st	Axelson	10	14.1	grass/alfalfa	1.43	20.19	5.44	6.39	0.50	0.60	67.32	1.07
		11	20.4	grass/alfalfa	1.43	29.22	5.44	9.25	0.50	0.60	97.39	1.55
		12	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.50	0.60	50.61	0.81
		13	3.9	grass/alfalfa	1.43	5.59	5.44	1.77	1.25	0.60	7.45	0.12
		14	12.9	grass/alfalfa	1.43	18.48	5.44	5.85	0.67	0.60	45.96	0.73
		15	7.8	grass/alfalfa	1.43	11.17	5.44	3.54	1.25	0.60	14.90	0.24
		16	2.1	grass/alfalfa	1.43	3.01	5.44	0.95	1.25	0.60	4.01	0.06
		17	5.7	grass/alfalfa	1.43	8.16	5.44	2.58	0.67	0.60	20.31	0.32
		18	4.3	grass/alfalfa	1.43	6.16	5.44	1.95	1.00	0.60	10.26	0.16
	Johnson	10	15.2	grass/alfalfa	1.43	21.77	5.44	6.89	0.50	0.60	72.57	1.16
		11	13.2	grass/alfalfa	1.43	18.91	5.44	5.98	1.25	0.60	25.21	0.40
		12	5.5	grass/alfalfa	1.43	7.88	5.44	2.49	0.50	0.60	26.26	0.42
Total Star 1st			**115.7**			**165.7**		**52.4**			**442.2**	**7.1**
Star 2nd	Johnson	6	25.6	grass/alfalfa	1.43	36.67	5.44	11.60	0.85	0.60	71.89	1.15
		7A	14.3	grass/alfalfa	1.43	20.48	5.44	6.48	0.85	0.60	40.16	0.64
		7B	22.2	grass/alfalfa	1.43	31.80	5.44	10.06	0.85	0.60	62.35	0.99
		8	10.5	grass/alfalfa	1.43	15.04	5.44	4.76	0.85	0.60	29.49	0.47
		9A	13.9	grass/alfalfa	1.43	19.91	5.44	6.30	0.85	0.60	39.04	0.62
		9B	9.3	grass/alfalfa	1.43	13.32	5.44	4.22	0.85	0.60	26.12	0.42
		16	5.6	grass/alfalfa	1.43	8.02	5.44	2.54	1000.00	0.60	0.01	0.00
		17	6.5	grass/alfalfa	1.43	9.31	5.44	2.95	1000.00	0.60	0.02	0.00
Total Star 2nd			**107.9**			**154.54**		**48.91**			**269.07**	**4.29**
Star 3rd	Cowles	1	38.8	grass/alfalfa	1.43	55.57	5.44	17.59	0.85	0.60	108.96	1.74
	Axelson	19	20.3	grass/alfalfa	1.43	29.07	5.44	9.20	0.50	0.60	96.92	1.55
		20	19.5	grass/alfalfa	1.43	27.93	5.44	8.84	0.75	0.60	62.06	0.99
Total Star 3rd			**78.6**			**112.6**		**35.6**			**267.9**	**4.3**
Total Star			**302.2**			**432.8**		**137.0**			**979.2**	**15.6**
Total Mgmt Area			**590.2**			**845.3**		**267.5**			**2350.0**	**37.5**

ERO RESOURCES CORPORATION

Scenario 3	0.0	corn	
Future	0.0	alfalfa	
	0.0	pasture	
	0.0	grass hay	
Fields subdivided	590.2	grass/alfalfa	
3/7/95	0.0	winter wheat	

DITCH	PROPERTY	FIELD	AREA	CROP	ANNUAL CU FEET	ANNUAL CU ACRE FEET	MAX MONTH CU INCHES	MAX MONTH CU ACRE FEET	CUMULATIVE CONVEYANCE EFFICIENCY	APPLICATION EFFICIENCY	ANNUAL DIVERSION RQMT ACRE FEET	MAX MONTH DIVERSION RQMT CFS
Johnson West	Axelson	1A	43.0	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		1B	29.6	grass/alfalfa	1.43	42.39	5.44	13.42	0.85	0.60	83.13	1.33
		2A	9.0	grass/alfalfa	1.43	12.89	5.44	4.08	0.85	0.60	25.28	0.40
		2B	1.8	none	0.00	0.00	0.00	0.00	0.85	1.00	0.00	0.00
		3	11.6	grass/alfalfa	1.43	16.61	5.44	5.26	0.85	0.60	32.58	0.52
		4	19.3	grass/alfalfa	1.43	27.64	5.44	8.75	0.85	0.60	54.20	0.86
		5	13.1	grass/alfalfa	1.43	18.76	5.44	5.94	0.85	0.60	36.79	0.59
		6	5.8	grass/alfalfa	1.43	8.31	5.44	2.63	0.85	0.60	16.29	0.26
		7	5.8	grass/alfalfa	1.43	8.31	5.44	2.63	0.85	0.60	16.29	0.26
		8	16.0	grass/alfalfa	1.43	22.92	5.44	7.25	0.85	0.60	44.93	0.72
		9	221.2	none	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
Total JW			**110.2**			**157.83**		**49.95**			**309.48**	**4.94**
Johnson East	Johnson	1A	23.5	grass/alfalfa	1.43	33.66	5.44	10.65	0.85	0.60	66.00	1.05
		1B	4.0	grass/alfalfa	1.43	5.73	5.44	1.81	0.85	0.60	11.23	0.18
		2	4.8	grass/alfalfa	1.43	6.87	5.44	2.18	0.85	0.60	13.48	0.22
		3	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.85	0.60	29.77	0.47
		4	12.1	grass/alfalfa	1.43	17.33	5.44	5.48	0.85	0.60	33.98	0.54
		5	13.3	grass/alfalfa	1.43	19.05	5.44	6.03	0.85	0.60	37.35	0.60
		13	21.6	grass/alfalfa	1.43	30.94	5.44	9.79	0.85	0.60	60.66	0.97
		14	5.9	grass/alfalfa	1.43	8.45	5.44	2.67	0.85	0.60	16.57	0.26
		15	11.4	grass/alfalfa	1.43	16.33	5.44	5.17	0.85	0.60	32.02	0.51
	Dawson	1	37.8	grass/alfalfa	1.43	54.14	5.44	17.13	0.85	0.60	106.16	1.69
		2	12.0	grass/alfalfa	1.43	17.19	5.44	5.44	0.85	0.60	33.70	0.54
		3	20.8	grass/alfalfa	1.43	29.79	5.44	9.43	0.85	0.60	58.41	0.93
Total JE			**177.8**			**254.7**		**80.6**			**499.3**	**8.0**
Total Johnson			**288.0**			**412.5**		**130.5**			**808.8**	**12.9**
Star 1st	Axelson	10	14.1	grass/alfalfa	1.43	20.19	5.44	6.39	0.85	0.60	39.60	0.63
		11	20.4	grass/alfalfa	1.43	29.22	5.44	9.25	0.85	0.60	57.29	0.91
		12	10.6	grass/alfalfa	1.43	15.18	5.44	4.80	0.85	0.60	29.77	0.47
		13	3.9	grass/alfalfa	1.43	5.59	5.44	1.77	1.25	0.60	7.45	0.12
		14	12.9	grass/alfalfa	1.43	18.48	5.44	5.85	0.85	0.60	36.23	0.58
		15	7.8	grass/alfalfa	1.43	11.17	5.44	3.54	1.25	0.60	14.90	0.24
		16	2.1	grass/alfalfa	1.43	3.01	5.44	0.95	1.25	0.60	4.01	0.06
		17	5.7	grass/alfalfa	1.43	8.16	5.44	2.58	0.85	0.60	16.01	0.26
		18	4.3	grass/alfalfa	1.43	6.16	5.44	1.95	1.00	0.60	10.26	0.16
	Johnson	10	15.2	grass/alfalfa	1.43	21.77	5.44	6.89	0.85	0.60	42.69	0.68
		11	13.2	grass/alfalfa	1.43	18.91	5.44	5.98	1.25	0.60	25.21	0.40
		12	5.5	grass/alfalfa	1.43	7.88	5.44	2.49	0.85	0.60	15.45	0.25
Total Star 1st			**115.7**			**165.7**		**52.4**			**298.8**	**4.8**
Star 2nd	Johnson	6	25.6	grass/alfalfa	1.43	36.67	5.44	11.60	0.85	0.60	71.89	1.15
		7A	14.3	grass/alfalfa	1.43	20.48	5.44	6.48	0.85	0.60	40.16	0.64
		7B	22.2	grass/alfalfa	1.43	31.80	5.44	10.06	0.85	0.60	62.35	0.99
		8	10.5	grass/alfalfa	1.43	15.04	5.44	4.76	0.85	0.60	29.49	0.47
		9A	13.9	grass/alfalfa	1.43	19.91	5.44	6.30	0.85	0.60	39.04	0.62
		9B	9.3	grass/alfalfa	1.43	13.32	5.44	4.22	0.85	0.60	26.12	0.42
		16	5.6	grass/alfalfa	1.43	8.02	5.44	2.54	1000.00	0.60	0.01	0.00
		17	6.5	grass/alfalfa	1.43	9.31	5.44	2.95	1000.00	0.60	0.02	0.00
Total Star 2nd			**107.9**			**154.54**		**48.91**			**269.07**	**4.29**
Star 3rd	Cowles	1	38.8	grass/alfalfa	1.43	55.57	5.44	17.59	0.85	0.60	108.96	1.74
	Axelson	19	20.3	grass/alfalfa	1.43	29.07	5.44	9.20	0.85	0.60	57.01	0.91
		20	19.5	grass/alfalfa	1.43	27.93	5.44	8.84	0.85	0.60	54.76	0.87
Total Star 3rd			**78.6**			**112.6**		**35.6**			**220.7**	**3.5**
Total Star			**302.2**			**432.8**		**137.0**			**788.7**	**12.6**
Total Mgmt Area			**590.2**			**845.3**		**267.5**			**1597.5**	**25.5**

ERO RESOURCES CORPORATION

Appendix C: Crop Budgets

The budgets have been adapted from Selected 1993 Crop Enterprise Budgets for Colorado (CSU Extension Publication No. XCM-182, August 1994) by Norman Dalstead, et al. Important assumptions include:

- Average to above average management;
- Adequate irrigation water for full yield;
- Continued City payment of all taxes, water costs, irrigation system capital improvements;
- City payment for establishment of grass hay (estimated cost of $55/acre). Presumably, some of this cost will be recaptured from higher lease revenues in the future. For example, past leases have calculated rent on the basis of $27.50 per acre and $35.00 per ton of new perennial crop yields.

GRASS HAY — 1993
BOULDER OPEN SPACE

	Unit	Price or Cost/Unit ($)	Quantity	Value or Cost Per Acre ($)
Gross Receipts From Production:				
Grass Hay	ton	110.00	2.50	275.00
Grazing Aftermath	aum	8.00	1.00	8.00
Total Receipts				283.00
Direct Costs:				
Operating — Preharvest:				
Nitrogen (actual)	lbs.	0.28	60.00	16.80
Phosphate	lbs.	0.28	40.00	11.20
Irrigation Labor	hrs.	6.00	2.00	12.00
Custom Application Nitrogen	acre	5.00	1.00	5.00
Mach Fuel & Lube	acre			0.35
Mach Repairs	acre			0.16
Interest on Op. Cap.	dols.	0.09	22.30	2.01
Total Preharvest	dols.			47.52
Operating — Harvest:				
Baler Twine	ton	2.00	1.75	3.50
Seasonal Labor	hr.	6.00	2.00	12.00
Mach Fuel & Lube	acre			4.19
Mach Repairs	acre			3.14
Interest on Op. Cap.	dols.	0.09	9.44	0.85
Total Harvest				23.68
Total Operating Costs				71.20
Equipment & Overhead Costs:				
Machinery Replacement	dols.			7.57
Machinery Taxes & Insurance	dols.			1.34
General Farm Overhead	dols.			10.00
Total Equipment & Overhead Costs	dols.			18.91
Total Direct Costs				90.11
Net Receipts	dols.			192.89

IRRIGATED ALFALFA HAY — 1993
BOULDER OPEN SPACE

	Unit	Price or Cost/Unit ($)	Quantity	Value or Cost Per Acre ($)
Gross Receipts From Production:				
Alfalfa	ton	90.00	4.50	405.00
Grazing Aftermath	aum	8.00	1.00	8.00
Total Receipts				413.00
Direct Costs:				
Operating — Preharvest:				
Seed (alloc. cost)	acre.	10.80	1.00	10.80
Insecticide (lorsban)	pt.	6.20	1.50	9.30
Insecticide Appl.	acre	4.00	1.00	4.00
Fertilizer (applied)	lbs.	29.00	1.00	29.00
Irrigation Labor	hr.	6.00	2.00	12.00
Mach Fuel & Lube	acre			3.19
Mach Repairs	acre			1.34
Interest on Op. Cap.	dols.	0.09	39.87	3.59
Total Preharvest	dols.			73.22
Operating — Harvest:				4.60
Baler Twine-Wire	ton	0.92	5.00	24.00
Custom Windrowing	acre	8.00	3.00	35.00
Custom Stacking	ton	7.00	5.00	2.25
Mach Fuel & Lube	acre			1.88
Mach Repairs	acre			2.98
Interest on Op. Cap.	dols.	0.09	33.08	70.70
Total Harvest				143.92
Total Operating Costs				
Equipment & Overhead Costs:				3.72
Machinery Replacement	dols.			0.65
Machinery Taxes & Insurance	dols.			30.00
General Farm Overhead	dols.			34.37
Total Equipment & Overhead Costs	dols.			178.29
Total Direct Costs				
Net Receipts	dols.			234.71

Flood irrigated
Seed and fertilizer costs are allocated over six years
At current yield of 3.5 tons/acre, net receipts are estimated to be $105.71/acre.

IRRIGATED CORN GRAIN — 1993
BOULDER OPEN SPACE

	Unit	Price or Cost/Unit ($)	Quantity	Value or Cost Per Acre ($)
Gross Receipts From Production:				
Corn	bu.	2.50	120.00	300.00
Grazing Aftermath	aum	8.00	1.00	8.00
Total Receipts				308.00
Direct Costs:				
Operating — Preharvest:				
Fertilizer	acre.	50.00	1.00	50.00
Insecticide (counter)	lbs.	1.75	9.00	15.75
Insecticide (comite)	acre	13.75	1.00	13.75
Fertilizer (application)	acre	6.00	1.00	6.00
Seed	acre	28.80	1.00	28.80
Herbicide	acre	18.00	1.00	18.00
Irrigation Labor	hr.	6.00	3.00	18.00
Mach Fuel & Lube	acre			9.22
Mach Repairs	acre			7.50
Interest on Op. Cap.	dols.	0.09	108.91	9.80
Total Preharvest	dols.			176.82
Operating — Harvest:				
Truck Driver	hr.	6.00	0.50	3.00
Cust Comb & Haul	acre	20.00	1.00	20.00
Mach Fuel & Lube	acre			1.43
Mach Repairs	acre			1.06
Interest on Op. Cap.	dols.	0.09	4.25	0.38
Total Harvest				25.87
Total Operating Costs				202.69
Equipment & Overhead Costs:				
Machinery Replacement	dols.			18.00
Machinery Taxes & Insurance	dols.			3.32
General Farm Overhead	dols.			30.00
Total Equipment & Overhead Costs	dols.			51.32
Total Direct Costs				254.01
Net Receipts	dols.			53.99

IRRIGATED BARLEY-FEED — 1993
BOULDER OPEN SPACE

	Unit	Price or Cost/Unit ($)	Quantity	Value or Cost Per Acre ($)
Gross Receipts From Production:				
Barley	bu.	2.95	80.00	236.00
Grazing Aftermath	aum	8.00	1.00	8.00
Total Receipts				244.00
Direct Costs:				
Operating — Preharvest:				
Nitrogen (actual)	lbs.	0.31	150.00	46.50
Phosphate	lbs.	0.28	40.00	11.20
Seed	lbs.	0.08	100.00	8.00
Herbicide (bronate)	pts.	9.63	1.50	14.45
Custom Herbicide Applic.	acre	4.00	1.00	4.00
Irrigation labor	hr.	6.00	1.00	6.00
Mach Fuel & Lube	acre			5.11
Mach Repairs	acre			2.80
Interest on Op. Cap.	dols.	0.09	66.00	5.94
Total Preharvest	dols.			104.00
Operating — Harvest:				
Custom Harvest	acre	30.00	1.00	30.00
Mach Fuel & Lube	acre			0.00
Mach Repairs	acre			0.00
Interest on Op. Cap.	dols.	0.09	10.00	0.90
Total Harvest				30.90
Total Operating Costs				134.90
Equipment & Overhead Costs:				
Machinery Replacement	dols.			7.21
Machinery Taxes & Insurance	dols.			1.38
General Farm Overhead	dols.			15.00
Total Equipment & Overhead Costs	dols.			23.59
Total Direct Costs				158.49
Net Receipts	dols.			85.51