COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

FINAL REPORT OF FINDINGS

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February 15, 1994

SMALL DAM SITE RECONNAISSANCE STUDY

COLORADO WATER CONSERVATION BOARD

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COLORADO WATER CONSERVATION BOARD

ATTACHMENTS

Reconnaissance Report for Each Dam Site (22), attached in alphabetical order:

Beaver Creek Dam and Reservoir
Big Battlement Dam and Reservoir
Bootleg Dam and Reservoir
Cactus Park Dam and Reservoir
Cucharas Dam and Reservoir
Currier Dam and Reservoir
East Lake Dam and Reservoir
Fort Morgan (City of) Alternative Site Study
Gould Dam and Reservoir
Granby #12 Dam and Reservoir
Idaho Springs Dam and Reservoir
Leroux Creek Water Users Dam Repair and Enlargement Assessment
Lilylands Dam and Reservoir
Mattie Dam and Reservoir
Orlando Dam and Reservoir
Palisade #1 Dam and Reservoir
Palisade #3 Dam and Reservoir
Prospect Dam and Reservoir
Red Mesa Dam and Reservoir
Sams Knob Dam and Reservoir
Todd Dam and Reservoir

One Page Descriptions of "39 Dam Sites" found during the inventory, attached in one section.

SMALL DAM SITE RECONNAISSANCE STUDY

COLORADO WATER CONSERVATION BOARD

CHAPTER I
INTRODUCTION

This report describes the results of the "Small Dam Site Reconnaissance Study" (Study) performed by Harris Water Engineering, Inc. (HWE), for the Colorado Water Conservation Board (CWCB). The work began on September 1, 1993 and was completed on February 15, 1993.

The broad philosophy of the Study is that Colorado is lagging behind downstream states in the utilization of allocated water supplies, which is especially true in the Colorado River basin. Given the difficulty of constructing large dams in today's social and environmental climate, the philosophy of constructing small dams is to minimize potential social and environmental problems while increasing the utilization of Colorado's water supplies, a little at a time. A baseball analogy would be to "hit a lot of singles to score runs rather than waiting for a home run".

The purpose of the Study is to identify and evaluate, at a reconnaissance level, dam sites where there is a real need for raw water storage. The sites may include the construction of a new dam, reconstruction of a dam that is currently breached, or enlargement of an existing dam. The Study includes recommendations on how to develop those sites which appear to have repayment capability. The CWCB will work with the respective sponsoring entities to attempt to develop a loan financing package, through the CWCB Construction Fund.

A related purpose of the Study is to assist smaller water entities, who do not have adequate staff, to perform the initial technical and cost evaluations to determine if their dam site is feasible. The smaller water entities typically have a system operator who have ideas on how to increase the water supply through storage, but do not have the resources nor time to make the necessary evaluations. Most of the sites included in the Study involve small irrigation companies, small water conservancy districts, or small towns.

The Study included five distinct tasks, which are listed below.

1. Canvas Water Users to Identify Potential Sites
2. Site Inspection of Most Sites
3. Prepare Reconnaissance Level Design Reports and Recommendations for Each Site
4. Design Reports and Recommendation Review
5. Finalize Designs Reports and Recommendations

Task 1 was performed in September of 1993. Task 2 was conducted in October of 1993. The design reports were prepared in Task 3 during November and December of 1993. The design reports were sent to the CWCB, the dam safety engineers, and the individual sponsoring entities for review and comment during January of 1994. The final report was completed and submitted to the CWCB and each entity on February 15, 1994.

The following chapters describe the work performed, and the results of the Study.

CHAPTER II
INVENTORY DAM SITES

Task 1 involved canvassing water users from throughout the State which was performed in September, 1993. The method of canvasing was to attempt to contact every water conservancy district, dam safety engineer and major water organization. Due to bad phone numbers and logistic difficulty of reaching so many people, not every water conservancy district was reached.

The general procedure was to contact entities, ask if they had any plans to increase water storage, if so obtain information; then ask if they knew of anyone else who should be contacted. About half of the identified sites were from the targeted entities and half from references.

During Task 1, 65 water users were contacted which are listed in Table A. From these calls a total of 39 reservoir sites were identified which are listed in Table B. One page descriptions of the 39 sites are included in the attachments, "39 Sites". Of the total of 39 sites, 22 of the sites met the intent of the Study.

During task 1, it became obvious that the larger entities usually have staff or consulting engineers, who know how to obtain CWCB funds; these groups did not have a need for the work performed as part of this Study. On the other hand, the smaller entities generally do not have time to plan projects and therefore received the greatest benefit from this Study.

The dam sites which were included in the study are owned or sponsored by smaller water organizations from around the state.

All of the sites involve a water organization; there are no individual owners or developers. The reason is probably the method of canvassing which concentrated on organizations, and the fact that individuals do not build many dams.

TABLE A
ORGANIZATIONS CONTACTED IN TASK 1

<u>Division of Water Resources</u>

- Water Division 1
- Water Division 2
- Water Division 3
- Water Division 4
- Water Division 5
- Water Division 6
- Water Division 7

<u>Water Conservancy Districts</u>

- Basalt
- Battlement Mesa
- Central Colorado
- Collbran
- Costilla County
- Dolores
- Fruitland Mesa
- Grand Mesa
- Lower South Platte
- Mancos
- Michigan River
- Middle Park
- North La Junta
- Northern Colorado
- Purgatoire River
- Rio Grande
- San Luis Valley
- Southeastern
- Upper Arkansas
- Upper Gunnison River
- Upper Yampa
- Ute
- West Divide
- Yellow Jacket

<u>Water Conservation Districts</u>

- Colorado River
- Southwestern

<u>Reservoir and Irrigation Companies</u>

- Henrylyn Irrigation District
- Rio Grande Ditch Company
- Surface Creek Ditch and Reservoir Company
- Granby Ditch Company
- North Poudre Irrigation Company
- Welton Ditch Company
- Water Supply and Storage Company

TABLE A
ORGANIZATIONS CONTACTED IN TASK 1
(continued)

Cities and Towns

- Delta
- Eagle
- Fort Collins
- Fort Morgan
- Greeley
- Gypsum
- Idaho Springs
- Kremmling
- Loveland
- Oak Creek
- Palisade
- Paonia
- Victor
- Walsenberg

Soil Conservation Service

- Durango
- Alamosa
- Greeley

Consultants

- Joanne Fagan - Delta
- Davis Engineering - Del Norte
- Smith Geotech - Fort Collins

Other Organizations

- Colorado Water Resources and Power Development Authority
- Summit County
- Eagle Valley Water and Sanitation District
- Mt. Crested Butte Water and Sanitation District
- Snowmass Water and Sanitation District
- Office of Community Services - Cortez
- Department of Local Affairs - Durango
- State Engineers Office
- Colorado Water Conservation Board

TABLE B
SMALL DAM INVENTORY
LIST OF ALL IDENTIFIED DAMS

Entity	Dam Name	Type	Size (AF)	Use
DAM SITES TO BE STUDIED IN MORE DETAIL				
Town of Paonia	Todd Reservoir	Enlargement	200	Mun
Town of Palisade	Palisade #1	Enlargement	80	Mun
	Palisade #3	Rebuild	80	Mun
City of Idaho Springs	Mattie	Diversion	10	Mun
	Idaho Springs	Enlargement	1200	Mun
City of Victor	#2 Reservoir	Enlargement	200	Mun
LeRoux Creek WUA	Sheepsdrive	Enlargement	200	Irrig
	Baily	Enlargement	small	Irrig
Red Mesa Ward Co.	Red Mesa Ward	Enlargement	1300	Ir,Mn
Welton Ditch Co.	Cuchares	Rebuild	35000	Ir,Mn
	Orlando	Purchase	3800	Irrig
Lilylands Canal Co.	Lilylands	Enlargement	1500	Irrig
Dolores WCD	Beaver Creek	New	7900	Fish
Henry Lyn ID	Bootleg	Rebuild	1700	Fld,Ir
	Prospect	Enlargement	12000	Irrig
City of Delta	Big Battlement	Rebuild	medium	Pwr,Mn
Granby Ditch Co.	Granby	Repair	small	Irrig
City of Fort Morgan	not selected	New	small	Mun
Don Meeks	Backmeadow	New	60	Irrig
Fruitland Mesa WCD	Gould	Enlargement	medium	Irrig
Battlement Mesa WCD	Currier	New	200	Irrig
Grand Mesa WCD	Cactus Park	New	15000	Irrig
Snowmass Water & San	Sams Knob	New	250	Mun
Vail Valley Con. Watr Dis	East Lake Creek	New	8000	Mun
DON'T NEED ASSISTANCE FROM THIS STUDY				
Town of Oak Creek	Sheriff	Rehab	980	Mun
Mt Crested Butte W&S	unnamed	New	medium	Mun
City of Durango	Terminal	Enlargement	1500	Mun
City of Greely	Milton-Seaman	Enlargement	10000	Mun
Town of Kremmling	Jones #2	Enlargement	small	Mun
City of Loveland	Green-Ridge Glade	Enlargement	6000	Mun
Central Colorado WCD	Koenig Pit	New	1500	Mun
Dolores WCD	Monument Creek	New	small	Mun
	Plateau	New	large	Pwr
Fruitland Mesa WCD	Soap Creek	New	large	all
Yellow Jacket WCD	Avery	Enlargement	medium	Irrg
Big Stick Ditch Co.	Big Stick	New	small	Irrg
Upper Arkansas WCD	North Fork	Enlargement	1100	Mun
Ute WCD	Owens	New	32000	all

CHAPTER III
SITE INSPECTIONS

Task 2 involved a field inspection of 19 of the 24 sites; the remaining 5 sites either did not require a inspection or HWE had previously been to the site. The 5 sites not visited, were Beaver Creek (late getting information), Sams Knob (couldn't arrange visit), East Lake Creek (couldn't arrange visit), Lilylands (inspected previously), and Backmeadow (wasn't considered). Figure A shows the location of the 24 sites.

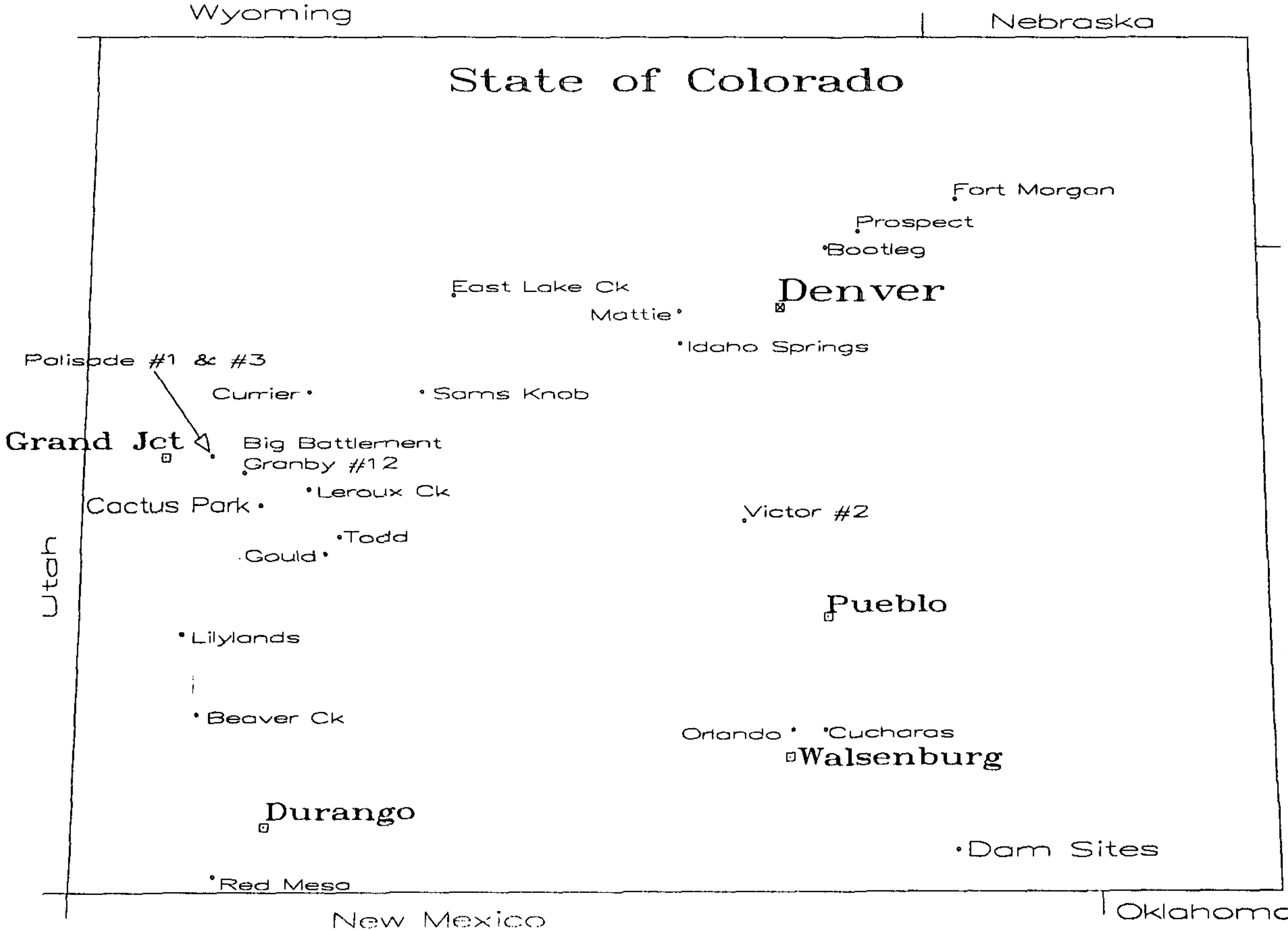
The field inspections also involved discussions with the respective entities to assess their need for the water and payment ability.

During the visits, as much data as could be found was copied or arrangements made to acquire the data. Most of the sites had existing data, from the Dam Safety Engineers or owners, because the sites involved an enlargement or reconstruction.

The larger new sites, such as Cactus Park, were studied extensively by the Bureau of Reclamation. Also, the CWCB had been involved in many site studies in the past. Generally, the sites that had been studied extensively in the past and found infeasible, had not changed to the point that they are feasible today.

The data collected and notes taken during the site inspections are summarized in the individual evaluation reports for each site.

Figure A – Dam Site Location Map



CHAPTER IV
DAM SITE RECONNAISSANCE REPORTS

Reconnaissance reports were prepared for 19 dam sites and 3 entities who did not have a specific dam site. The sites and type of analysis was generally the same as envisioned in Task 1 but some of the sites changed in scope or new information showed the site was at a different stage of development than originally thought.

The reports are attached in alphabetical order by dam site. Each report is self supporting; it does not need this summary or other information to be reviewed.

The reports are based on the best available data, which in some cases is significant and others minimal.

The general assumptions used in the reports are described in the following sections of this chapter.

Design Assumptions

The designs included in the Study primarily involve a new dam or enlargement of an existing dam. Most of the sites included in the Study are earth embankments; however, there is at least one site which is probably best suited to roller compacted concrete (RCC) because of spillway requirements.

The basic earth dam embankment design assumption is that when in doubt of stability, flatten the embankment slopes. Flattening the slopes increases the amount of material to be placed but reduces the design costs and makes the construction simpler. Also, the embankments are usually assumed to be homogeneous, not zoned. This assumption is based on the availability of impervious material at most locations.

Most of the entities prefer to use local contractors who are familiar with compacted earth embankments but are not familiar with internal drainage systems (e.g. chimney drains) and may have problems with zoned embankments. Even though the amount of embankment material is increased, the total construction cost is probably less because of simpler designs and construction procedures.

The "Rules and Regulations for Dam Safety and Dam Construction" (Regulations) prepared by the State of Colorado, Office of the State Engineer, Division of Water Resources were used for the preliminary designs.

The dam height is based on the necessary reservoir capacity plus 5 feet of freeboard. Five feet of freeboard is the minimum allowed by the Regulations, but since essentially all of the reservoirs have small surface areas the wave action should not require more than 5 feet. If freeboard is increased at any site, it was to raise the water depth over the spillway to pass the inflow design flood. The maximum crest width is 25 feet as stated in the Rules and Regulations.

The typical upstream slope is 3.0H:1.0V and the downstream slope is 2.5H:1.0V, which should provide a good factor of safety unless the soils tests shows the material to have some deficiency. If there is an impervious core with a pervious shell, the impervious core has minimum slopes of 1.0H:1.0V upstream and downstream.

The embankment quantity is estimated by using the best available topography to determine the cross section at the dam centerline; the average end area method is used to estimate the volume. The embankment volume is increased by 30% for compaction to determine the quantity of material to be placed.

If an RCC dam best fits the site, the upstream slope is vertical and the downstream slope is 0.8H:1.0V, as suggested in the publication "Roller Compacted Concrete II".

A cutoff trench is included in all embankments, normally 20 feet wide and 20 feet deep. The trench wall is assumed vertical for quantity estimates but will probably not be vertical in actual construction.

The crest width is determined from the Regulations which state that the crest width shall be the "height divided by 5 plus 10 feet" or 25 feet which ever is less.

The outlet pipe size, if not an enlargement, is assumed to be larger than necessary, usually 3 or 4 feet in diameter. The pipe material is suggested to be reinforced concrete or steel. A slide gate is included if not already in place. Most of the dams include a hand wheel to control the gate; a motorized control mechanism is needed on only a few of the dams.

The appropriate inflow design flood to be passed around the dam is based on Bureau of Reclamation criteria for reconnaissance studies. Where the spillway is existing, the current size is assumed to be adequate for an enlargement, unless there is a known safety problem. Most of the reservoirs have very small drainage areas. A concrete cutoff wall is included at each spillway, if not in rock, to maintain the channel shape and the channel crest elevation.

Rip rap was assumed on the face of each dam to be 2 feet thick including the blanket.

Reservoir capacity is determined from USGS Quad map topography if not available otherwise, e.g. Division Engineer's office. The reservoir volume is estimated assuming a straight line increase in area between known areas at specified elevations. There is likely to be a large error if Quad map topography is all that is available.

The annual reservoir yield was generally assumed to be the reservoir capacity. In most cases this is a very safe assumption, but for some sites this would not be true; these cases are noted. Also, an evaluation of the annual yield is recommended for further study for some dam sites.

Cost Information

A reconnaissance level cost estimate is prepared for each dam site. The cost estimate is plus or minus 25% and is included to generally determine which sites may be feasible and which sites are clearly not feasible. For purposes of this Study, "feasible" means the sponsoring entity can repay the amortized construction cost.

The construction cost is the total of the embankment, outlet pipe, and spillway costs. An amount of 30% is added for contingencies, which is greater than the normal 20% because of the low level of detail. The engineering and administration cost varies from 5% to 15% depending upon the difficultly of the design and the amount of detailed data that is needed. For instance, if materials testing has been performed in the past, the percentage can be decreased.

A mobilization cost is included for each dam site. The cost varies considerably from nearly nothing to significant. The higher mobilizations costs indicate access problems, particularly where an access road must be reconstructed.

The embankment quantity is the largest factor in the cost estimate and the cost per cubic yard to place material is the most difficult to determine. Three costs per cubic yard were assumed depending upon: (1) the difficulty of construction, (2) from previous studies and (3) contractor estimates. Also, two of the entities have contacted contractors in their local area, as noted for those sites. The assumed cost per cubic yard are explained:

$2 per cubic yard - Used at sites with minimal difficulty and the borrow area nearby or where the sponsoring entity has data to support the cost.

$4 per cubic yard - Used at sites with average difficulty where the borrow area is within a half mile and there are no major problems with placement.

$6 per cubic yard - Used at sites with difficult construction such as restricted access in US Forest Service land, borrow areas not obvious, access over poor roads, or in high cost areas (e.g. Aspen).

Rip rap was assumed to be $20 per cubic yard because most sites are in areas with rock in the immediate vicinity.

The outlet pipe cost is the price of the particular size pipe doubled. The control gates are not a significant cost and are estimated to the nearest $5000.

The cost per cubic yard to excavate the spillway, if needed, is assumed to be half the cost of material placement. Concrete in the cutoff wall is $300 per cubic yard.

A toe drain is included at nearly every site, which will consist of a 5 foot deep, 2 foot wide trench (0.27 cubic yards per linear foot) filled with ASTM C-33 sand. A drain pipe with 1/16th inch slotted is placed in the sand to convey water from the trench to a surface channel. The sand is estimated at $30 per cubic yard delivered, the pipe is $1.50 per foot, and the placement cost is estimated to be $20 per cubic yard. The composite total of the costs is $20 per linear foot of toe drain.

The above items are totaled to determine the estimated construction cost for each dam site.

Financing

The total construction cost for each dam site is evaluated using several different financing options. The standard CWCB financing terms (as of December, 1993) of either 4% for 30 years or 3.5% for 20 years were evaluated for each site. It is understood that the rates change according to the financial markets which was not incorporated herein.

If an irrigation entity could not repay under those terms, the financing terms were improved until they could. In order to be affordable, irrigation water was assumed to be less than $30 per acre-foot for year. Municipal water was assumed to be repayable at the standard CWCB rates, even though there are some small towns which might have justification for slightly better terms.

A "Financing Option" table is included for each dam site which shows the annual amortized construction cost and the cost per acre-foot based on the annual yield. The values in the table for each dam site was a major factor in evaluating the feasibility of each site and the recommendations described in Chapter V.

CHAPTER V
FINDINGS AND RECOMMENDATIONS

The findings and recommendations are separated into (1) dam site recommendations which deal with the sites evaluated during the Study and (2) general findings concerning water storage in the state not related to specific sites.

Dam Site Recommendations

The 22 dam sites are broadly categorized by:

Good Sites - Sites that have good potential for being implemented and appear to be feasible. These sites do not have any obvious major problems; technically, environmentally, financially, or ownership.

Moderate Sites - Sites that have reasonable potential but have a technical, environmental, financial, or ownership problem which may preclude development, in the near future or ever. Usually, the problem concerns a lack of immediate buyers for the water.

Poor Sites - Sites that have little or no chance of being developed because of one or more major problems. Usually, involves an irrigation dam which is beyond the irrigators ability to repay the costs, even with reduced financing terms.

Misc. Sites - Sites that need additional study to determine what facilities would be needed.

Each of the sites was placed in a category, based on objective and subjective information. The key question for inclusion in the Good Category is: "Is this dam site ready for immediate implementation?" Implementation broadly means, is the site ready to proceed to the next step in development; in most cases this includes plans and specifications but some sites need additional planning studies.

Identification of the Good Sites was the primary purpose of this Study. There are 9 sites in this category. 3 sites are for irrigation which require some degree of reduced financial terms. The remainder are for municipal water with standard financing terms. Two of the "Moderate Sites", Big Battlement and Granby #12, could be ready for development in the near future if negotiations to sell water for hydropower move quickly.

Tables C, D, E, and F list the dam sites in each category. Pertinent data, such as construction cost, financing terms needed for feasibility, and major problems are shown.

The sites that involve rebuilding or enlarging existing dams can be implemented sooner than new dams. Quick development of a new dam would be 4 years; 6 to 8 years is more realistic. Enlargements of existing dams will be easier but not easy. There are still many steps, permits, and approvals to obtain; feasibility study funds are suggested for several of these sites to allow the entity to begin this process, almost immediately, rather than waiting for the CWCB construction fund process.

The specific recommendations for each dam site are included in the evaluation report for each site. The general recommendations on how to proceed include:

1. For "good sites", it is recommended that the sponsoring entity seriously consider development of their dam site and that the CWCB contact, if necessary, each of the 9 entities in the near future to assess their interest. Each report includes specific recommendations on the next step, if any, for the particular dam site.

2. The "moderate" sites should be tracked, because they may be ready for development at some point in the future.

3. The "poor" sites do not show any potential for development using the CWCB Construction Fund. Several of these sites may be eligible for Colorado River Storage Project funds, if that is ever available directly to the state.

4. The "misc." sites generally recommend feasibility study funds to perform planning work to assess the needs of the entity. For instance, the Leroux Creek Water Users Associations is recommended to apply for feasibility study funds to assess the repair needs, and enlargement potential, at the numerous dams owned by the association; then apply for construction funds to make the repairs and enlargements, if appropriate, while the long term interest rates are low.

<u>General Recommendations</u>

These recommendations generally concern water storage issues, based on the findings of this Study.

1. Development of water storage for irrigation will require reduced financing terms; the amount of reduction depends on the dam site and the entity. This report recommends that the CWCB consider appropriate reduced financing terms to allow development of irrigation reservoirs.

2. Many of the entities, especially, irrigators are unlikely to apply for feasibility study funds on a loan basis. This report suggests that the CWCB return to the past policy where feasibility study funds are forgiven, if a feasible development is not found. If the feasibility study results in development, the study costs are added to the construction loan.

3. The Study showed that there are several potential enlargements or new dams in the idea stage which are not moving forward because of personnel time. The staff, if any, of small sponsoring entities are busy with operations and do not have time to formulate plans, involve engineers and process the CWCB requirements. Also, the smaller entities are reluctant to pay for engineering services and were very receptive to having the CWCB send an engineer to evaluate their situation. It is these smaller entities who benefitted the most from this Study, and who will probably need assistance to prepare and process the CWCB requirements, possibly followed by engineering assistance for plans and designs.

4. The Study also showed that there are many entities with restricted dams who do not have the time nor funds to correct the problems. Many of the dam repairs do not require much cost to prepare engineering designs or construction. Design of a toe drain or determination of the PMF for the spillway, are typical plans and specifications. Major reconstruction is needed on less than half of the restricted dams. Many people wanted to convey the message that the water storage infrastructure needs repair to maintain the present water usage.

5. In order to follow up on the sites identified in this Study, the CWCB will need to continue to provide assistance to the small entities. The CWCB staff can provide assistance to entities around Denver but do not have the time to assist entities in the western part of the State (Water Divisions 3, 4, 7 and part of 5) because of travel time. This report suggests that the CWCB consider retaining a consultant, or re-instituting a CWCB engineering staff member, in the western part of the state to assist entities.

It is further suggested that if a consultant, the firm be retained for one year at a time with annual renewals if the work is progressing satisfactorily, for a maximum of 3 or 4 years. The CWCB selection process requires too much time and staff effort to select a consultant each year if the work is satisfactory.

The west slope CWCB representative would: (a) assist in preparing and processing any CWCB administrative requirements associated with the follow up of dams identified in this Study, (b) coordinate with water users, Division Engineers and dam safety inspectors to continue to identify potential new dams or enlargement of existing dams, and (c) coordinate with the dam safety inspectors to determine what is necessary to repair restricted dams and if appropriate implement plans to make the repairs.

Since the smaller entities will probably need engineering assistance, it is also suggested that the representative assist with: (a) any engineering work required for the CWCB, (b) minor engineering designs for dam repairs for the SEO (such as plans and specifications), and (c) assist the entity in selecting an engineering firm for major repairs. The CWCB could add all or part of these costs to the loan if one is eventually received.

6. An increasingly important issue for dam owners is with the US Forest Service, particularly in the Grand Mesa area. The agency is seriously restricting access to private dams; to the detriment of public safety. In some cases the water user is not allowed to make minimal improvements to roads in order to repair dams within the Forest. The USFS has also suggested that dam owners may be required to notify the USFS prior to any visit to a dam, even to adjust the headgate. The local water users have not been successful in dealing with the local USFS office and would like the CWCB and SEO to assist at a higher level.

TABLE C

SMALL DAM SITE RECONNAISSANCE STUDY – GOOD SITES*

Dam Name	Entity	Description	Storage Volume (ac–ft)	Estimated Construction Cost	Recommended Financing Terms	Annual Loan Repayment	Cost per Ac–Ft	Feasibility Funds Needed
East Lake Crk	Vail Valley Water Dis	New, Mun	5780	$12,230,000	4% for 30 yrs	$707,300	$109	Yes
Lilylands	Lilylands Canal Co.	Enlarge, Irrg	1686	$1,470,000	1% for 40 yrs	$44,800	$27	Yes**
Mattie	City of Idaho Springs	Diversion	n/a	$45,200	Probably None			
Orlando	Welton Ditch Co.	Purchase, Irg	2966	$1,500,000	3.5% for 30 yrs	$81,600	$28	Yes***
Palisade #1	Town of Palisade	Repair, Mun	11	$27,300	None			
Palisade #3	Town of Palisade	Rebuild, Mun	40	$289,000	3% for 20 yrs	$19,500	$488	Yes**
Red Mesa	Red Mesa Ward Co.	Enlarge, Irrg	2900	$2,068,000	2% for 40 yrs	$75,600	$26	Yes
Sams Knob	Snowmass W&S Dis	New, Mun	537	$2,765,000	4% for 30 yrs	$159,900	$226	Yes
Todd Reservoir	Town of Paonia	Repair, Mun	110	$168,000	3% for 15 yrs	$14,000	$127	No
		TOTALS	14030	$20,562,500		$1,102,700		

* Good Sites are dams which appear to be ready to proceed toward construction.

** Feasibility funds will be used for plans and specifications.

*** Feasibility funds for water supply evaluation and property appraisal.

TABLE D
SMALL DAM SITE RECONNAISSANCE STUDY – MODERATE SITES*

Dam Name	Entity	Description	Storage Volume (ac–ft)	Estimated Construction Cost	Needed to Move Foreward	Feasibility Funds Needed
Beaver Creek	Dolores WCD	New, Fish	1500	$1,300,000	Fishery Entity To Pay Most of Cost	Eventually
Big Battlement	City of Delta	Rebuild, Pwr	816	$348,000	Hydropower Pay Most of Cost	Maybe
Bootleg	Henry Lyn ID	Rebuild, Irrg	1500	$3,087,000	Flood Control to Pay Most of Cost	Maybe
Cucharas	To Be Determined	Rebuild, all	28800	$8,590,000	A Sponsoring Entity & Water Market	Eventually
Granby #12	Granby Ditch Co.	Repair, Irrg	227	$77,900	Delta Proceed with Big Battlement	No
Idaho Springs	City of Idaho Springs	Enlarge, Mun	1400	$6,760,000	Market for Water	Eventually
Prospect	Henrylyn Irrig. Co.	Enlarge, Irrg	2958	$1,780,000	Reduce Existing Debt	Maybe
		TOTALS	37201	$21,942,900		

* Moderate Sites are dams that need something to be ready for construction, usually entities to purchase water.

TABLE E
SMALL DAM SITE RECONNAISSANCE STUDY – POOR SITES*

Dam Name	Entity	Description	Storage Volume (ac–ft)	Estimated Construction Cost	Description of Problem
Backmeadow	Don Meeks	New, Irrg			Too Expensive
Cactus Park	Grand Mesa WCD	New, Irrg	11300	$40,837,000	Water is Beyond Irrigators Ability to Pay
Currier	Battlment Mesa WCD	New, Irrg	115	$214,000	Water is Beyond Irrigators Ability to Pay
Gould	Fruitland Mesa WCD	Enlarge, Irrg	4000	$7,557,000	Water is Beyond Irrigators Ability to Pay

* Poor Sites are dams that have no chance of being constructed because the cost is too high, all for irrigation.

TABLE F

SMALL DAM SITE RECONNAISSANCE STUDY – MISC. SITES*

Dam Name	Entity	Description of Issue	Feasibility Funds Needed
Not Identified	City of Fort Morgan	Needs a peaking reservoir but not for many years.	Yes
Numerous Dams	LeRoux Creek WUA	Assess repair needs to existing dams, with possible enlargements.	Yes
Reservoir #2	City of Victor	Other options for raw water storage, rather than repair Reservoir #2.	No

* Misc. Sites are dams or entities that need other work prior to considering a specific dam site or have other options.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

BEAVER CREEK DAM AND RESERVOIR
Sponsored By The Dolores Water Conservancy District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
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February 15, 1994

BEAVER CREEK DAM AND RESERVOIR

PLAN DESCRIPTION

Beaver Dam & Reservoir would be a new structure located on Beaver Creek which is a tributary of the Dolores River. Beaver Creek flows into McPhee Reservoir on the Dolores River. The dam and reservoir would be about 20 miles north of the Town of Dolores, Adjacent to the Dolores-Norwood Road. Figure 1 shows the general reservoir location, Figure 2 is a copy of a USGS Quad map showing the reservoir site and drainage basin.

The sponsoring entity for the dam and contact person are:

Dolores Water Conservancy District
John Porter, Manager 303-565-7562
P.O. Box 1117
Cortez, Colorado 81321

The dam would be constructed by the Dolores Water Conservancy District (DWCD) for additional fishery releases to the Dolores River below McPhee Reservoir. The fishery flow below McPhee Dam has been an issue for several years because the Dolores Project releases turned out to be inadequate in dry years, the Bureau of Reclamation is in the process of attempting to obtain additional water for the releases. Beaver Creek reservoir would be one possibility for the water supply.

Data for a second reservoir, Bear Creek Dam and Reservoir, is included herein because the site is located on the east fork of the Dolores River and can provide augmentation water as well as fish water. The site is shown on Figure 1 and Figure 3 shows the Quad map for the Bear Creek Reservoir. The cost of Bear Creek Dam is substantially greater than Beaver Creek.

The drainage basin above Beaver Creek Reservoir is about 25 square miles, covered with brush and grass, and an average elevation of about 9000 feet.

This reconnaissance report describes the engineering issues, construction, and costs of constructing Beaver Creek dam primarily and Bear Creek dam in less detail. The preliminary designs developed for this report are based upon Quad map data, a site visit was not made nor is any field data available, so there will be significant changes as more detailed studies are performed.

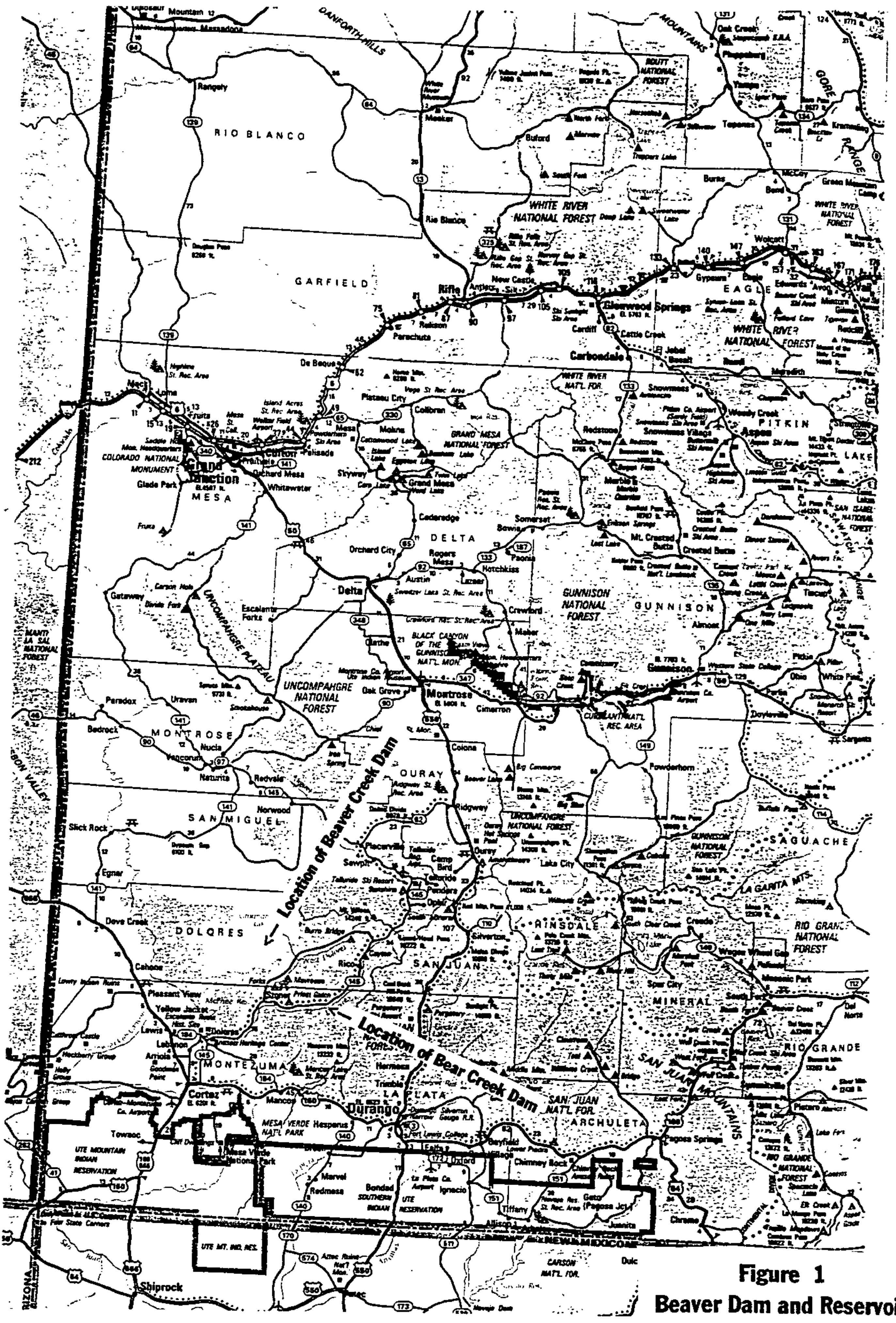


Figure 1
Beaver Dam and Reservoir
Location Map

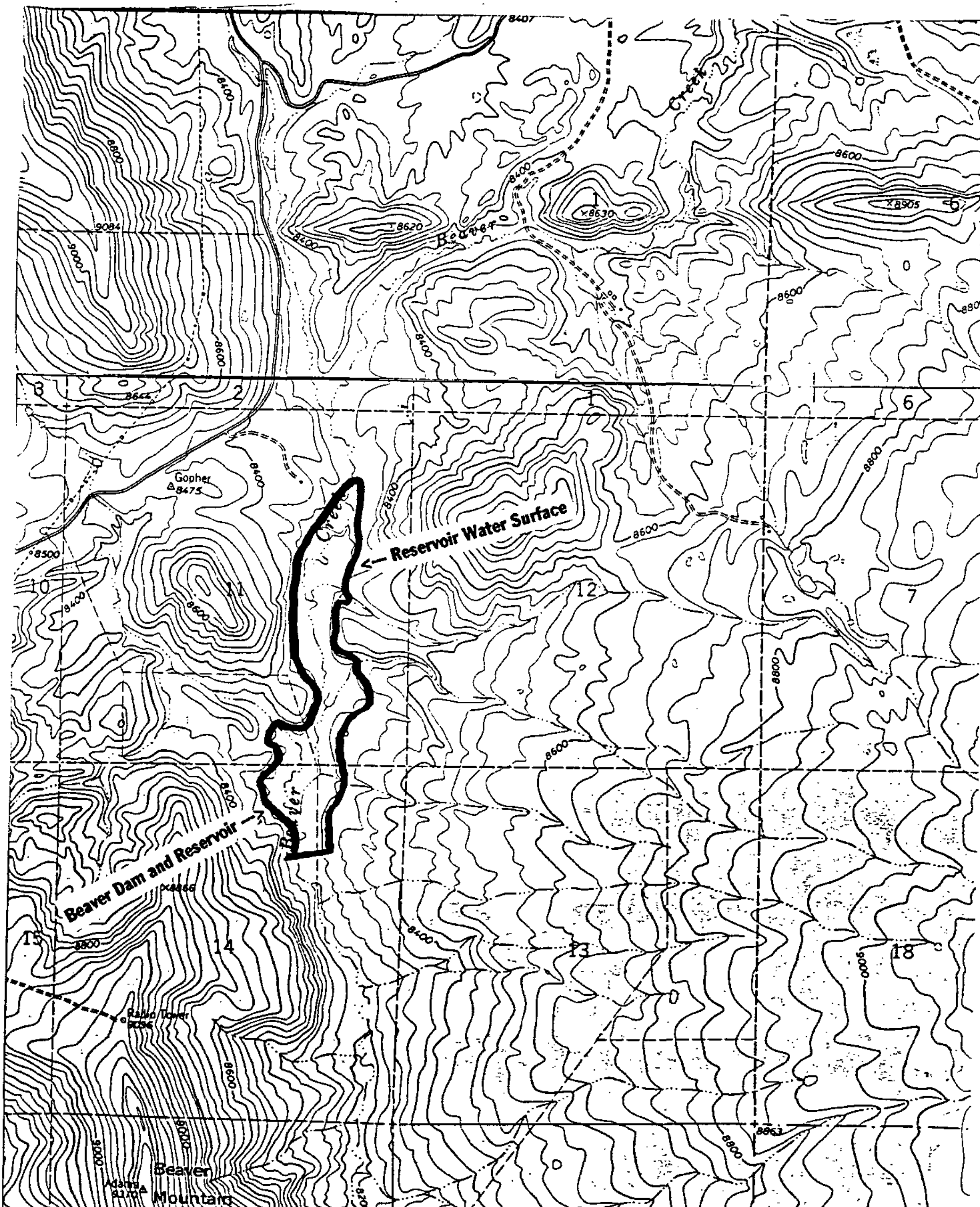


Figure 2
Beaver Dam and Reservoir
Dam and Reservoir Site Map

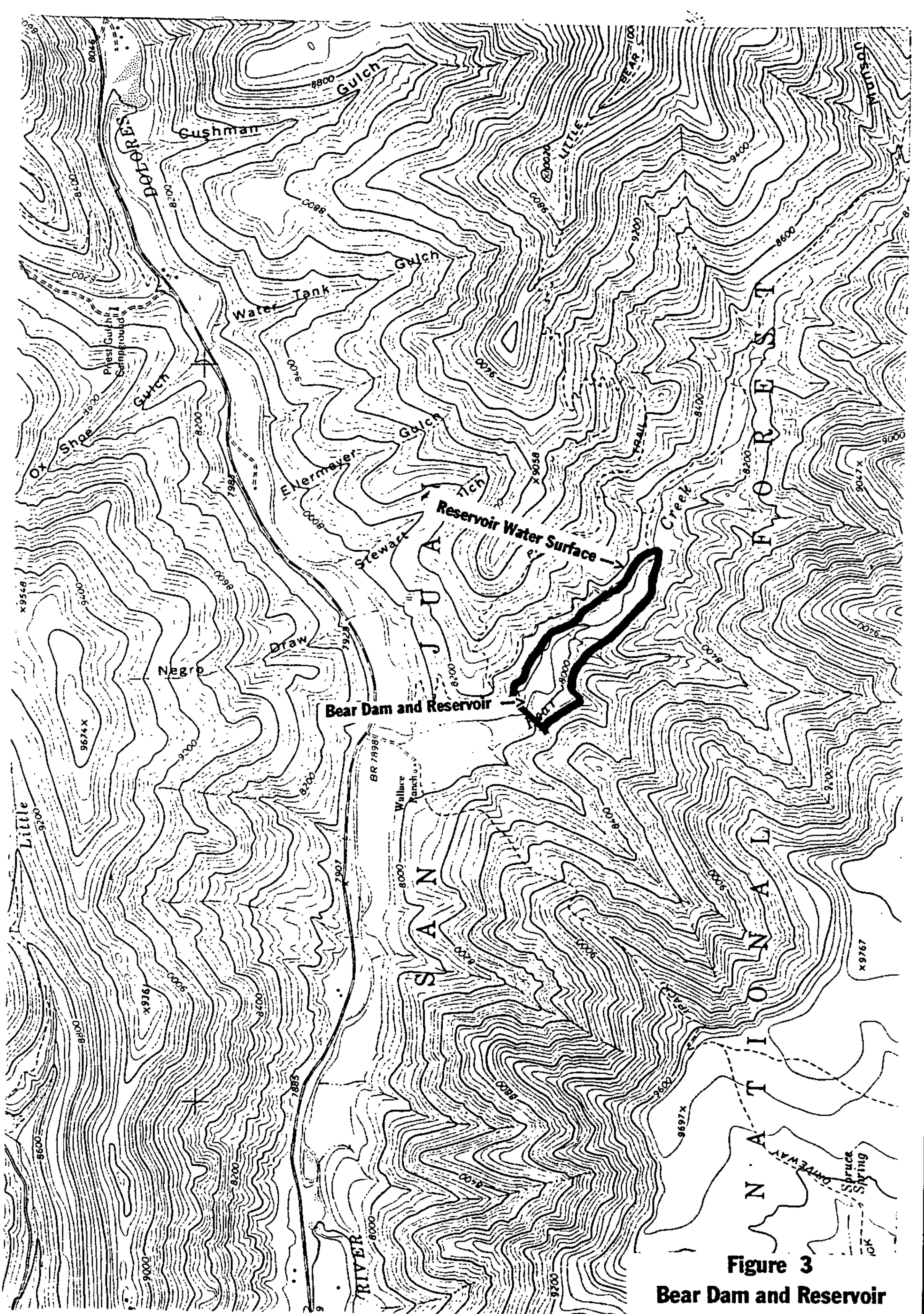


Figure 3
Bear Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The DWCD holds storage water rights for the Beaver Creek Reservoir for over 16,000 acre-feet.

The average annual runoff was estimated using Bureau of Reclamation runoff correlations for the years 1952 through 1971 which estimated the average runoff to be 350 acre-feet per square mile for the average basin elevation of 9000 feet. The total average annual runoff for the basin would be 8750 acre-feet per year. Assuming a dry year yield of 25% of the average year, would result in 2200 acre-feet.

The annual water supply should be adequate to fill a 1500 acre-foot reservoir each year.

The alternative Bear Creek Reservoir has a significantly larger drainage area and a higher average elevation which would yield considerably more water to fill the proposed 1500 acre-foot reservoir. The DWCD also has water rights for this site.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the Beaver Creek Reservoir. Table 2 shows the same data for the Bear Creek Reservoir. The areas and associated capacities were developed from 1 inch equals 2000 feet USGS Quad maps.

In order to store 1500 acre-feet the Beaver Creek reservoir water level would be at elevation 8284 feet, 39 feet above the stream channel. The Bear Creek reservoir water level would be at elevation 8046 feet, 92 feet above the stream channel. About 40 acre-feet of inactive storage is included in each reservoir. The water level for the Beaver Creek Dam is 53 feet less than Bear Creek Dam.

TABLE 1
BEAVER DAM & RESERVOIR
Elevation – Area – Capacity

Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8320	115	4979.5	
8319	113.9	4865.1	
8318	112.8	4751.7	
8317	111.7	4639.5	
8316	110.6	4528.3	
8315	109.5	4418.3	
8314	108.4	4309.3	
8313	107.3	4201.5	
8312	106.2	4094.7	
8311	105.1	3989.1	
8310	104	3884.5	
8309	102.9	3781.1	
8308	101.8	3678.7	
8307	100.7	3577.5	
8306	99.6	3477.3	
8305	98.5	3378.3	
8304	97.4	3280.3	
8303	96.3	3183.5	
8302	95.2	3087.7	
8301	94.1	2993.1	
8300	93	2899.5	
8299	91.9	2807.1	
8298	90.8	2715.7	
8297	89.7	2625.5	
8296	88.6	2536.3	
8295	87.5	2448.3	
8294	86.4	2361.3	Proposed Top of Dam
8293	85.3	2275.5	
8292	84.2	2190.7	
8291	83.1	2107.1	
8290	82	2024.5	
8289	80.9	1943.1	
8288	79.8	1862.7	
8287	78.7	1783.5	
8286	77.6	1705.3	
8285	76.5	1628.3	
8284	75.4	1552.3	Proposed Spillway Crest
8283	74.3	1477.5	
8282	73.2	1403.7	
8281	72.1	1331.1	
8280	71	1259.5	

TABLE 1
BEAVER DAM & RESERVOIR
Elevation – Area – Capacity

Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8279	69	1189.5	
8278	67	1121.5	
8277	65	1055.5	
8276	63	991.5	
8275	61	929.5	
8274	59	869.5	
8273	57	811.5	
8272	55	755.5	
8271	53	701.5	
8270	51	649.5	
8269	49	599.5	
8268	47	551.5	
8267	45	505.5	
8266	43	461.5	
8265	41	419.5	
8264	39	379.5	
8263	37	341.5	
8262	35	305.5	
8261	33	271.5	
8260	31	239.5	
8259	29	209.5	
8258	27	181.5	
8257	25	155.5	
8256	23	131.5	
8255	21	109.5	
8254	19	89.5	
8253	17	71.5	
8252	15	55.5	
8251	13	41.5	
8250	11	29.5	Intake to Outlet Pipe
8249	9	19.5	
8248	7	11.5	
8247	5	5.5	
8246	3	1.5	
8245	0	0.0	

TABLE 2
BEAR CREEK DAM & RESERVOIR
Elevation – Area – Capacity

Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8080	58	3231.6	
8078	56.9	3116.7	
8076	55.8	3004.0	
8074	54.7	2893.5	
8072	53.6	2785.2	
8070	52.5	2679.1	
8068	51.4	2575.2	
8066	50.3	2473.5	
8064	49.2	2374.0	
8062	48.1	2276.7	
8060	47	2181.6	
8058	45.9	2088.7	
8056	44.8	1998.0	Proposed Top of Dam
8054	43.7	1909.5	
8052	42.6	1823.2	
8050	41.5	1739.1	
8048	40.4	1657.2	
8046	39.3	1577.5	Proposed Crest of Spillway
8044	38.2	1500.0	
8042	37.1	1424.7	
8040	35	1352.6	
8038	34	1283.6	
8036	33	1216.6	
8034	32	1151.6	
8032	31	1088.6	
8030	30	1027.6	
8028	29	968.6	
8026	28	911.6	
8024	27	856.6	
8022	26	803.6	
8020	25	752.6	
8018	24	703.6	
8016	23	656.6	
8014	22	611.6	
8012	21	568.6	
8010	20	527.6	
8008	19	488.6	
8006	18	451.6	
8004	17	416.6	
8002	16	383.6	
8000	15.6	352.0	

TABLE 2
BEAR CREEK DAM & RESERVOIR
Elevation – Area – Capacity

Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
7998	14.9	321.5	
7996	14.2	292.4	
7994	13.5	264.7	
7992	12.8	238.4	
7990	12.1	213.5	
7988	11.4	190.0	
7986	10.7	167.9	
7984	10	147.2	
7982	9.3	127.9	
7980	8.6	110.0	
7978	7.9	93.5	
7976	7.2	78.4	
7974	6.5	64.7	
7972	5.8	52.4	
7970	5.1	41.5	Intake to Outlet Pipe
7968	4.4	32.0	
7966	3.7	23.9	
7964	3	17.2	
7962	2.3	11.9	
7960	1.8	7.8	
7958	1.4	4.6	
7956	1	2.2	
7954	0.6	0.6	
7952	0	0.0	

DAM EMBANKMENT

Both dams would be jurisdictional requiring preparation of plans and specifications for approval by the State Engineer prior to construction. Beaver Dam is expected to be an intermediate Class II structure; there would probably be no loss of life if the dam failed. Bear Creek Dam is expected to be an intermediate Class I dam, there would be loss of life if the dam failed. The reconnaissance designs described herein are based upon data taken from Quad maps and general knowledge of the area; more detailed engineering work may result in a different designs.

The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, 25 feet maximum,
* a spillway capable of passing 100% of the PMP flood for Class I and 50% of the PMP for Class II,
* upstream rip rap to protect the embankment,
* and complete soils investigation and analysis.

EMBANKMENT: Both dams are expected to be homogeneous earth embankments constructed from impervious material in the reservoir basin. Two alternative sites were looked at for the Beaver Creek dam with the site resulting in the greatest capacity for the shortest embankment chosen and is described herein.

The Bear Creek drainage was inspected for suitable sites and the site chosen at the mouth of the creek is by far the best location. Sites upstream not only had poor reservoir basins but access would be a major problem because there are no roads.

Tables 3 and 4 show the estimated embankment volumes for the Beaver and Bear Creek dams respectively. The Bear Creek dam has a significantly greater volume and associated cost, the cost of the two dams are shown in Tables 5 and 6. The following description is for the Beaver Creek Dam and Reservoir only because the cost of Bear Creek dam does not appear to be feasible.

Beaver Creek Dam would have the following the dimensions:

* 49 feet high, 10 feet of freeboard
* crest length of about 600 feet,
* crest width of 20 feet,
* 3.25H:1.0V upstream and 2.5H:1.0V downstream slopes
* 36 inch diameter outlet pipe,
* 90 foot wide spillway to pass 50% of the PMP.

A 20 foot deep, 20 foot wide core trench would be excavated most of the length of the and upstream of the centerline of the embankment.

Figure 4 shows the cross section of the dam at the outlet pipe. Figure 5 shows the front elevation view of the embankment looking upstream from below the dam.

There is assumed to be adequate impermeable material for the embankment available in the reservoir basin. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir. Table 3 shows the estimated volume of material required to construct the embankment. The material would be placed in lifts and compacted to at least 95% Standard Proctor. Adequate testing will be required to monitor the compaction.

Rip rap is expected to be available in the immediate area.

A toe drain is included to control seepage through the embankment. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 350 feet long.

The reservoir would be on private land which will require the purchase of about 100 acres for the dam, reservoir, and needed access.

OUTLET PIPE: The outlet pipe size is suggested to be 36 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance and if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be thick walled steel, possibly lined with mortar or another material, reinforced concrete pipe is also a possibility; CMP is not recommended.

SPILLWAY: The spillway will be sized to pass 50% of the PMF (probable maximum flood). Since the drainage basin is 25 square miles the size of the flood will be significant, estimated to be about 15,000 using Bureau of Reclamation reconnaissance study criteria. One half of the flood would be 7500 cfs which the spillway should pass in combination with the reservoir surcharge.

A spillway width of 90 feet with 1:1 side slopes, excavated on the east abutment is assumed herein. The freeboard of 10 feet is included in the design. Based upon the equation: flow is equal to the length (90 feet) times a flow factor "C" (2.7) times the water depth (10 feet) to the 1.5 power, the spillway would pass about 7600 cfs. This is a conservative estimate because the reservoir surcharge would reduce the flood peak.

The spillway would discharge into the channel below the dam. A concrete cutoff wall perpendicular to the flow of water is included to stabilize the spillway section. The wall would be about 2 feet thick, at least 2 feet below the ground surface at any point along the wall, and be the desired shape of the spillway cross section (15 wide at the base and sloping up a 1:1 on either side).

TABLE 3
BEAVER CREEK DAM – EMBANKMENT VOLUME

2 foot Stripping Depth
3.25 :1 Upstream
2.5 :1 Downstream
20 foot Crest Width
8294 foot Crest Elevation

20 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
1000	8320	0	0				
				422	1333	632	1965
1270	8282	14	844				
				2645	19593	2963	22556
1470	8260	36	4446				
				6472	43147	2667	45814
1650	8245	51	8498				
				5940.5	15401	1037	16438
1720	8265	31	3383				
				2113.5	6262	1185	7447
1800	8282	14	844				
				422	642	304	946
1930	8320	0	0				

Total Volume of Enlarged West Embankment (cubic yards) 95200

Total Material Excavated and Placed in Cubic Yards (30% Compaction) 123800

TABLE 4
BEAR CREEK DAM – EMBANKMENT VOLUME

2	foot Stripping Depth
3.25	:1 Upstream
2.5	:1 Downstream
25	foot Crest Width
8056	foot Crest Elevation
20	foot Key Trench Width
20	foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
1000	8080	2	62				
				722	963	400	1363
1090	8040	18	1382				
				6252	25471	1630	27101
1200	8000	58	11122				
				20592	53387	1037	54424
1270	7960	98	30062				
				32508	252840	3111	255951
1480	7952	106	34954				
				32508	144480	1778	146258
1600	7960	98	30062				
				20592	45760	889	46649
1660	8000	58	11122				
				6252	9262	593	9855
1700	8040	18	1382				
				691	717	207	924
1770	8080	0	0				

Total Volume of Embankment (cubic yards) 542500

Total Material Excavated and Placed in Cubic Yards (30% Compaction) 705300

Figure 4
Beaver Creek Dam and Reservoir
Cross Section at Outlet Pipe

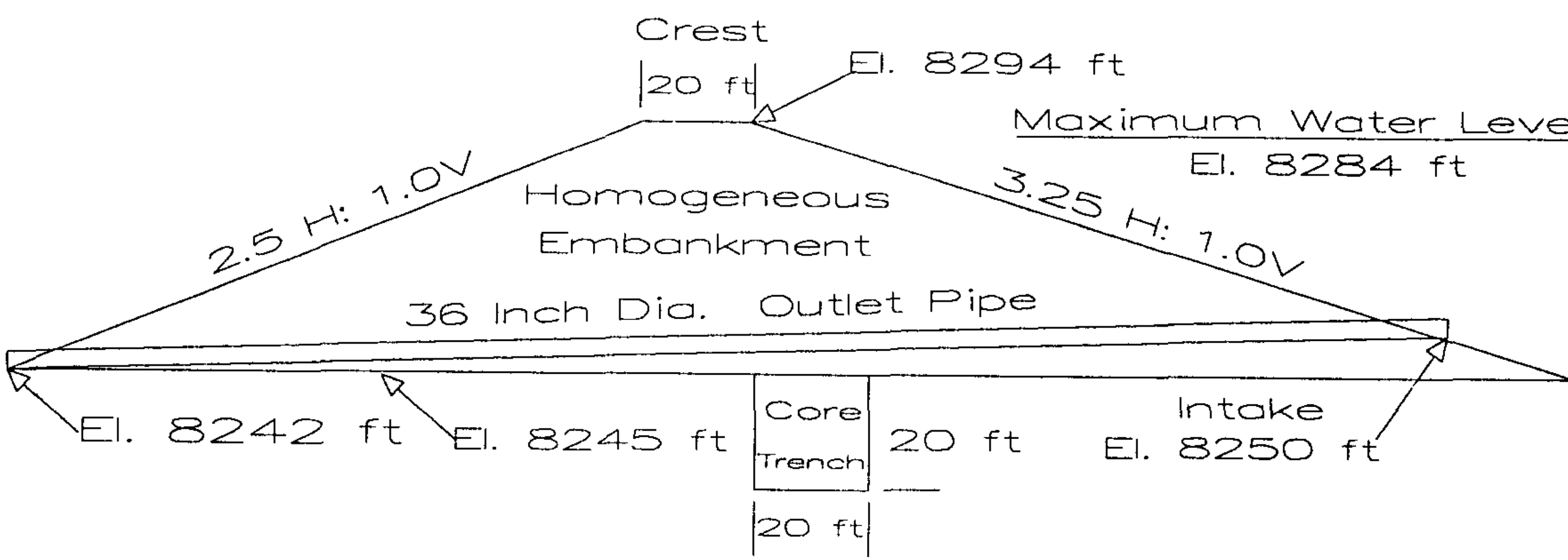
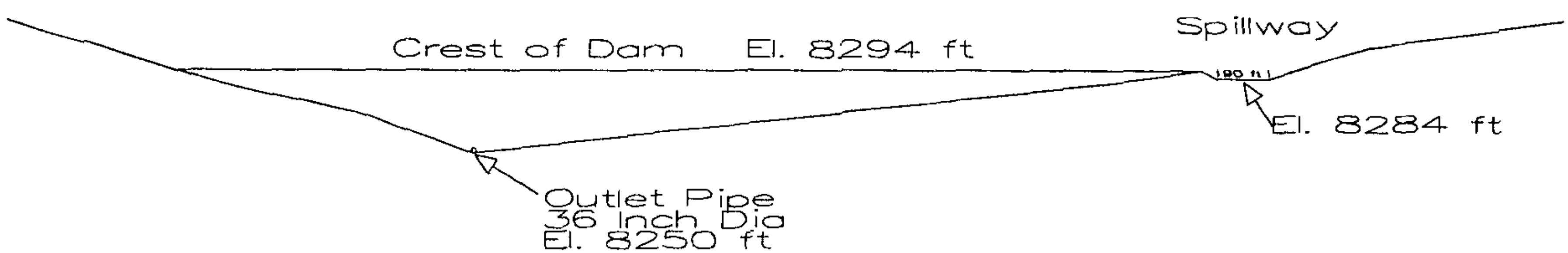


Figure 5
Beaver Creek Dam and Reservoir
Cross Section at Dam Center Line



COST ESTIMATE

The estimated cost to construct the Beaver Creek Dam is shown in Table 5 and Bear Creek Dam in Table 6. The unit costs are based upon unit cost for rural areas of the state. The land cost is estimated at $1000 per acre.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% based which includes: permit applications, preparation of plans and specifications and construction observation.

A 404 permit will be needed from the Corp of Engineers which will trigger endangered species consultation and wetlands evaluations. The Beaver Creek site does not appear to have any obvious environmental problems but the process could be lengthy.

FINANCING

Even though Beaver Creek Dam and Reservoir would be constructed by the DWCD, the repayment would be provided mostly by other sources which might include: Federal Government, Division of Wildlife, etc.. The process to arrange the repayment has not been identified and the costs and financing herein may be the motivation to pursue construction of the reservoir.

Assuming that the reservoir might be ready for construction in the near future, Table 7 shows several financing options assuming financing from the CWCB. Option 1 is the standard CWCB loan terms as of December, 1993; the terms change with national interest rates. The other options are better terms which might be available but with special CWCB approval.

RECOMMENDATIONS

Beaver Creek Dam and Reservoir is significantly less costly than Bear Creek Dam and Reservoir, even though the latter is more centrally located. Beaver Creek probably offers the best reservoir site in the upper Dolores River drainage.

Beaver Creek Dam and Reservoir is a relatively inexpensive site and could offer significant cost advantages if additional storage would solve the fishery problem. The site should be kept on the "back burner" in the event that additional storage is needed. There are no specific recommendations on how to proceed with development because the entities to repay the costs are not determined. Bear Creek dam is probably very costly and other alternatives should be investigated.

TABLE 5
BEAVER CREEK DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$20,000
Embankment				
Compacted Fill	cy	123800	$4.00	$495,200
Rip Rap	cy	2890	$20.00	$57,800
Toe Drain	lf	350	$25.00	$8,750
	Embankment Subtotal			$561,750
Outlet Works				
Outlet Pipe, 36 inch	lf	260	$300	$78,000
Gate and Controls	ls			$15,000
	Outlet Works Subtotal			$93,000
Spillway				
Excavation	cy	66670	$2.00	$133,300
Concrete Control Section	cy	10	$300.00	$3,000
	Spillway Subtotal			$136,300
	Total of Above Items			$791,050
	Contingency (30%)			$237,300
	Land Cost (100 acres)			$100,000
	Field Cost Subtotal			$1,128,350
	Engineering & Admin (15%)			$169,300
TOTAL ESTIMATED CONSTRUCTION COST				$1,300,000
Construction Cost per Acre-Foot of Additional Storage				$870
Additional Reservoir Storage in Acre-Feet				1500

TABLE 6
BEAR CREEK DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$20,000
Embankment				
Compacted Fill	cy	542500	$4.00	$2,170,000
Rip Rap	cy	6220	$20.00	$124,400
Toe Drain	lf	500	$25.00	$12,500
	Embankment Subtotal			$2,306,900
Outlet Works				
Outlet Pipe, 36 inch	lf	550	$300	$165,000
Gate and Controls	ls			$15,000
	Outlet Works Subtotal			$180,000
Spillway				
Excavation	cy	66670	$2.00	$133,300
Concrete Control Section	cy	20	$300.00	$6,000
	Spillway Subtotal			$139,300
	Total of Above Items			$2,626,200
	Contingency (30%)			$787,900
	Land Cost (40 acres)			$40,000
	Field Cost Subtotal			$3,454,100
	Engineering & Admin (15%)			$518,100
TOTAL ESTIMATED CONSTRUCTION COST				$3,970,000
Construction Cost per Acre–Foot of Storage				$2,650
Reservoir Storage in Acre–Feet				1500

TABLE 7
BEAVER CREEK DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$1,300,000	4.0%	30	$75,179	$50
2	$1,300,000	4.0%	40	$65,681	$44
3	$1,300,000	3.5%	30	$70,683	$47
4	$1,300,000	3.5%	40	$60,875	$41
5	$1,300,000	3.0%	30	$66,325	$44
6	$1,300,000	3.0%	40	$56,241	$37
7	$1,300,000	2.0%	40	$47,522	$32
	Volume of Reservoir Storage in Acre–Feet:				1500

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

BIG BATTLEMENT DAM AND RESERVOIR
Owned By The City of Delta

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

BIG BATTLEMENT DAM AND RESERVOIR

PLAN DESCRIPTION

Big Battlement Reservoir (aka Battlement #2) is an existing reservoir located in the Dirty George Creek drainage of the Gunnison River basin about 12 miles north of the Town of Cedaredge. The reservoir is in the Grand Mesa National Forest. Figure 1 is a location map showing the reservoir within in Colorado and relative to the Town of Cedaredge. Figure 2 is a copy of a USGS Quad map showing the reservoir site.

The dam and reservoir are owned by the City of Delta. The address and contact person are:

City of Delta
P.O. Box 19
Delta, Colorado 81416

Ron Alexander, Public Works Director 874-7566

The dam was constructed in the early part of the century with a height of about 24 feet. A restriction is imposed on the dam because of sink holes on the embankment which indicate piping of embankment materials. The restriction is at gage height 8 feet which leaves about one third of the reservoir capacity. The seepage and piping problem appears to be controlled at the restricted water level but a further restriction may be imposed if corrective measures are not initiated in the next few years or the restricted water level is not adequately controlled.

Due to the number and extent of the sink holes, a plan which has a reasonable chance of controlling the embankment and foundation seepage cannot be identified. Reconstruction of the dam is believed to be the best option to utilize the reservoir.

The major construction problem is that the reservoir is located in the Grand Mesa National Forest and the local Forest office will not allow improvement to the access road for construction equipment and materials. The present road is extremely rough and almost inaccessible. No outside materials, such as sand for a toe drain or concrete, can be hauled to the dam.

Big Battlement Reservoir is adjacent to Granby #12 Reservoir, which is owned by the Granby Ditch and Reservoir Company, see Figures 1 and 2. Granby #12 Dam and Reservoir, as explained in the report for that dam, is also in need of repairs. Due to the access difficulty, this report is predicated on the construction work at both reservoirs being performed jointly. One engineer and one contractor are assumed to perform the work at both sites, and any other repairs that may be needed at other dams in the area.

The work at Big Battlement is much greater than at Granby #12 so that the schedule for Big Battlement will control the schedule for Granby #12. In short, Granby #12 repairs cannot be economically accomplished, with present access road, without cooperation from the City; the opposite is not true, the City could proceed with reconstruction of Big Battlement without joint repairs at Granby #12.

Negotiations are being conducted with the Forest Service to allow the access road to be upgraded to make access easier. The outcome of these discussions will have a major impact on the cost of Big Battlement reconstruction for both mobilization and unit costs.

This reconnaissance report describes the engineering issues, construction, and costs of reconstruction of the dam to its historical water level. Technically the embankment reconstruction is an enlargement because the spillway was lowered in the mid 1980's and the plan herein is to have the reservoir water level at the previous water elevation.

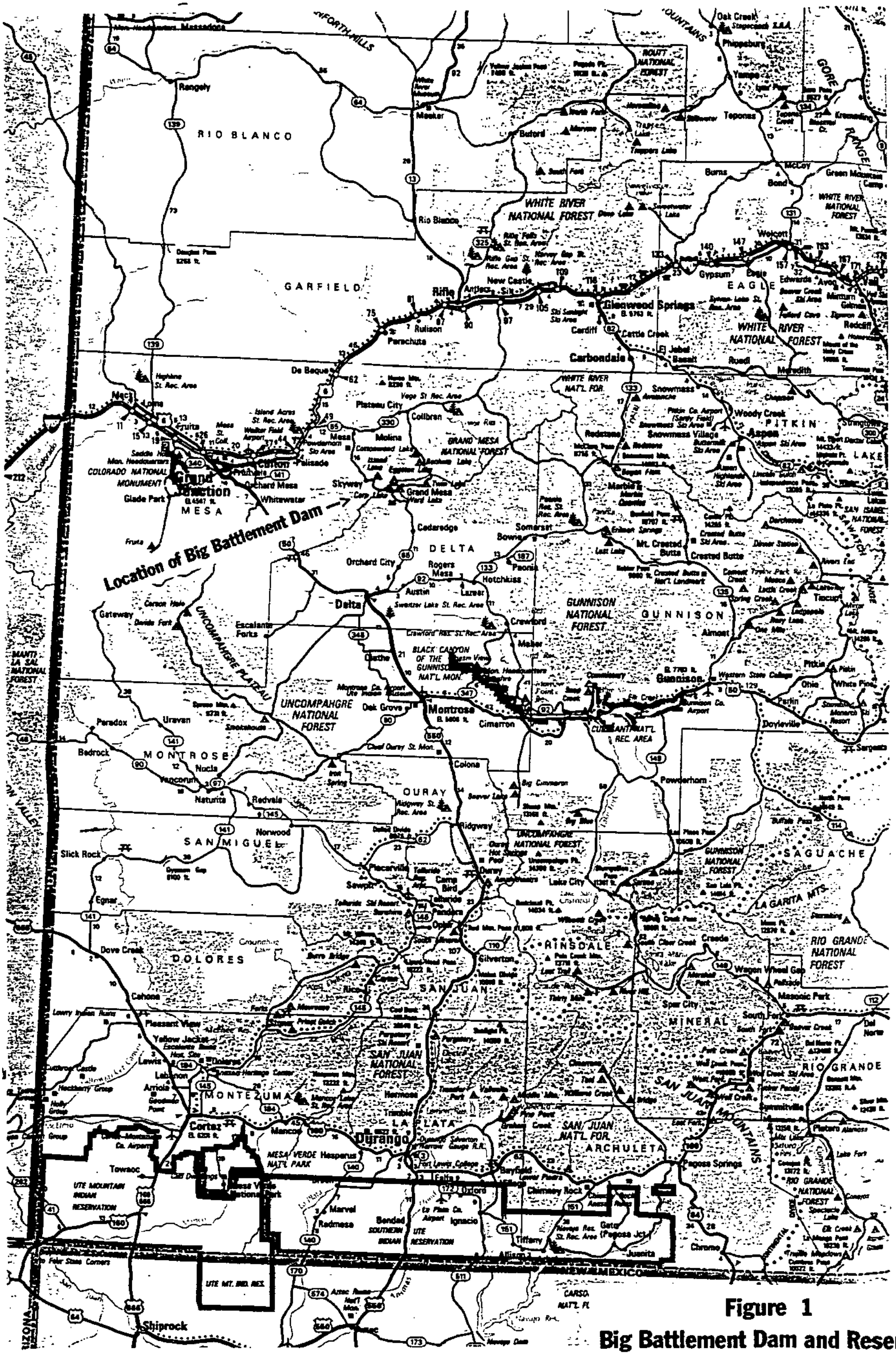


Figure 1
Big Battlement Dam and Reservoir Location Map

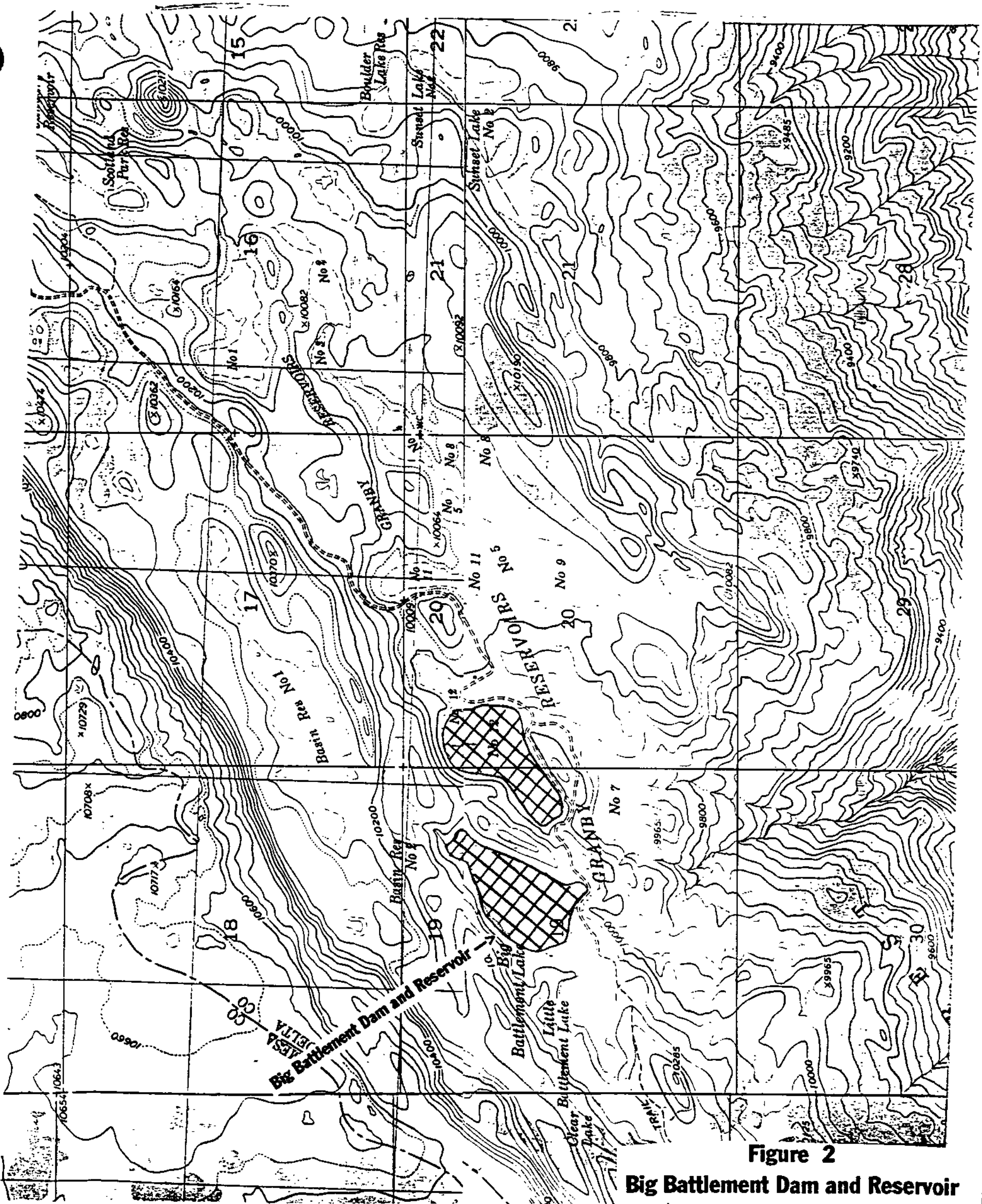


Figure 2
Big Battlement Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The City of Delta owns Big Battlement Reservoir and the adjacent Little Battlement Reservoir. There is essentially no drainage area above the reservoir; the reservoir surface is the drainage area. The reservoir is filled from excess water from upstream reservoirs, conveyed through ditches and primarily from overflow from Little Battlement which is constantly filled by a large spring.

The reservoirs in the system fill each year except in the driest periods. The capacity of the reconstructed reservoir will be about 816 acre-feet; the restricted volume is 257 acre-feet.

Presently the City of Delta sells the water stored in the reservoirs to irrigators around Cedaredge. The City water supply is provided by "Project 7", a municipal water system in the Uncompahgre Valley; which will be adequate for about 20 years. In the long term the City plans to obtain water from the Battlement Reservoirs for municipal water.

In the short term, the City has an agreement with a hydropower company to sell Big Battlement Reservoir water for hydropower production by releasing water from the reservoir into a penstock and then dropped through a power plant. After release through the power plant, the City is attempting to negotiate with an aquaculture company to purchase the water for fish rearing.

The hydropower plan includes reconstructing Big Battlement so that the storage capacity is available to release water in the late summer. The City can either repair Big Battlement themselves and receive greater revenue from the hydropower production or the hydropower company will reconstruct the dam with reduced revenues to the City.

RESERVOIR

An elevation-area-capacity for the reservoir is included in Table 1. The inlet to the outlet pipe is presently at relative elevation 100 feet; the existing crest is at relative elevation 124.1 feet over the outlet pipe. The reconstructed reservoir is assumed to have the same elevations for the outlet pipe and the crest, however, detailed surveys should be performed to determine if the dam can be raised to 127 or 128 feet for a small increase in storage.

The reservoir is presently restricted to relative elevation 108 feet (gage height 8), which is 257.3 acre-feet. With repairs, the capacity of the reservoir would be at least 816.8 acre-feet. The additional yield from the reconstructed reservoir is assumed to be 559 acre-feet, the difference between the potential capacity and the restricted capacity.

TABLE 1
BIG BATTLEMENT DAM & RESERVOIR
Elevation– Area–Capacity

Gage Height (feet)	Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
25	125	60	1098.9	Top of Reconstructed Dam
24	124	58	1038.9	
23	123	56	980.9	
22	122	54.7	924.9	
21	121	53.4	870.2	
20	120	52.2	816.8	Spillway Crest
19	119	51.3	764.6	
18	118	50.2	713.3	
17	117	49.3	663.1	
16	116	48.3	613.8	
15	115	47.2	565.5	
14	114	46	518.3	
13	113	45	472.3	
12	112	44.1	427.3	
11	111	43	383.2	
10	110	42.1	340.2	
9	109	40.8	298.1	
8	108	39.6	257.3	Current Restriction
7	107	38.3	217.7	
6	106	37	179.4	
5	105	36.5	142.4	
4	104	32	105.9	
3	103	28	73.9	
2	102	24	45.9	
1	101	21.9	21.9	
0	100	0	0.0	Intake to Outlet Pipe

DAM EMBANKMENT

The dam is jurisdictional and rated as small Class II. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days, suggested but not required,
* a crest width equal to the vertical height divided by 5 plus 10 feet,
* a spillway capable of passing 50% PMP,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications. The reconnaissance designs described herein are based upon a site inspection and review of available data; more detailed engineering work may result in a different design.

EMBANKMENT: The Big Battlement dam is listed as 23 feet high by the State Engineer but the survey performed by the City indicates the dam is 24 feet high, a small difference. The dam is restricted because of excessive seepage through the embankment and foundation, as shown by several seepage holes on the upstream slope. Major modifications are necessary to correct the problems so reconstruction appears to be the best long term solution.

The existing dam has the following dimensions:

* 24 feet high,
* crest length of about 350 feet,
* crest width of 10 feet,
* 3.0H:1.0V upstream and 2.0H:1.0V downstream slopes
* 12 inch diameter outlet pipe,
* 15 foot wide spillway.

The shape and type of design for the reconstructed dam embankment is difficult to estimate until foundation testing and the access issue are resolved. For purposes of this report the embankment is assumed to be an earth embankment constructed with materials in the reservoir area and with the following the dimensions:

* 24 feet high,
* crest length of about 350 feet,
* crest width of 16 feet,
* 3.75H:1.0V upstream and 3.0H:1.0V downstream slopes
* 24 inch diameter outlet pipe,
* 15 foot wide spillway.

Figure 3 shows the cross section of the dam at the outlet pipe. Figure 4 shows the front elevation view of the embankment looking upstream from below the dam.

The existing embankment material would be removed and stockpiled for use in the new embankment. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir. Table 2 shows the estimated volume of material to be excavated.

The dam site is extremely rocky. The foundation rock is apparently highly fractured. Installation of cutoff trench will be difficult both for excavation in the fractured rock and efficiency of the cutoff. Grouting of the foundation and abutments would normally be recommended but may be impractical because of the difficult access to the site. The next best recommendation is a core trench, but excavation of the foundation is required to determine if the trench can be excavated to an adequate depth. For purposes of this report, a 15 foot deep, 15 foot wide core trench is assumed most of the length of the embankment and upstream of the centerline.

The availability of impermeable materials for the core of the dam is a major question. Early on, borrow areas must be tested to determine whether there is adequate permeable and impermeable material; also whether the US Forest Service will issue a permit to excavate the borrow.

The design of the embankment included herein is approximate and included for cost estimating. Significant testing and design work will be needed to determine the best embankment design based on the availability of materials. The design assumes that there will be impervious material available but not in suitable quantities to construct the entire embankment, therefore the embankment design includes an impervious core with an pervious shell. If there is adequate impervious material to construct the entire embankment, it should be used.

The embankment design includes an impervious core with 1.5H:1.0V slopes upstream and downstream. A pervious shell would be placed around the core with an upstream slope of 3.75H:1.0V and a downstream slope of 3.0H:1.0V. The slopes of the embankment are flatter than may normally be required because suitable filter materials are not expected to be available. The flatter slopes are included to add mass to the dam so that filters are not needed.

Embankment material would be obtained from the stockpiled existing material and from a borrow area to be determined. The material would be placed in lifts and compacted to the appropriate density. Adequate testing will be required to monitor the compaction. Table 3 shows the estimated volume of material to be placed and compacted; 30% additional material is assumed to allow for compaction.

There is rock in and around the reservoir basin which is expected to usable for rip rap. The rock is very hard but may not be the best sizes for rip rap which may require a thicker layer than the estimated 2 feet.

There is also an auxiliary dam which will be evaluated during the plans and specification phase. The cost of any repairs are minor compared to the main embankment but should be addressed in detailed studies.

OUTLET PIPE: The outlet pipe size is suggested to be 24 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance and if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be thick walled steel, possibly lined or encased with mortar or concrete; CMP is not recommended. During the design process, the necessity for a concrete bed for the pipe or encasing the pipe in concrete should be investigated.

SPILLWAY: The spillway will be sized to pass one half the PMP. The existing spillway width is expected to be adequate but can be easily widened if necessary. The spillway channel is presently in rock and no additional rip rap is expected to be required.

TABLE 2
BIG BATTLEMENT DAM AND RESERVOIR
REMOVAL OF EXISTING EMBANKMENT

0 feet Stripping Depth
3 :1 Upstream
2 :1 Downstream
10 foot crest width
124 feet Crest Elevation

0 foot Key Trench Width
0 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
100	125	0	0				
				146.5	122	0	122
125	115	9	293				
				693	642	0	642
150	105	19	1093				
				1387	1284	0	1284
175	100	24	1680				
				1815	1681	0	1681
200	98	26	1950				
				1815	1681	0	1681
225	100	24	1680				
				1680	1556	0	1556
250	100	24	1680				
				1680	1556	0	1556
275	100	24	1680				
				1386.5	1284	0	1284
300	105	19	1093				
				693	642	0	642
325	115	9	293				
				147	123	0	123
350	125	0	0				

Total Embankment Removal Volume (cubic yards) 10600

TABLE 3
BIG BATTLEMENT DAM AND RESERVOIR
VOLUME OF RECONSTRUCTED EMBANKMENT

2 feet Stripping Depth
3.75 :1 Upstream Slope
3 :1 Downstream Slope
16 foot Crest Width
125 foot Crest Elevation

15 foot Key Trench Width
15 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
100	125	2	46				
				362	335	83	418
125	115	12	678				
				1332	1233	208	1441
150	105	22	1986				
				2439	2258	208	2466
175	100	27	2892				
				3097	2868	208	3076
200	98	29	3302				
				3097	2868	208	3076
225	100	27	2892				
				2892	2678	208	2886
250	100	27	2892				
				2892	2678	208	2886
275	100	27	2892				
				2439	2258	208	2466
300	105	22	1986				
				1332	1233	208	1441
325	115	12	678				
				362	335	83	418
350	125	2	46				

Total Embankment Volume (cubic yards) 20600

Total Cubic Yards of Compacted Fill (30% compaction) 26800

Figure 3
Big Battlement
Cross Section at Outlet Pipe

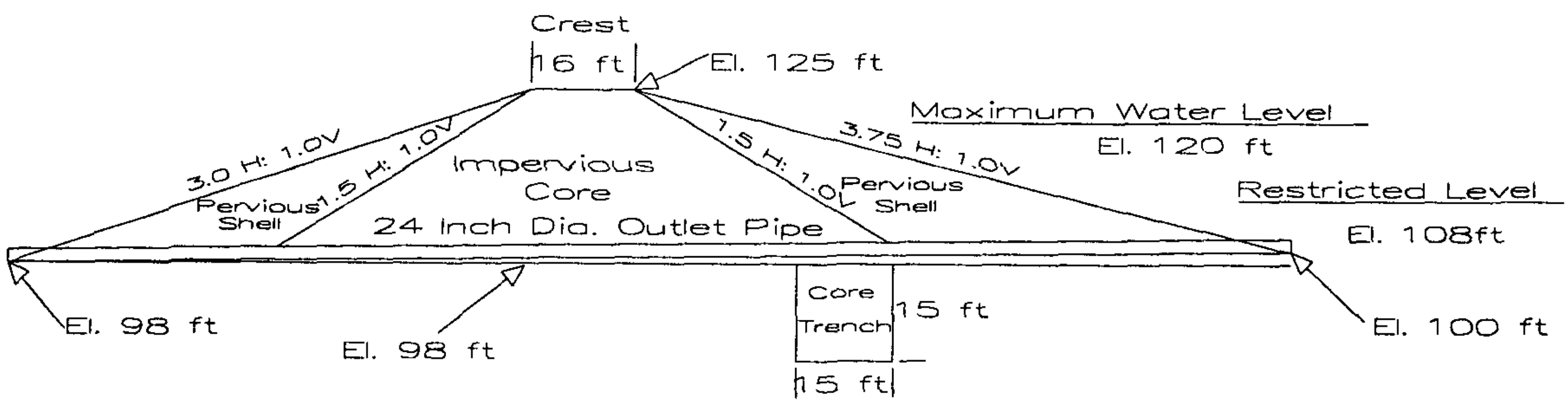
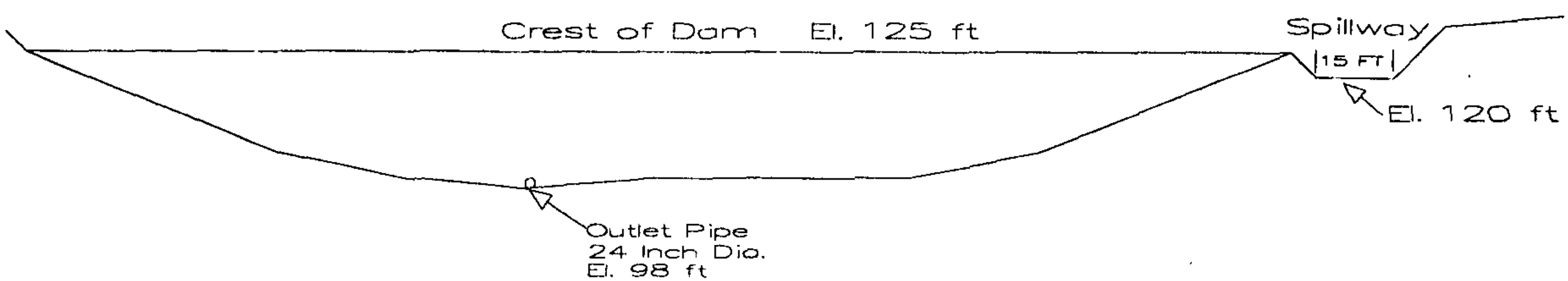


Figure 4
Big Battlement
Embankment Looking Upstream



COST ESTIMATE

The estimated cost to repair the dam is shown in Table 1. The unit costs are approximately 50% higher than normal costs because of the difficult access problems associated with getting equipment and materials to the site. Transport of fuel for the equipment will be very costly.

A mobilization cost of $100,000 is assumed for both Granby #12 and Big Battlement dams. The amount was split approximately by the ratio of total construction costs, resulting in Big Battlement being allocated $80,000 for mobilization. Obviously, if more favorable arrangements can be negotiated with the Forest Service to make access easier, the cost of the project could be reduced significantly.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because of the access problems. Engineering and administration is estimated at 15% which includes: materials testing, preparation of plans and specifications and construction observation.

The land is owned by the US Forest Service but permitted to the Ditch Company so there is no land cost. However, permits to perform the work and excavate borrow material will be necessary, which may include an environmental assessment. Obtaining these permits could potentially delay and increase the costs of the project and should be initiated as soon as practical.

FINANCING

The cost for this work is large for the City of Delta and is expected to require financing. The construction is predicated upon the sale of water to the hydropower company and possibly to the aquaculture company as well. If those agreements happen, then the City would be able to borrow the funds at one of the normal CWCB financing arrangements.

Table 5 shows various financing options. Options 1 and 2 are the standard financing terms; Options 3 and 4 show the increased annual payment for shorter repayment periods. Option 2, 4% for 30 years is suggested.

TABLE 4
BIG BATTLEMENT DAM
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$80,000
Embankment				
Excavate Existing Dam	cy	10600	$3.00	$31,800
Compacted Fill	cy	26800	$6.00	$160,800
Rip Rap	cy	590	$20.00	$11,800
	Embankment Subtotal			$204,400
Outlet Works				
24" Outlet Pipe	lf	170	$100.00	$17,000
Gate	ls			$10,000
	Outlet Works Subtotal			$27,000
Spillway				
Excavation	cy	80	$3.00	$200
Rip Rap	cy	60	$20.00	$1,200
	Spillway Subtotal			$1,400
	Total of Above Items			$232,800
	Contingency (30%)			$69,800
	Land Cost			$0
	Field Cost Subtotal			$302,600
	Engineering & Admin (15%)			$45,400
TOTAL ESTIMATED CONSTRUCTION COST				$348,000
Construction Cost per Acre-foot of Storage				$430
Estimated Annual Reservoir Storage in Acre-Feet				816

TABLE 5
BIG BATTLEMENT DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$348,000	3.5%	20	$24,486	$30
2	$348,000	4.0%	30	$20,125	$25
3	$348,000	3.5%	15	$30,215	$37
4	$348,000	3.5%	10	$41,844	$51

Volume of Reservoir Storage in Acre–Feet: 816

RECOMMENDATIONS

The followings steps are recommended to reconstruct Big Battlement Dam and Reservoir:

1. The City's negotiations with the hydropower company and the aquaculture company are assumed to continue. If the negotiations are fruitful and if most of the cost of reconstruction can be repaid by one or both of these companies, then the following steps to reconstruct the dam are recommended. If the negotiations are discontinued, then it is assumed that the reconstruction will be delayed until other companies step forward or the City needs the water. There is the potential that the State Engineer will require that the dam be breached if repair plans are not moving forward. Schedule not known, but soonest is spring of 1994.

2. Coordinate with the Granby Ditch and Reservoir Company to select a consulting engineer and contractor to perform the work. Obviously the City will have the greatest input because their project is the largest. Soonest spring of 1994.

3. Perform necessary materials tests on the embankment and borrow area soils. In conjunction with the materials tests, the contractor, and State Dam Safety Engineer; the Consulting Engineer will prepare plans, specifications, and a construction plan to reconstruct the dam. Soonest early summer of 1994.

4. Evaluate the estimated costs to determine that the project is still feasible. Initiate the CWCB financing process. Soonest late summer of 1994.

5. Apply for permits from the US Forest Service for access to the dams and for borrow material. The permits would include Granby #12, Big Battlement and any other repairs needed at dams in the area. Assistance from the State Engineer and the CWCB Director may be necessary to obtain the permits. Soonest for permit applications is late summer of 1994; soonest permits are received is summer of 1995.

6. Construct the repairs. The work must begin as soon as snow and weather conditions allow because the work at all of the dam sites will require all or most of the summer season. Soonest is summer 1996.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

BOOTLEG DAM AND RESERVOIR
Owned By The Henrylyn Irrigation District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

BOOTLEG DAM AND RESERVOIR

PLAN DESCRIPTION

Bootleg Dam and Reservoir is an existing breached dam located on Box Elder Creek in the South Platte River drainage about 6 miles south of the Town of Hudson. Figure 1 shows the reservoir relative to Denver and the Town of Hudson. Figure 2 is a copy of a USGS Quad map showing the reservoir site.

The Dam owner and contact is:

Henrylyn Irrigation District
Lawrence (Butch) Gerkin, Manager   303-536-4702
P.O. Box 85
Hudson, Colorado   80642

The dam was breached in 1984 due to various problems with the embankment and spillway. The embankment is owned by the Henrylyn Irrigation District but the reservoir basin is privately owned with ROW held by the District.

The best plan for reconstructed of the dam was developed by the Central Colorado Water Conservancy District in cooperation with the Colorado Water Conservation Board and the Army Corp of Engineers. The plan was to reconstruct and raise the dam for irrigation storage and flood control on Box Elder Creek.

The Corp of Engineers prepared a reconnaissance study on the reconstruction in April of 1990. The information, drawings and descriptions herein were obtained from the Corp report. The report addressed the structural requirements and cost of raising the embankment but did not address the benefits, potential repayment, or allocation of storage space and costs to flood control and irrigation.

The Corp report is apparently based on the reservoir being used only for flood control; however, there appears to be about 1,300 to 1,500 acre-feet of storage in the reservoir below the proposed spillway crest that could be used for irrigation. Though this would reduce the flood control benefits somewhat, 1,000 acre-feet is assumed for irrigation storage in this report.

The drainage basin above the reservoir is 240 square miles in size. The basin is very flat and is covered primarily with brush and grasses.

This report summarizes the Corp report findings and how the reservoir could be used to increase irrigation storage to the Henrylyn Irrigation District as well as provide flood control on Box Elder Creek.

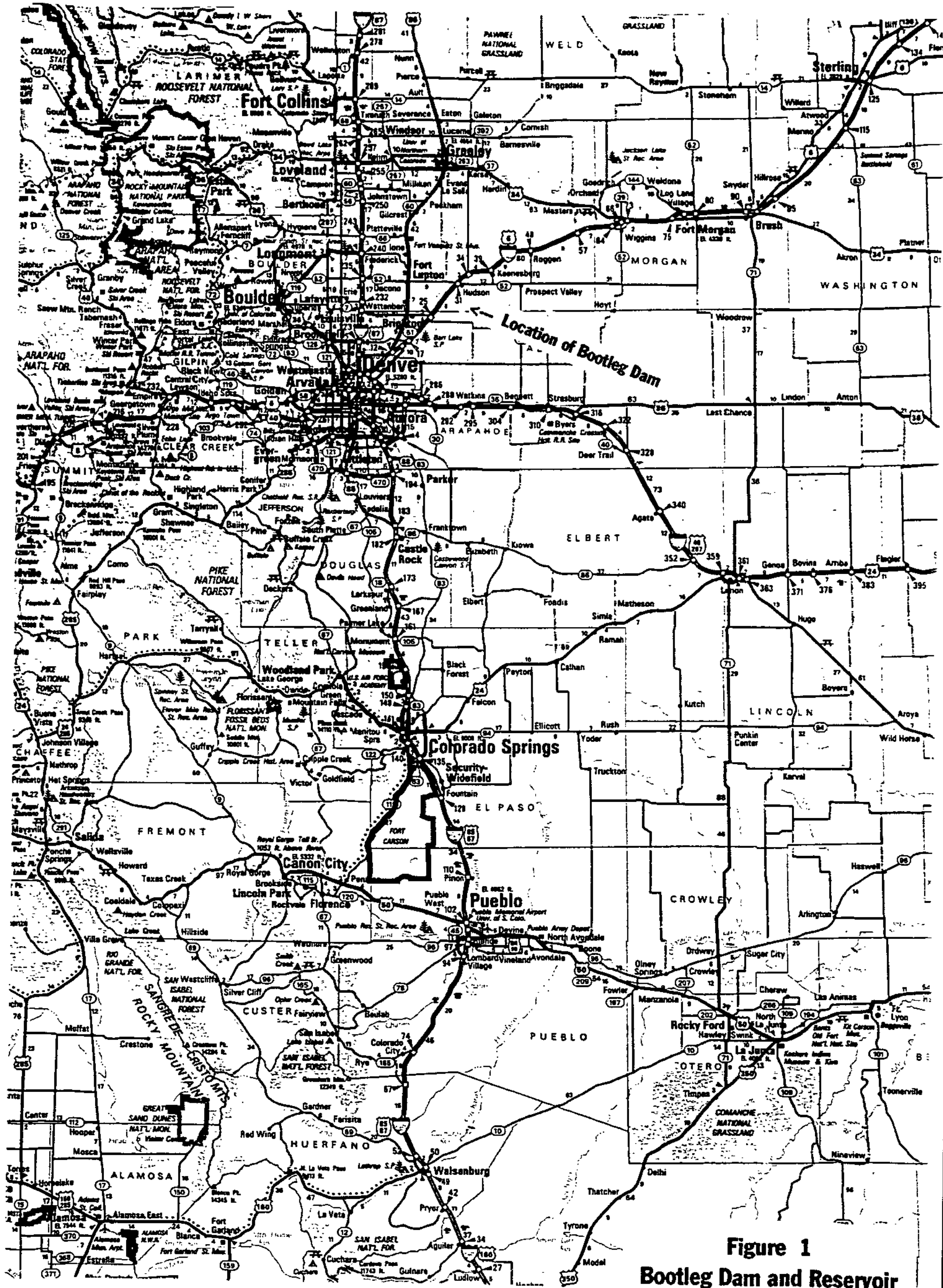


Figure 1

Bootleg Dam and Reservoir

Location Map

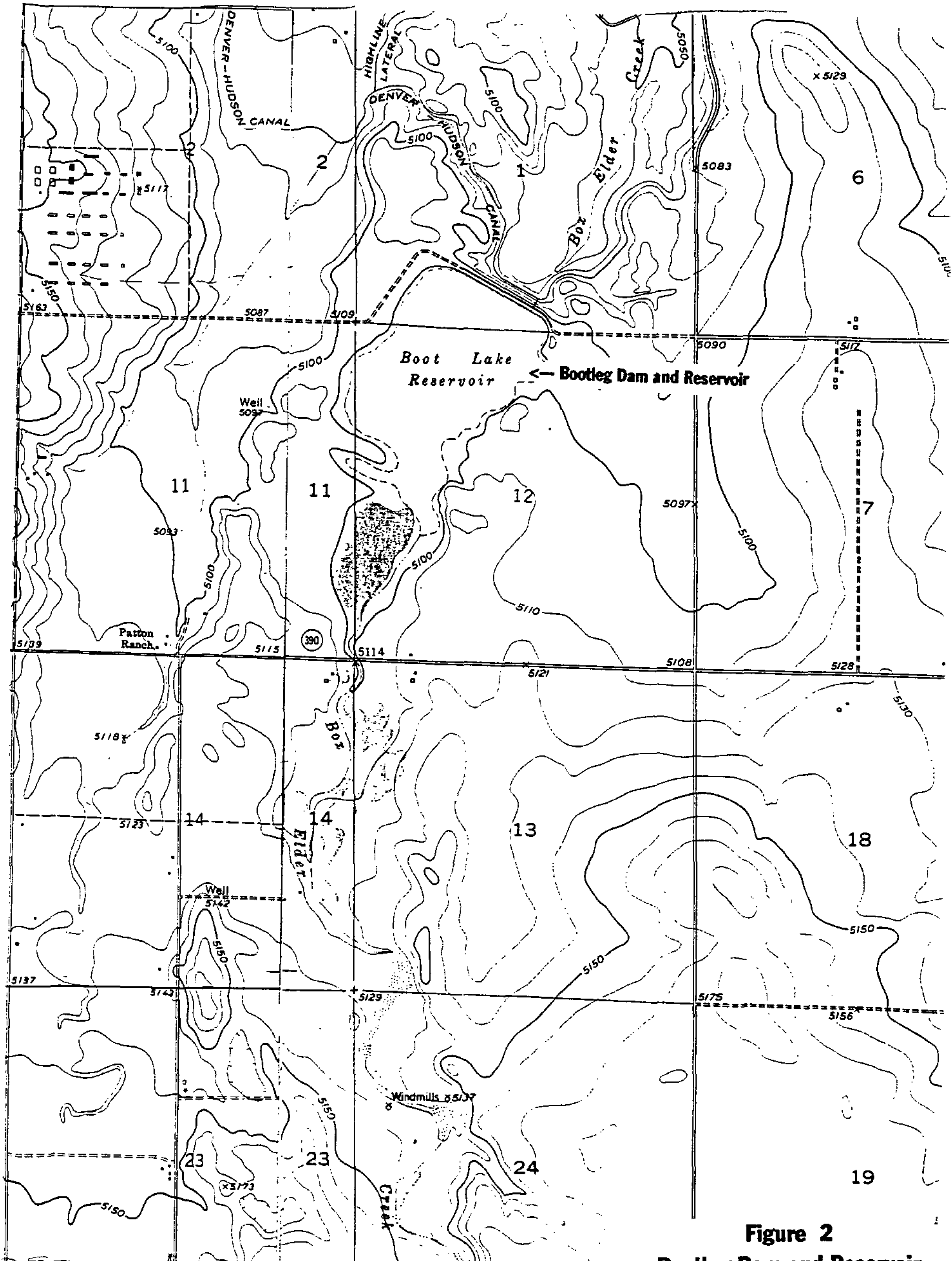


Figure 2
Bootleg Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The District has direct flow and storage water rights from the South Platte River. The water is diverted during high spring flows to fill the three reservoirs owned by the District and to irrigate about 32,800 acres of land. When the water rights are out of priority and no further water can be diverted from the South Platte River, the District then uses water from the reservoirs. Bootleg Reservoir is the highest elevation reservoir in the system which offers the greatest flexibility for providing water to all of the water users. In an average year the District provides about 30,000 acre-feet of storage water to 32,800 acres, this is in addition to the direct flow water when available.

The reservoir would be filled with irrigation water from the Hudson Canal which diverts water from the South Platte River. There is very little flow in Box Elder Creek except during flood flows. In order to maximize the flood control benefits and provide irrigation water, the reservoir could be operated so that it would be the first storage water released by District. In this manner the reservoir would normally be empty by mid to late July, in time for the late summer and fall flood season.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir which are based upon the original filing in 1906 and recent Corp estimates. The Corp developed a different elevation-capacity which uses a bottom elevation of 5084 feet rather than 5068 feet and total storage of 4900 versus 6209 acre-feet. The reasons for the discrepancy are not known; a guess might be that the reservoir has filled with sediment since 1906.

The reservoir capacity at the proposed spillway crest of 5097 feet is estimated to be 2817 acre-feet, with sediment occupying from 1,000 to 1,300 acre-feet. The storage capacity below the spillway is assumed to be 1,800 acre-feet of which 1,500 acre-feet can be used for irrigation storage early in the season and the remainder for flood storage.

The 240 square mile drainage area is estimated (Corp) to have a 100 year flood of 8,000 cfs and a PMF of 497,000 cfs. Reduction and storage of all or part of the 100 year flood flow is the primary flood benefit. The dam and spillway was designed to pass larger floods.

TABLE 1
BOOTLEG DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
5108	454.6	6209.6	Top of Dam
5107	406.9	5778.8	
5106	381.2	5384.8	
5105	357.4	5015.5	
5104	343.1	4665.2	
5103	307.8	4339.8	
5102	276	4047.9	
5101	271.5	3774.1	
5100	253.6	3511.6	
5099	235.6	3267.0	
5098	229	3034.7	
5097	205.9	2817.2	Spillway Crest
5096	192.9	2617.8	
5095	183.2	2429.8	
5094	169.9	2253.2	
5093	160.5	2088.0	
5092	154.5	1930.5	
5091	148.5	1779.0	
5090	143.8	1632.8	
5089	136.6	1492.7	
5088	130.8	1359.0	
5087	126.1	1230.5	
5086	121.6	1106.7	
5085	117.2	987.3	
5084	112.7	872.3	
5083	108.2	761.9	
5082	102.9	656.3	
5081	97.6	556.1	
5080	92.2	461.2	
5079	86.9	371.6	
5078	81.5	287.4	
5077	66.8	213.3	
5076	55.7	152.0	
5075	45	101.7	
5074	27.8	65.3	
5073	16.9	42.9	
5072	13.6	27.7	
5071	10.2	15.8	
5070	6.9	7.2	
5069	3.6	2.0	
5068	0.3	0.0	

Capacities were developed from original survey, sedimentation has reduced capacity an estimated 1,000 to 1,300 acre–feet.

DAM EMBANKMENT

The embankment, spillway and outlet pipe are described in this section. Again the information is summarized from the Corp of Engineers 1990 report.

EMBANKMENT: The reconstructed dam would be an earth embankment with following the dimensions:

* 20 feet high,
* crest length of about 7,525 feet,
* crest width of 10 feet,
* 3.0H:1.0V upstream and 2.5H:1.0V downstream slopes
* 48 inch diameter outlet pipe,
* 1,500 foot wide spillway.

Figure 4 shows the cross section of the dam at the outlet pipe. Figure 5 shows the front elevation view of the embankment looking upstream from below the dam. Figure 6 shows a plan view of the dam and spillway.

The dam crest would be raised an average of 4.5 feet for the entire length of the existing crest. The Corp proposed a 10 foot wide crest which should be 14 feet according to Colorado "Rules and Regulations for Dam Safety and Dam Construction".

A new 10 foot high embankment would be constructed on the west to prevent the reservoir from flowing through the natural spillway. The existing concrete upstream face would be removed. A cutoff trench would located near the upstream toe of the existing embankment, approximately under the centerline of the new embankment. The embankment would be constructed of impervious material obtained from the spillway excavation.

A 27 inch layer of rip rap and bedding is suggested on the upstream face covering 20 feet vertically and 2000 feet horizontally.

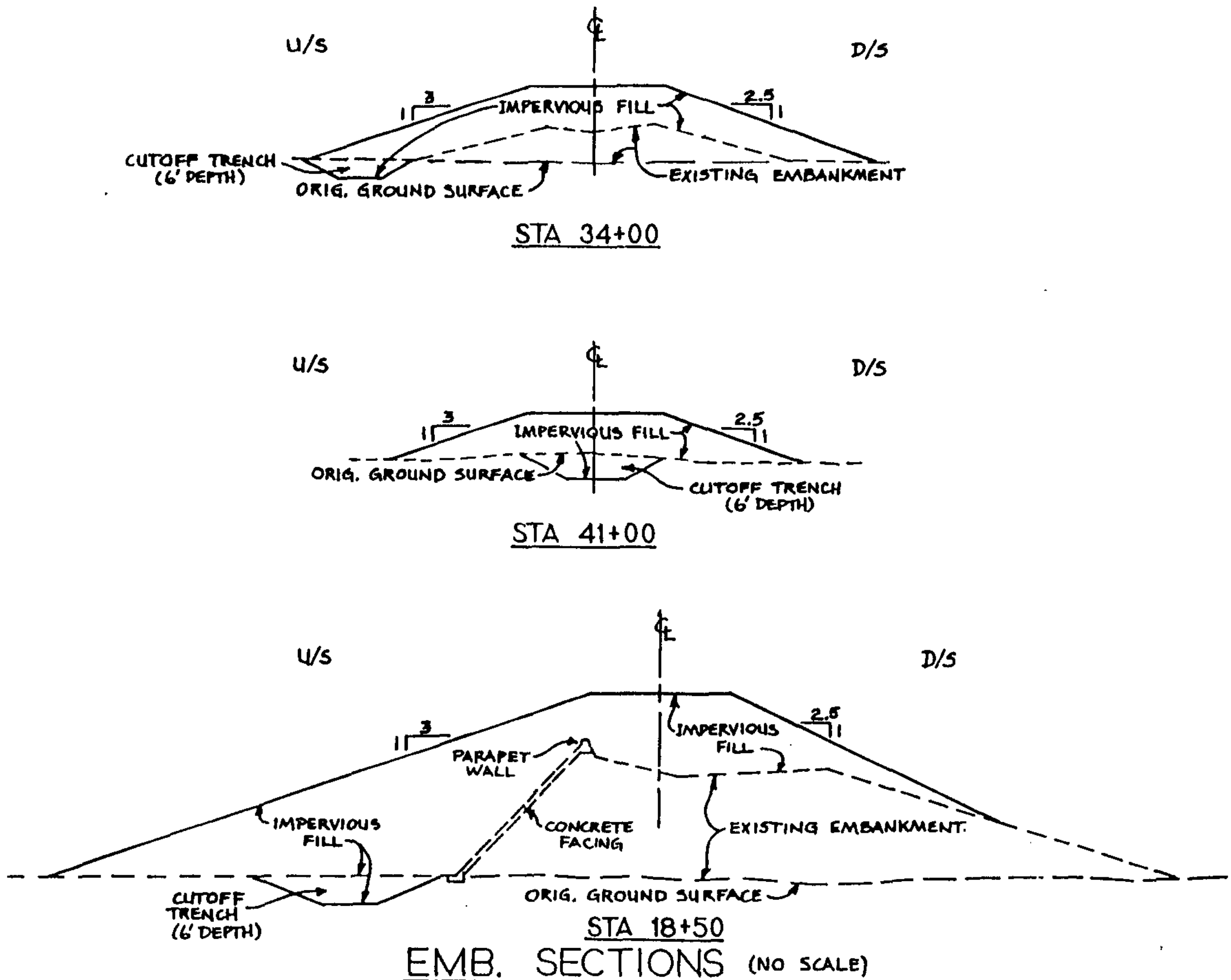
The Hudson Canal, adjacent to the downstream toe of the embankment must be moved further to the north.

OUTLET PIPE: The existing outlet pipe would be removed and a 48 inch diameter pipe installed. The pipe is expected to be reinforced concrete pipe installed on a concrete cradle.

SPILLWAY: The spillway in combination with surcharge was sized to pass 50% of the PMP. The crest of the spillway would be at elevation 5095.2 feet and be 1,500 feet wide. The spillway channel would extend upstream 1,600 feet and downstream 1,700 feet downstream.

A soil cement cutoff wall perpendicular to the flow of water is included to stabilize the spillway section. Rip rap would be placed on the left side of the spillway.

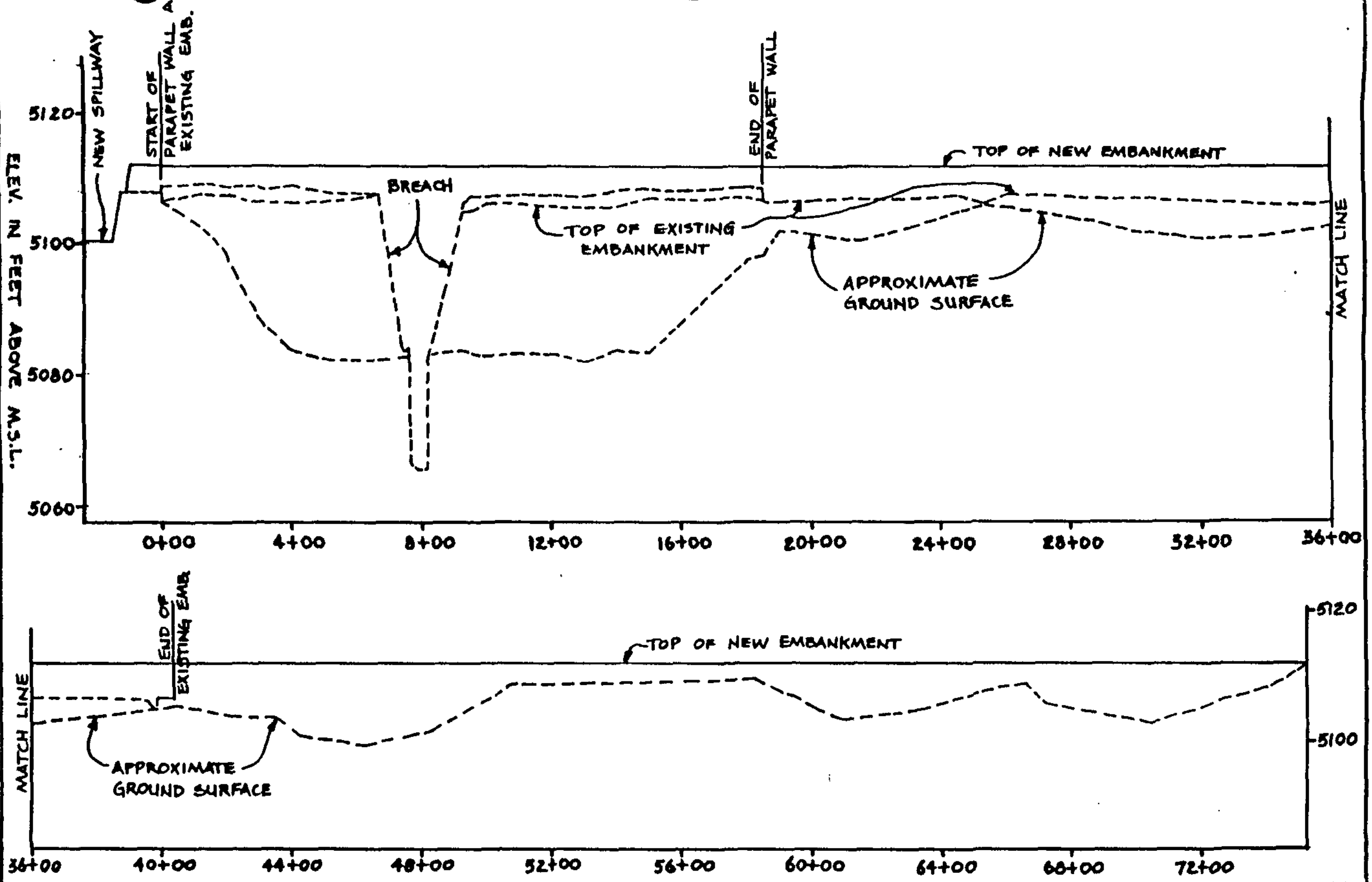
The method to convey water from the ditch into the reservoir was not addressed in the Corp report. Possible methods include pumping, construction of a higher elevation ditch, or an inlet pipe into the dam. Since the dam is not considered financially feasible as presently planned, a solution to this problem was not formulated herein.



BOOTLEG RESERVOIR REHABILITATION
SECTION 22 COLORADO

U. S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
APRIL 1990

Figure 3 - Maximum Section



BOOTLEG RESERVOIR REHABILITATION
SECTION 22 COLORADO

EMB. PROFILE
CENTERLINE

U. S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
APRIL 1990

Figure 4 - Embankment Looking Upstream

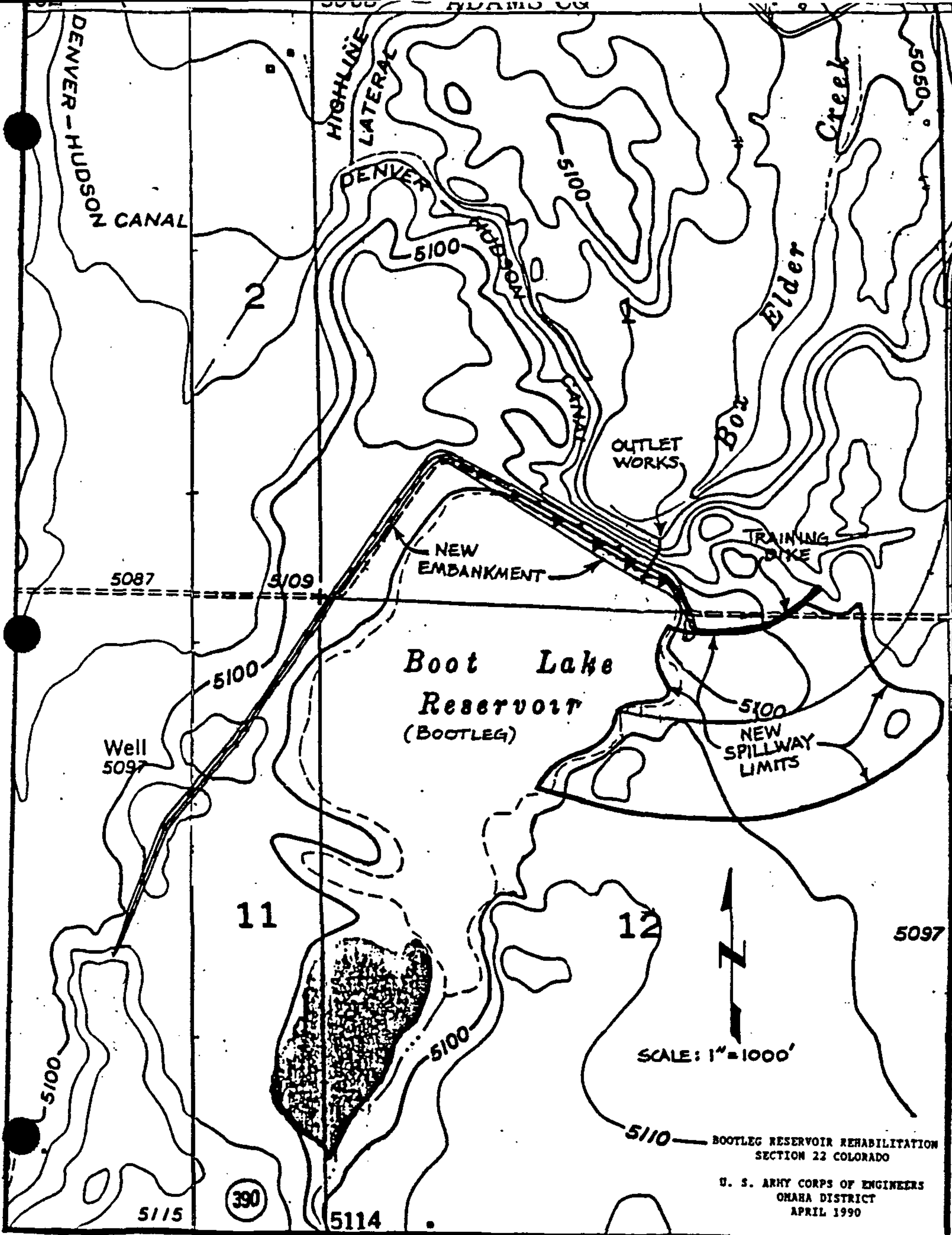


Figure 5 - Plan View of Dam

COST ESTIMATE

The estimated cost to raise the water level is shown in Table 2, as prepared by the Corp. Table 3 includes items not included in the Corp estimate and shows the total estimated construction cost. The unit costs used by the Corp in 1990 are used without indexing because they appear to be reasonable.

The Corp used an amount of 30% for contingencies. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation. The land cost of $500 per acre is included.

The required permits should be minimized because it is a reconstruction of an existing dam nor should there be an increase in the historical consumptive use. The need for environmental compliance permits should be investigated.

FINANCING

The Henrylyn Irrigation District cannot fund nor repay the entire cost of the project. Repayment of a large portion of the cost by other entities would be necessary for the project to be realistic for the District.

The District presently assess $13 per acre for 32,800 acres. The total annual budget is about $500,000. The District presently has two loans with the CWCB; for original amounts of $653,000 and $260,000 which have been paid down to $440,000 and $189,000 respectively. The annual payments are $28,248 and $15,152, for a total of $43,400.

The District will not, in the near future, reconstruct Bootleg and enlarge Prospect. The financial analysis herein assumes that Bootleg will be reconstructed with financial assistance from other entities.

Repayment summaries are shown in the following table, without trying to allocate costs to the purposes.

RECOMMENDATIONS

Arrangements must be made with the CWCB and others to repay the flood control benefits of the project. Until this is accomplished there is little need to continue.

The enlargement of Prospect Reservoir appears to be the better plan for increased storage because the cost is only slightly more for 3 times the storage and no other entities are involved.

Table 2
Bootleg Dam and Reservoir
Corp of Engineers - 1990 Cost Estimate

1. OMISSIONS. This cost estimate does not include the items of instrumentation, land acquisition, stone protection, or relocation of the Denver-Hudson Canal.

ITEM	QUANTITY	UNIT	UNIT COST	TOTAL COST
Dam				
Clear & Grub	4	Acre	650.00	$ 2,600
Embankment	184,500	C.Y.	0.51	94,095
Stripping/Topsoil	9,400	C.Y.	1.71	16,074
Concrete Removal	7,800	S.Y.	6.56	51,168
Care of Water	L.S.			4,184
Seeding	11.5	Acre	1,109.00	12,754
Gravel Surfacing	930	C.Y.	20.00	18,600
Spillway				
Excavation	184,500	C.Y.	1.56	287,820
Embankment/Berm	4,000	C.Y.	1.27	5,080
Riprap	3,400	Tons	21.63	73,542
Bedding	1,000	Tons	12.64	12,640
Soil Cement	2,400	C.Y.	60.00	144,000
Seeding	80	Acre	1,193.00	95,440
Waste	527,500	C.Y.	1.33	701,575
Outlet Works				
Excavation/Backfill	11,100	C.Y.	7.23	80,253
Slide Gate	L.S.		30,000.00	30,000
48" Diameter RCP	150	L.F.	290.71	43,607
Flared Inlet	L.S.		900.00	900
Stilling Basin	L.S.		77,359.00	77,359
Demolition	L.S.		12,647.00	12,647
			TOTAL	$1,764,338
			30% CONTINGENCY	514,910
			TOTAL CONSTRUCTION COST	$2,279,248

TABLE 3
BOOTLEG DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Corp of Engineers Estimate – Table 2				$2,279,000
Additional Items				
Rip Rap	cy	17780	$20.00	$356,000
Canal Relocation	ls			$10,000
	Embankment Subtotal			$366,000
	Total Field Cost			$2,645,000
	Engineering & Admin (15%)			$396,800
	Land Cost (90 acres)			$45,000
TOTAL ESTIMATED CONSTRUCTION COST				$3,087,000
Construction Cost per Acre–Foot of Storage				$2,060
Reservoir Storage Volume in Acre–Feet				1500

TABLE 4
BOOTLEG DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$3,087,000	4.0%	30	$178,522	$119
2	$3,087,000	3.5%	30	$167,844	$112
3	$3,087,000	4.0%	40	$155,966	$104
4	$3,087,000	3.5%	40	$144,556	$96
5	$3,087,000	3.0%	40	$133,551	$89
6	$3,087,000	2.0%	40	$112,848	$75

Volume of Reservoir in Acre-Feet: 1500

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

CACTUS PARK DAM AND RESERVOIR
Sponsored By The Grand Mesa Water Conservancy District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

CACTUS PARK DAM AND RESERVOIR PROJECT

PLAN DESCRIPTION

Cactus Park Dam and Reservoir is the main feature of a project to develop additional water supplies for the Surface and Currant Creek drainage areas on the south slope of the Grand Mesa. The dam would be a new structure on an unnamed tributary of Currant Creek about 3 miles east of Town of Cedaredge. Figure 1 shows the reservoir location in Colorado, Figure 2 is a copy of a USGS Quad map showing the reservoir site.

The dam is proposed by the Grand Mesa Water Conservancy District. The contact person is:

Bud Burgess (835-3347)
P.O. Box 129
Cedaredge, Colorado 81413

The dam and reservoir have been studied by the Bureau of Reclamation (USBR) as part of the proposed Grand Mesa Project, since 1946. Two USBR reports have been published in 1973 and 1982. In 1983, the Grand Mesa WCD and CWCB jointly sponsored a study prepared by Western Engineers, Inc.. In 1986, the Grand Mesa WCD and CWCB sponsored a second report prepared by PRC Engineers primarily evaluating the water supply for the project and appraisal level cost estimates.

The evaluations and conclusions herein are primarily derived from the latest report prepared by PRC Engineers in 1986. The report concluded that the local water users must cooperate to re-operate existing water rights to maximize water availability and have financial assistance in the form of grants in order for the local water users to repay the costs.

The Western Engineers report evaluated hydro power plant sites to collect water running off the Grand Mesa, to produce power then distribute the water to irrigators. The power plants were not determined to be feasible at that time and rates paid by electric utilities are less now than in 1983, so the feasibility of the hydro power plants was not considered herein.

This report summarizes the technical findings and updates the cost estimates to determine if the project is feasible at today's financing terms.

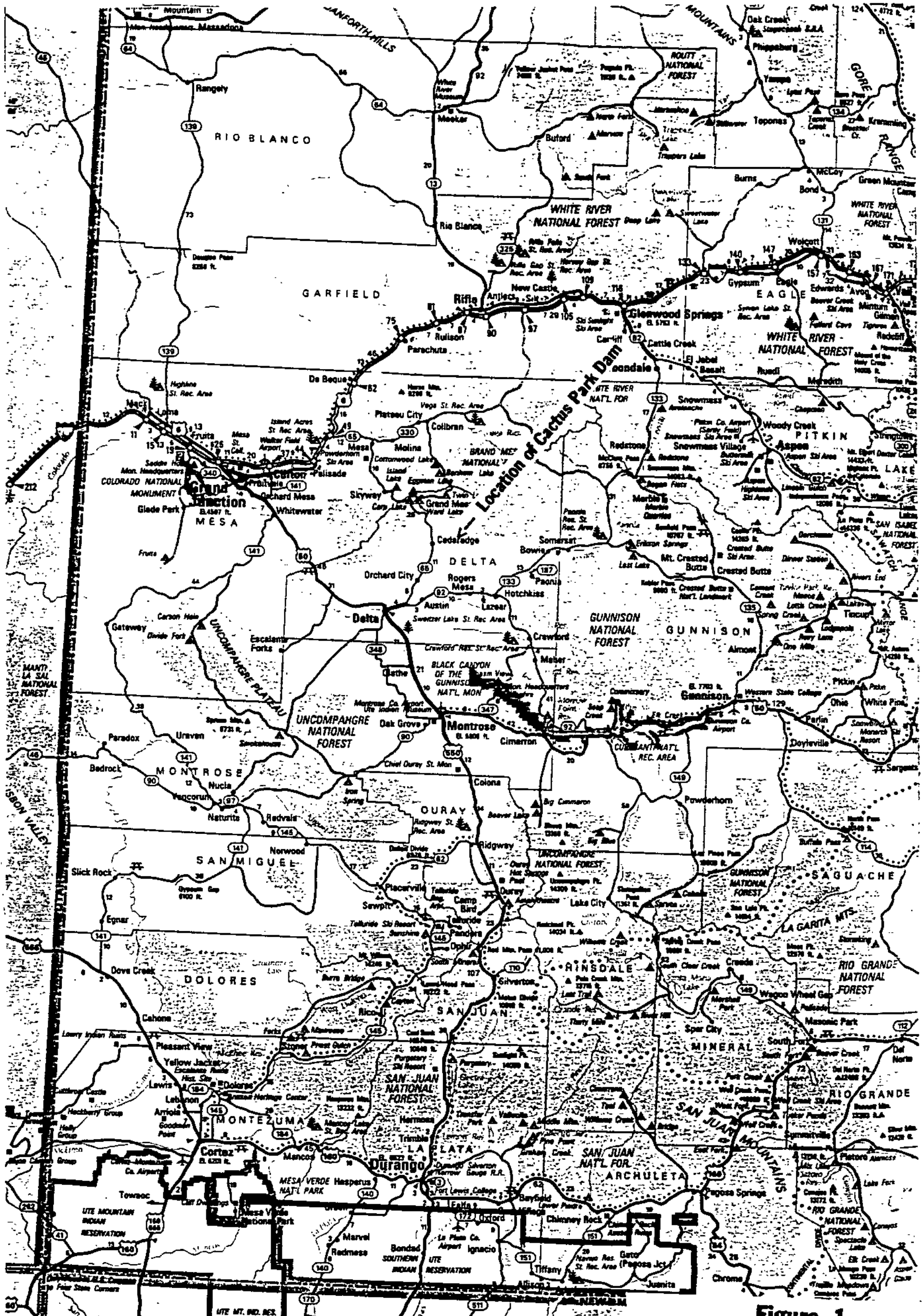


Figure 1
Cactus Park Dam and Reservoir Location Map

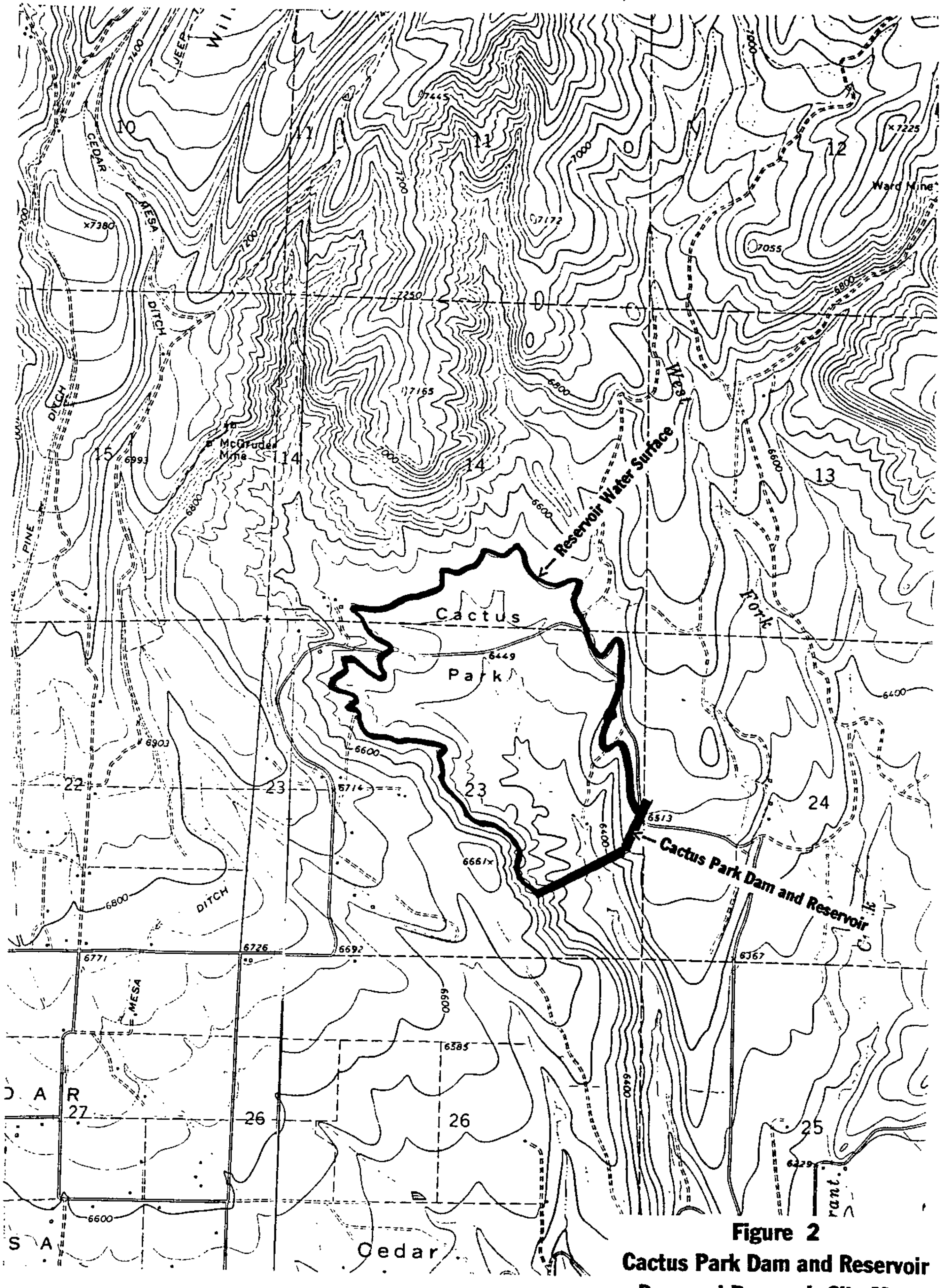


Figure 2
Cactus Park Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The water source for Cactus Park Reservoir would involve a re-operation of existing ditches and water rights. Presently, the irrigators in the lower elevation (southern) part of Surface and Currant Creek drainages have the senior water rights and call for water when it is available. The upper elevation irrigators (northern) have junior rights.

The general plan for Cactus Park Reservoir is to store excess spring flows that are currently diverted because the water is available. The modified scenario the upper elevation irrigators would use water from the streams according to their crop water needs. The excess water and return flow is collected and conveyed by the Surface Creek Feeder Ditch to Cactus Park Reservoir then released into the Cedaredge Canal for distribution to the lower elevation irrigators according to crop needs.

Three alternative plans were evaluated: (1) maximize the use of flows within the Surface and Currant Creek drainages, (2) import water from LeRoux Creek, immediately to the east, and (3) import water from LeRoux Creek and Overland Ditch. The three alternatives were evaluated to determine the size and cost of facilities to provide 85%, 90% or 95% firmness of annual water supply to 15,000 acres of presently irrigated land. Some of the irrigated land presently receives a full supply and some is considerably short.

The alternative which maximizes water supplies within the irrigated area and does not import water from adjacent streams was used for evaluation herein because it would be the easiest to implement. However, the cost per acre foot is about 12% higher than importing water from LeRoux Creek and Overland Ditch.

In order to maximize water supplies and provide 85% firmness of water availability, a 15,900 acre-foot capacity reservoir with a dam about 170 feet high. The annual average additional yield would be 11,300 acre-feet.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir from the estimated bottom of 6360 feet to the proposed dam crest of 6530 feet. The table was developed from data obtained from the Bureau of Reclamation.

TABLE 1
CACTUS PARK DAM & RESERVOIR
Elevation – Area – Capacity

Depth	Area (acres)	Accumulative Capacity (Ac-Ft)	Description
6575	427	34284	
6570	413	32184	
6565	398	30154	
6560	378	28212	
6555	363	26360	
6550	349	24580	
6545	337	22866	
6540	326	21209	
6535	312	19614	
6530	298	18089	Top of Proposed Dam
6525	284	16633	Spillway Crest El 6523
6520	269	15250	
6515	254	13943	
6510	240	12709	
6505	226	11544	
6500	213	10447	
6495	201	9412	
6490	189	8437	
6485	178	7519	
6480	167	6657	
6475	155	5852	
6470	142	5109	
6465	131	4427	
6460	122	3795	
6455	110	3215	
6450	98	2695	
6445	86	2235	
6440	74	1835	
6435	65	1488	
6430	57	1184	
6425	49	918.0	
6420	40	695.0	
6415	32	516.8	
6410	27	370.3	
6405	19	257.5	
6400	15	173.7	
6395	11	108.9	
6390	7.6	62.7	
6385	4.6	32.6	
6380	2.6	15.0	
6375	1.2	5.8	
6370	0.4	2.0	
6365	0.2	0.5	
6360	0	0.0	

DAM EMBANKMENT

EMBANKMENT: The Cactus Park Dam would be an earth structure and would be a jurisdictional intermediate Class I dam. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources, state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, maximum of 25 feet,
* a spillway capable of passing 100% PMP,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. USBR has performed most, if not all, of the field testing necessary to design the dam. The reconnaissance designs described herein are based upon data contained in the PRC report; more detailed engineering work may result in a different design.

The proposed dam is planned to be a zoned earthfill structure with 3.0H:1.0V upstream and 1.75H:1.0V downstream slopes with a 30 foot wide crest (Western Engineers report). It is assumed that the PRC report used the same preliminary design. For the proposed capacity of 15,900 acre-feet the dam height would be about 170 feet with an embankment volume of about 3,400,000 cubic yards (PRC report).

The spillway and outlet works are not described in the PRC report.

RELATED STRUCTURES: The PRC report described:

(1) The Surface Creek Feeder canal to collect and convey water from streams and irrigation return flow to Cactus Park Reservoir. The canal would be about 7.7 miles long and vary in capacity from 80 cfs to 200 cfs.

(2) The Cedaredge Canal would convey reservoir releases to various points in the irrigated area. The canal would be 10.2 miles long with a capacity varying from 50 cfs to 150 cfs.

COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 3, summarized from the PRC report. The costs were indexed up by 15%, approximately 2.5% per year from 1986.

PRC used an amount of 20% for contingencies and 15% for engineering and administration.

FINANCING

The construction of this project will require financing. The Grand Mesa WCD would need to finance the entire cost of the project.

The financial analysis herein assumes that Cactus Park Reservoir will be constructed with a loan from the CWCB. The construction would yield about 11,300 acre-feet of additional water annually, with the assumption that the water users would pay the same annual cost regardless of whether the water is available in dry years. Repayment options are shown in Table 3, assuming a 100% loan; if the District can include some cash the loan amount would be reduced.

RECOMMENDATIONS

The cost for construction of Cactus Park Dam and Reservoir is greater than the irrigators ability to repay using any of the financing scenarios shown in Table 3. The project would require $30 to $35 million dollars in non-reimbursable funds to allow repayment by the local water users. Simply stated grant funds are not available from the CWCB nor any other existing source.

The Grand Mesa Water Conservancy District may want to coordinate with the San Miguel Water Conservancy District, represented by Bill Bray and Senator Dan Noble, who have a similar problem with the San Miguel Project; but have a long range plan to obtain Colorado River Storage Project (CRSP) funds.

This project is not recommended for further consideration, unless a source of non-reimbursable funds is available.

TABLE 2
CACTUS PARK DAM AND RESERVOIR PROJECT
CONSTRUCTION COST ESTIMATE

Cost Item	PRC Report Cost Estimate
Cactus Park Dam (PRC Report)	$19,922,000
Surface Creek Feeder Canal (PRC Report)	$8,494,000
Cedaredge Canal (PRC Report)	$7,094,000
PRC Report Subtotal	$35,510,000
Index from 1986 to 1993 (15%)	$5,327,000
TOTAL ESTIMATED CONSTRUCTION COST	$40,837,000
Cost per Acre–Foot of Reservoir Yield	$3,610
Reservoir Yield in Acre–Feet	11300

TABLE 3
CACTUS PARK DAM AND RESERVOIR PROJECT
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Period (years)	Annual Cost	Annual Cost per Acre-Foot
1	$40,837,000	4.0%	30	$2,361,608	$209
2	$40,837,000	4.0%	40	$2,063,228	$183
3	$40,837,000	3.5%	40	$1,912,286	$169
4	$40,837,000	3.0%	40	$1,766,706	$156
5	$40,837,000	2.0%	40	$1,492,827	$132
6	$40,837,000	1.0%	40	$1,243,715	$110
7	$40,837,000	0.0%	40	$1,020,925	$90

Volume of Reservoir Yield in Acre-Feet: 11300

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

CUCHARAS DAM AND RESERVOIR

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

CUCHARAS DAM AND RESERVOIR

PLAN DESCRIPTION

Cucharas Dam and Reservoir is an existing structure located on the Cucharas River, a tributary to the Huerfano River and the Arkansas River. Cucharas means spoon in Spanish which describes the shape of the reservoir basin and the canyon downstream of the basin; the basin is the spoon and the downstream canyon is the handle of the spoon. In other words, a very small dam forms a very large reservoir basin. Figure 1 shows the reservoir location in Colorado, Figure 2 is a copy of a USGS Quad map showing the dam site and reservoir basin. The dam is owned by the Huerfano-Cucharas Irrigation Company.

The dam is a rock fill structure originally constructed in 1914 to a height of 125 feet; the dam was raised again in 1965 to a height of 145 feet. The dam has serious structural problems which nearly caused a failure in 1987. Since 1987 the reservoir has been restricted to a fraction of the capacity; unless rock stability problems adjacent to outlet channel are addressed the reservoir could be restricted to zero storage in 1994.

Numerous geotechnical investigations have been made by engineering firms during the last 15 years to address various problems. Based on a review of the data, the October 29, 1993 site review and discussions with the State Dam Safety Engineer, the existing embankment is not repairable. In order to continue to store water in the reservoir a new dam, just downstream from the existing structure appears to be the best option. The new dam would be about 100 feet high and probably be a roller compacted concrete embankment because of the large flood flow and narrow canyon that does not easily allow a side channel spillway. The estimated storage capacity would be about 28,000 acre-feet.

To further confuse the situation, the existing owners of the dam are trying to sell the dam and reservoir and do not appear to be interested in constructing a new dam. The entity that appears to be interested in water from the reservoir is the Welton Ditch Company (also involved in the Orlando Dam and Reservoir) and represented by Mr. John Singletary (719-542-5656, 201 W8th, Suite 410, Pueblo, Colorado 81003).

Mr. Singletary's idea is to form a water conservancy district covering a large area south of Pueblo, which would purchase the dam from the present owners then sell the water to irrigators, municipalities, include fish and wildlife and recreation, and possibly sell augmentation water in the Lower Arkansas River basin. Given that the Arkansas River is a very water short basin and the Cucharas Dam and Reservoir site is an excellent site, there should be some effort to attempt to utilize the site.

The problem is how and who should begin the process to determine if the reservoir can be repaired.

This reconnaissance report describes the engineering issues, construction, and costs of constructing a new dam immediately downstream of the existing dam. The plans described herein are preliminary based upon existing information; the plans may change as detailed plans and specifications are prepared.

Also addressed in this report, for discussion purposes only, because the final decision must be made by the existing owners and others interested in the dam, is the assumption that a water conservancy district is formed to purchase the existing dam and reservoir, construct a new dam, then operate the reservoir to sell water to various entities. Obviously if this were an easy process it would have been accomplished by now, but deserves further discussion.

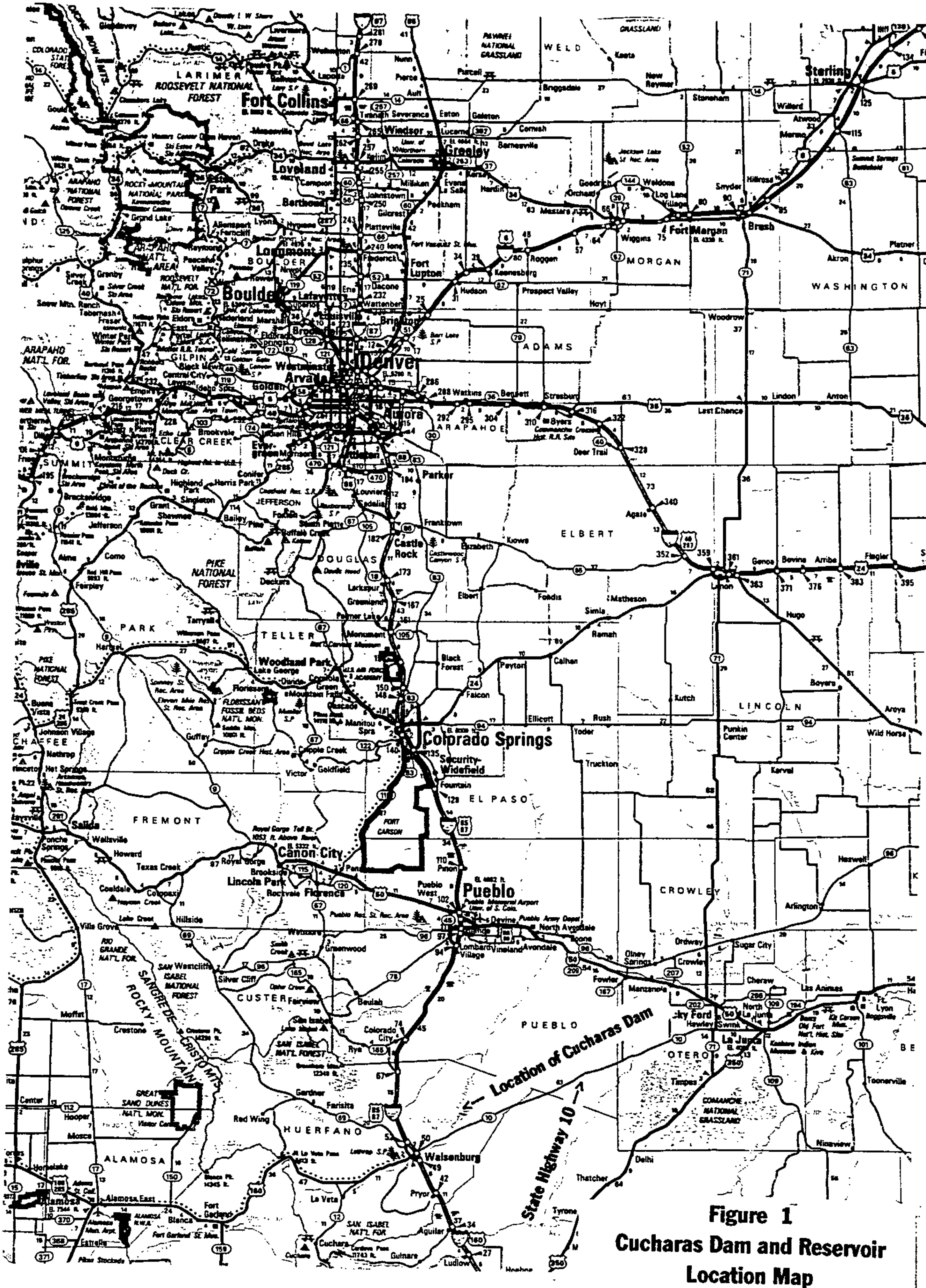


Figure 1
Cucharas Dam and Reservoir Location Map

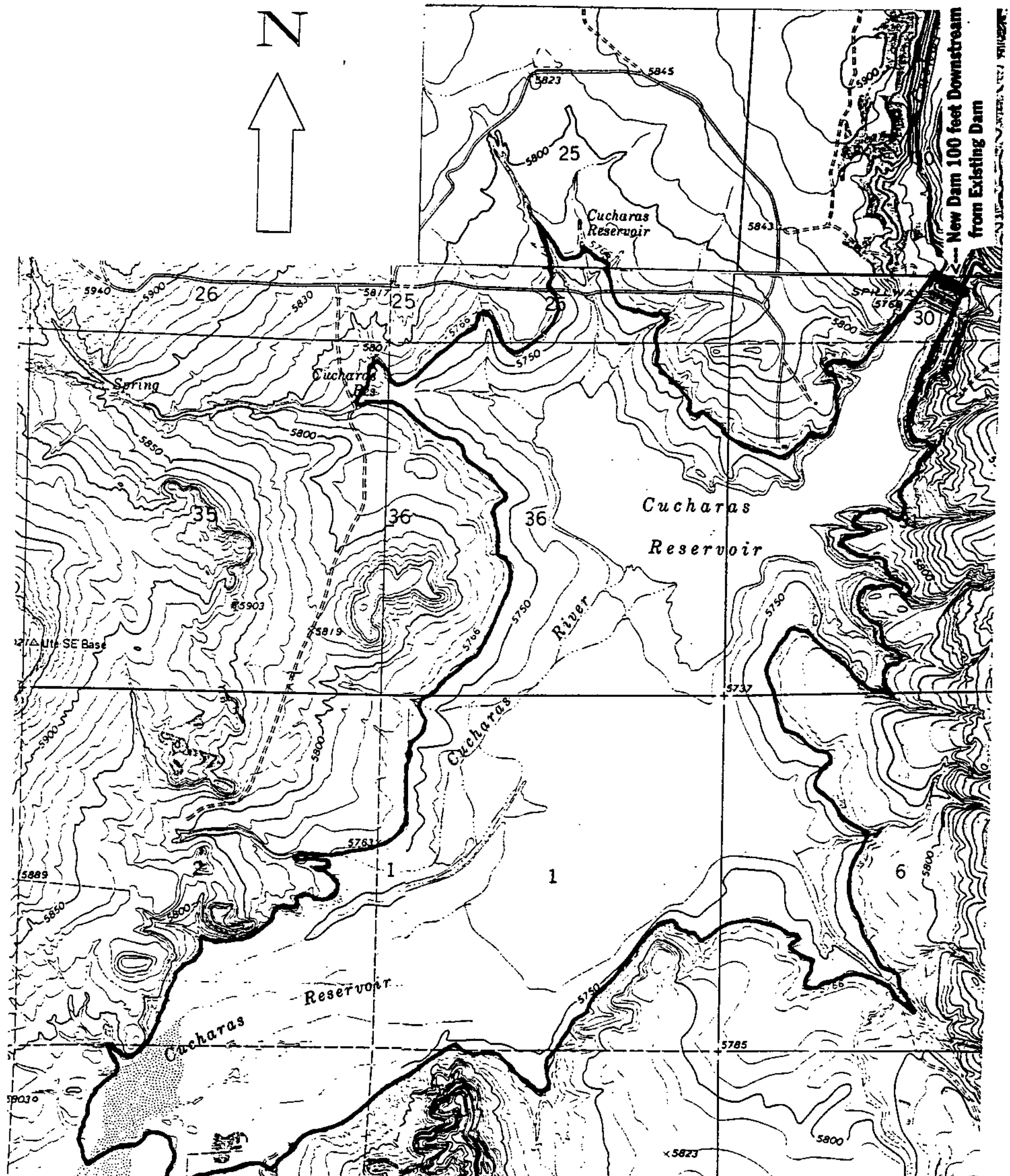


Figure 2
Cucharas Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The Cucharas Reservoir is filled by flows from the Cucharas River which drains a 650 square mile area. There are no gages on the Cucharas River near the reservoir to estimate the yield from the basin; there are gages further upstream which could be helpful. The reservoir has about 35,000 acre-feet of storage decrees which is greater than the proposed 28,000 acre-feet included herein. Rough estimates of the annual water supply by persons familiar with the reservoir indicate that the reservoir would probably yield between 15,000 and 20,000 acre-feet per year.

In order to quantify the runoff from the drainage basin, a correlation with a gaged drainage area would be necessary. The work to perform this study would be significant and should be included in the feasibility study that would be needed prior to construction. For purposes of this report, the annual water supply is assumed to be 18,000 acre-feet from the 28,000 acre-foot reservoir.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir from the estimated gage height of 80 feet, which is the top of the silt level, to the proposed crest of the new dam at gage height 114 feet (elevation 5760 feet). The data in Table 1 was taken from the elevation-area-capacity data on file at the Division of Water Resources Office.

The volume of silt in the reservoir was estimated to attempt to predict the rate that the reservoir would fill with silt. The volume below gage height 80 feet was estimated to be about 4,200 acre-feet assuming the bottom of the reservoir was gage height 0 feet. Further assuming that the silt level of 80 feet at the dam probably means that the silt level is higher at the upper end of the reservoir, the silt volume is estimated to be 5,000 acre-feet.

The construction of the dam was completed in 1915, so between 1915 and 1993, 5,000 acre-feet of silt was deposited. The rate is about 63 acre-feet per year, in the next 100 years the reservoir would fill with silt an additional 6,300 acre-feet. Though this will decrease the storage volume, the remaining 22,000 acre-feet of water storage would still provide significant benefits. The reservoir has a greater silt problem than most reservoirs but the problem does not preclude use of the reservoir site.

TABLE 1
CUCHARAS DAM & RESERVOIR
Elevation– Area–Capacity

Gage Height (feet)	Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
114	5760	1882.46	28580.9	New RCC Dam Crest
113	5759	1798.07	26740.6	
112	5758	1713.68	24984.7	
111	5757	1629.29	23313.2	
110	5756	1460.49	21768.3	
109	5755	1382.77	20346.7	
108	5754	1305.05	19002.8	
107	5753	1227.33	17736.6	
106	5752	1149.61	16548.1	
105	5751	1071.88	15437.4	
104	5750	1034.33	14384.3	
103	5749	996.78	13368.7	
102	5748	959.23	12390.7	
101	5747	921.68	11450.2	
100	5746	884.14	10547.3	
99	5745	842.93	9683.8	
98	5744	801.72	8861.5	
97	5743	760.51	8080.3	
96	5742	719.3	7340.4	
95	5741	678.1	6641.7	
94	5740	656.7	5974.3	
93	5739	635.3	5328.3	
92	5738	613.9	4703.7	
91	5737	592.5	4100.5	
90	5736	571.1	3518.7	
89	5735	549.7	2958.3	
88	5734	497.97	2434.5	
87	5733	446.24	1962.4	
86	5732	394.51	1542.0	
85	5731	312.47	1188.5	
84	5730	282.56	891.0	
83	5729	252.65	623.4	
82	5728	222.74	385.7	
81	5727	192.83	177.9	
80	5726	162.92	0.0	Silt Level

DAM EMBANKMENT

EMBANKMENT: The existing Cucharas Dam is a rock fill structure about 145 feet high, with a concrete upstream face and soil/rock downstream face. The reservoir is full at about gage height 120 feet. The dam nearly failed in 1987 from excessive seepage through the embankment (approximately 100 cfs), the year after extensive geotechnical studies were performed which suggested that the dam be allowed to store at full water level.

Following the 1987 incident the reservoir was restricted to gage height about 100 feet.

The dam safety engineer has told the owners of the dam that if they do not have a geotechnical evaluation performed on the rock slope above the outlet channel this spring, he may recommend that the State Engineer impose a zero water storage restriction on the dam. The fear is that a large piece of the rock slope could break off and fall into the outlet channel, plugging the outlet pipe.

There does not appear to be a reasonable method to repair the existing rock fill embankment to allow reservoir storage. Pumping grout into the rock fill would be possible but the likelihood of filling the voids is very questionable.

Based on discussions and field observations, construction of a new dam just downstream of the existing dam is the preferred option. The new dam is proposed to be a roller compacted concrete (RCC) embankment because of the narrow canyon, steep abutments, and need for a very large spillway.

The preliminary design for the RCC embankment would have the dam constructed about 100 feet downstream of the existing dam. The RCC dam would have a vertical upstream face and a downstream slope of 0.8H:1.0V, which is the standard RCC embankment shape. The crest width is 25 feet but this width may be reduced when detailed plans are prepared. The dam would be 105 feet high and would store water to the present gage height of 114 feet.

The existing rock fill embankment would be lowered to about gage height 100 feet and left in place to contain sediment. In this manner the sediment on the upstream face of the new RCC dam would be minimized.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications. The reconnaissance designs described herein are based upon a site inspection and review of available data; more detailed engineering work may result in a different design.

Cucharas Dam is an intermediate Class I dam. The maximum section of the proposed enlarged dam will be an RCC embankment with the following the dimensions:

* 105 feet high at a height of 5760 feet,
* crest length of about 640 feet,
* crest width of 25 feet and no freeboard,
* 0.8H:1.0V upstream and vertical downstream slopes
* 4 - 60 inch diameter outlet pipes,
* spillway across the crest of the dam as needed.

Figure 3 shows the maximum cross section of the dam. Figure 4 shows the front elevation view looking upstream from below the dam.

The top 3 feet of material below the new embankment would be removed and wasted because it contains humus and rocks. A core trench is included assumed under the embankment that is 20 feet deep and 20 feet wide.

The foundation and abutments will be grouted to reduce seepage around and under the embankment. The volume of grout was estimated by assuming that the area to be grouted would be 740 feet long, 100 feet wide, 100 feet deep, with 5% of the volume filled with grout.

The volume of roller compacted concrete to be placed for the new dam is estimated and shown in Table 2.

The availability of suitable materials for concrete aggregate was not evaluated. There appeared to be suitable rock in the area but this must be confirmed during plans and specifications.

OUTLET PIPE: Four 60 inch diameter outlet pipes are included in the embankment to roughly replace the existing outlet capacity; the outlet pipes are at the level of the silt. Motor controlled slide gates would control inflow to the pipes. A low level outlet pipe to flush sediment through the dam is a consideration in the final designs.

The outlet works in the existing dam would be opened to allow water to pass through the old dam as well as over the top.

SPILLWAY: The spillway would be constructed on the crest of the dam and to the width necessary to pass 100% of the probable maximum flood. The short distance on either side of the spillway, the crest will be raised so that the outside edges of the dam are not overtopped during the probable maximum flood.

TABLE 2
CUCHARAS DAM AND RESERVOIR
ROLLER COMPACTED CONRETE EMBANKMENT

3 foot Stripping Depth
Vertical Upstream Slope
0.8 :1 Downstream Slope
5760 foot Crest Elevation
25 foot Crest Width

20 foot Wide Cutoff Trench
20 foot Deep Cutoff Trench

Station	Ground Elevation	Stripping + Height	End Area	Average Area	Embank. Volume	Trench Volume	Total Volume
1000	5760	3	79				
				1621	6000	0	6000
1100	5700	63	3163				
				4991	27730	1110	28840
1250	5660	103	6819				
				7092.5	15800	890	16690
1310	5655	108	7366				
				5264.5	40950	2370	43320
1470	5660	103	6819				
				3803	8450	370	8820
1520	5700	63	3163				
				1975	730	0	730
1530	5740	23	787				
				433	1760	0	1760
1640	5760	3	79				

TOTAL VOLUME OF ROLLER COMPACTED CONCRETE (cubic yards): 106160

Figure 3
Cucharas Dam and Reservoir
Cross Section at Outlet Pipe

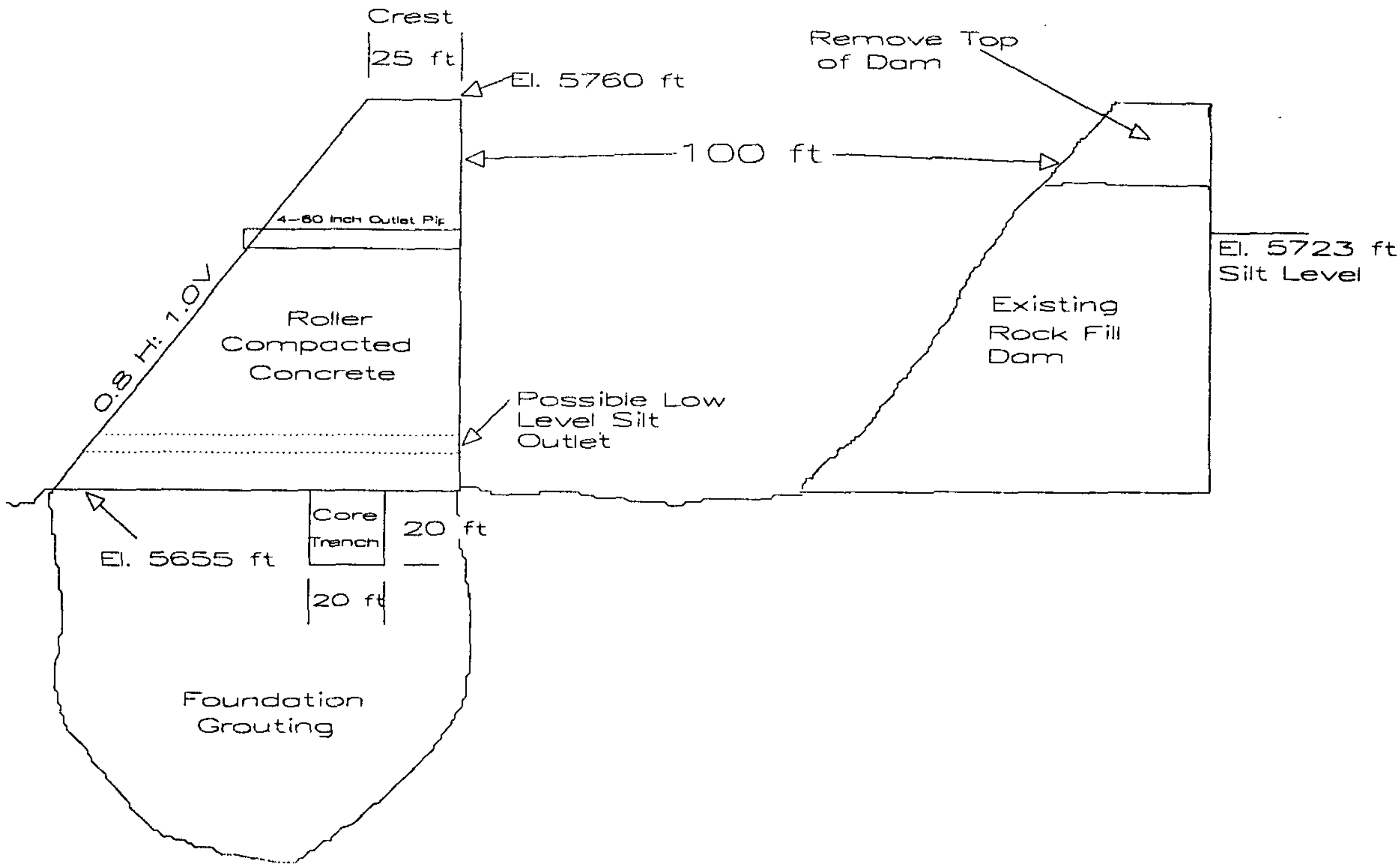
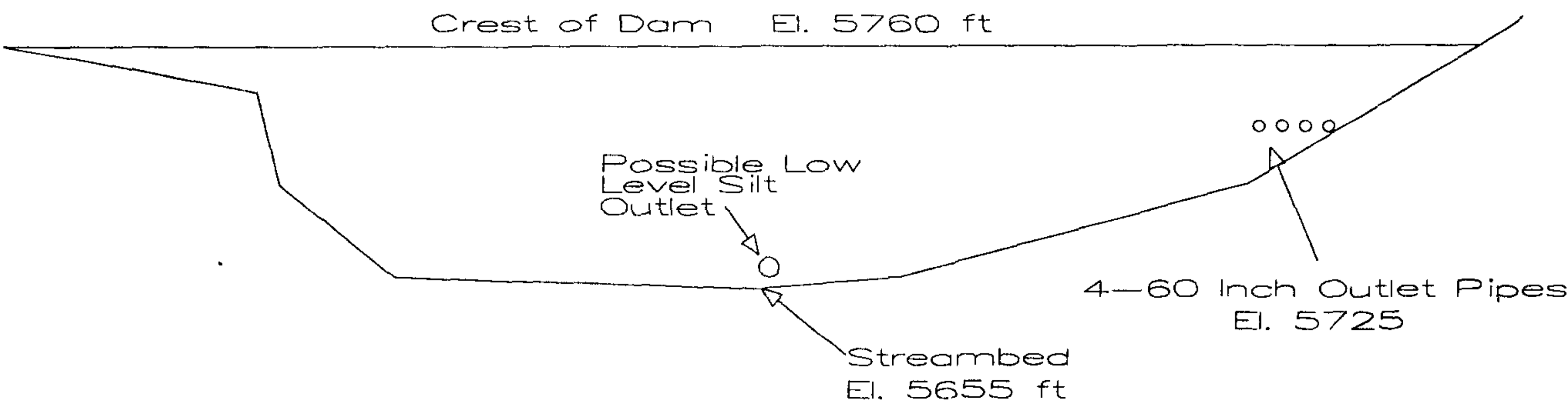


Figure 4
Cucharas Dam and Reservoir
Cross Section at Dam Center Line
Looking Upstream



COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 3. The unit cost of $50 per cubic yard for placement of RCC was taken from literature on RCC dams and indexed.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes: testing for designs, preparation of plans and specifications, construction observation, CWCB financing costs, and any necessary permitting.

FINANCING

The financing options are shown in Table 4 which indicate that the dam and reservoir will have reasonable annual cost per acre-foot of water if there are entities to purchase the water. The cost is less than $30 per acre-foot of yield even at the standard CWCB terms. Option #1, 4% for 30 years is the recommended financing plan.

The financial options are shown to provide a general idea of what the cost of water might be from the reconstructed Cucharas Dam. There are many steps before the dam can be constructed which may change the construction and cost and financing terms.

TABLE 3
CUCHARAS RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$40,000
Embankment				
Roller Compacted Concrete	cy	106160	$50.00	$5,308,000
Foundation Grouting	cy	11850	$20.00	$237,000
	Embankment Subtotal			$5,545,000
Outlet Works				
4 – 60" Outlet Pipes	lf	400	$350	$140,000
Gates & Mechanisms	each	4	$15,000	$60,000
	Outlet Works Subtotal			$200,000
Spillway				
Included in Embankment	cy	0	$0.00	$0
	Spillway Subtotal			$0
	Total of Above Items			$5,745,000
	Contingency (30%)			$1,723,500
	Land Cost			$0
	Field Cost Subtotal			$7,468,500
	Engineering & Admin (15%)			$1,120,300
TOTAL ESTIMATED CONSTRUCTION COST				$8,590,000
Construction Cost per Acre–Foot of Reservoir Storage				$300
Reservoir Storage in Acre–Feet				28800

TABLE 4
CUCHARAS DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$8,590,000	4.0%	30	$496,761	$28
2	$8,590,000	3.5%	20	$604,402	$34
3	$8,590,000	3.5%	30	$467,050	$26
4	$8,590,000	4.0%	40	$433,997	$24
5	$8,590,000	3.5%	40	$402,246	$22

Estimated Annual Yield from Reservoir in Acre-Feet: 18000

RECOMMENDATIONS

The primary issue with construction of a new Cucharas dam is who will step forward to be responsible. All indications are that the present owners are not interested, if so another entity would have to step forward. If the owners are successful in selling the reservoir then possibly the new owners may be interested.

Mr. Singletary's idea to create a new water conservancy district to purchase, construct, operate, and sell water has the most merit. However, creation of the district takes time.

Based on the uncertainty, the recommendation herein is to encourage persons in the area to evaluate creation of a water conservancy district.

The first technical task, that an interested entity should perform, is an evaluation of the average and firm annual yield of water from the reservoir. This evaluation would involve an analysis of existing stream gages and runoff in the Cucharas River basin and, if needed, correlations with similar drainage basins.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

CURRIER DAM AND RESERVOIR
Sponsored By The Battlement Mesa Water Conservancy District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

CURRIER DAM AND RESERVOIR

PLAN DESCRIPTION

Currier Dam & Reservoir would be a new structure located on an unnamed tributary of Buzzard Creek about 10 miles east of Collbran, Colorado. Figure 1 shows the reservoir location in Colorado, Figure 2 is a copy of a USGS Quad map showing the reservoir site and drainage basin.

The sponsoring entity for the dam and contact person are:

Battlement Mesa Water Conservancy District
Ed Currier, President 303-242-0905
832 25 Road
Grand Junction, Colorado 81505

The dam would be constructed by the Battlement Mesa Water Conservancy District (BMWCD) at an off stream site, on private land. Water would be diverted through a short ditch from the Carter Creek drainage, immediately to the east, to fill the reservoir. One of the BMWCD Board members, Ed Currier, is a registered professional engineer with considerable experience in designing and building dams; he has agreed to prepare the designs and specifications followed by construction observation, for no cost. He also will organize equipment owned by members of the Board to construct the dam so that operators will be the primary expense.

The drainage basin, about 0.15 square miles, is covered with brush and grass.

This reconnaissance report describes the engineering issues, designs, and costs of constructing the dam.

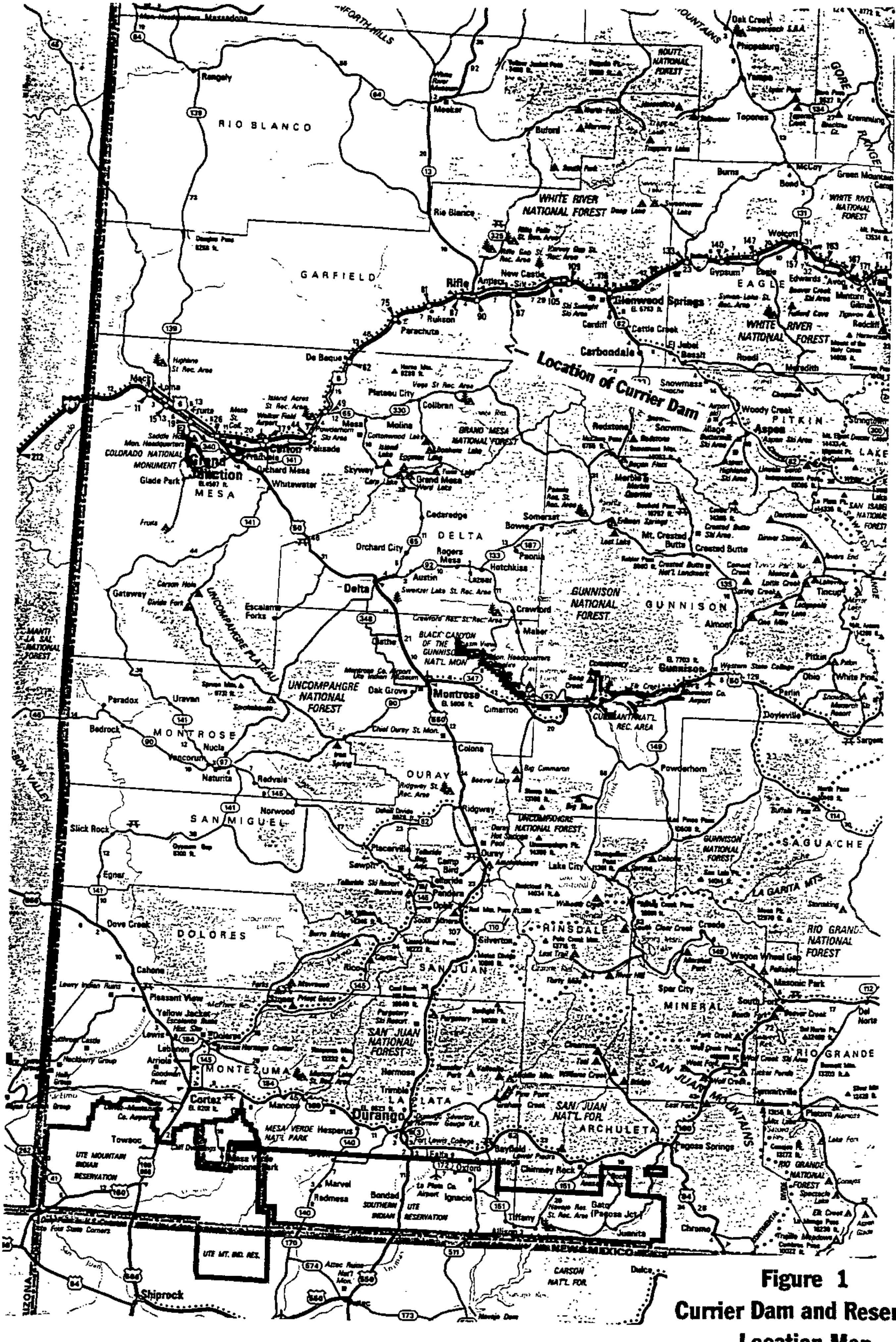


Figure 1
Currier Dam and Reservoir Location Map

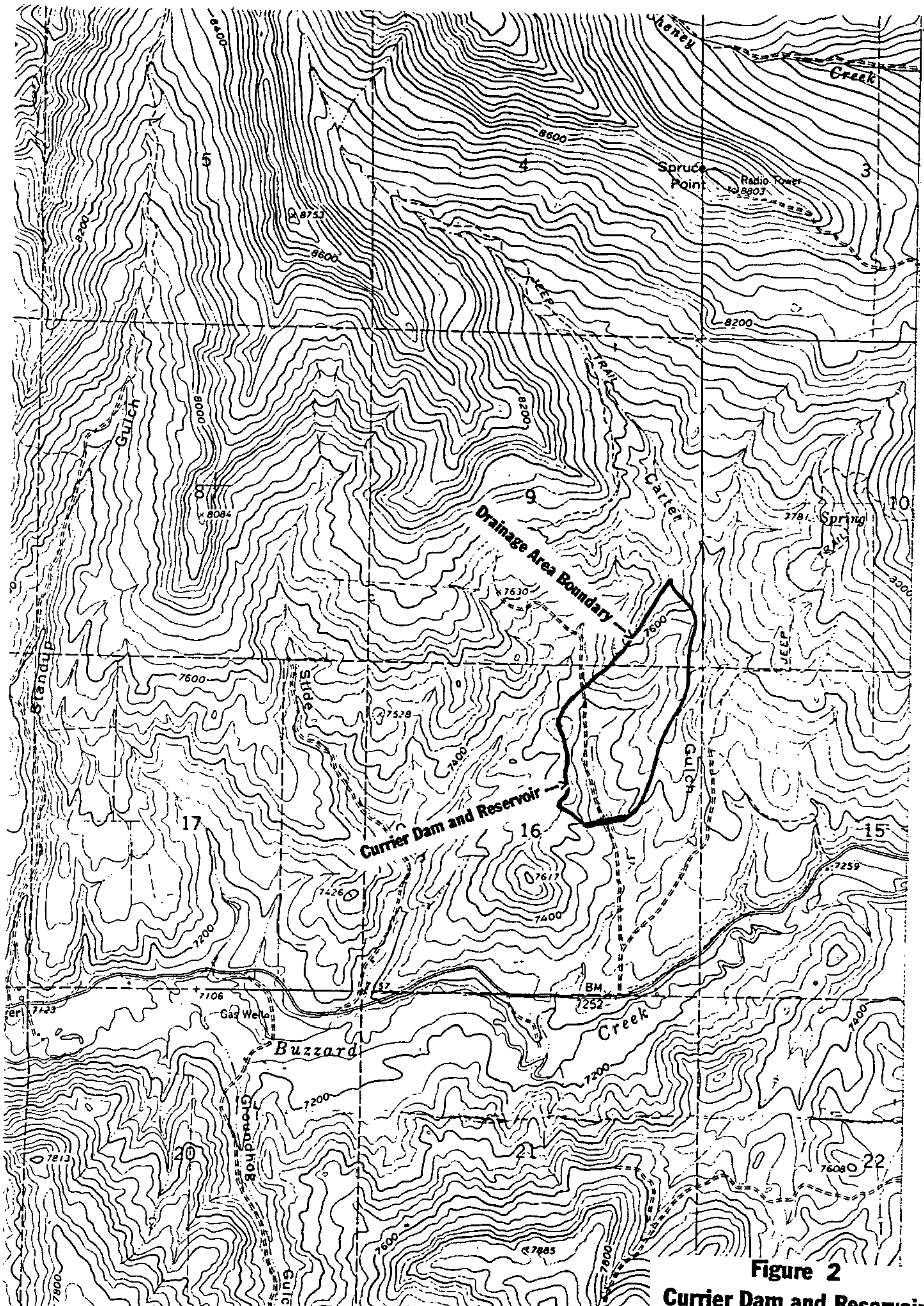


Figure 2
Currier Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The BMWCD holds direct and storage water rights in the Buzzard Creek drainage for the Battlement Mesa Project, which was a Bureau of Reclamation Project but is no longer being considered. The BMWCD plans to transfer storage rights from one of the reservoir sites considered for the old project to the Currier site.

The water supply for the reservoir would be provided by the small amount of runoff from the 0.15 square mile drainage area (refer to drainage area delineation in Figure 2) and a short (about 1200 feet) diversion ditch from Carter Creek. The two water sources will be adequate to fill the small reservoir, described in the following section.

The annual water supply will be the reservoir storage capacity of about 115 acre-feet as described below.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir. The area was developed from 1 inch equals 400 feet, 10 foot contour topography developed by Reclamation for the Battlement Mesa Project, which coincidentally included the Currier Dam and Reservoir.

The crest of the dam is planned to be at elevation 7380 feet. The stream channel is at elevation 7330 feet. The height of the dam is therefore 50 feet with a water depth of 45 feet to allow 5 feet of freeboard. The capacity of the reservoir is estimated to be 115 acre-feet at elevation 7375 feet. The outlet pipe will be near the bottom of the reservoir so essentially all of the capacity will be useable.

TABLE 1
CURRIER DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
7380	9.87	159.6	Top of Proposed Dam
7379	9.49	149.9	
7378	9.11	140.6	
7377	8.73	131.7	
7376	8.35	123.1	
7375	7.97	115.0	Crest of Spillway
7374	7.59	107.2	
7373	7.21	99.8	
7372	6.83	92.8	
7371	6.45	86.1	
7370	6.02	79.9	
7369	5.75	74.0	
7368	5.48	68.4	
7367	5.21	63.0	
7366	4.94	57.9	
7365	4.67	53.1	
7364	4.4	48.6	
7363	4.13	44.3	
7362	3.86	40.3	
7361	3.59	36.6	
7360	3.3	33.1	
7359	3.1	29.9	
7358	2.9	26.9	
7357	2.7	24.1	
7356	2.5	21.5	
7355	2.3	19.1	
7354	2.1	16.9	
7353	1.9	14.9	
7352	1.7	13.1	
7351	1.5	11.5	
7350	1.28	10.2	
7349	1.19	8.9	
7348	1.1	7.8	
7347	1.01	6.7	
7346	0.92	5.7	
7345	0.83	4.9	
7344	0.74	4.1	
7343	0.65	3.4	
7342	0.56	2.8	
7341	0.47	2.2	
7340	0.33	1.8	
7339	0.3	1.5	
7338	0.27	1.2	
7337	0.24	1.0	
7336	0.21	0.7	
7335	0.18	0.5	
7334	0.15	0.4	
7333	0.12	0.2	
7332	0.09	0.1	
7331	0.06	0.0	
7330	0	0.0	Channel Bottom

DAM EMBANKMENT

The dam would be a jurisdictional dam requiring preparation of plans and specifications for approval by the State Engineer prior to construction. The dam is expected to be an intermediate Class I structure; there would probably be loss of life if the dam failed. The reconnaissance designs described herein are based upon a site inspection in October of 1993 and a review of available data; more detailed engineering work may result in a different design.

The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, maximum of 25 feet,
* a spillway capable of passing a PMP flood,
* upstream rip rap to protect the embankment,
* and complete soils investigation and analysis.

EMBANKMENT: The dam is expected to be a homogeneous earth embankment constructed from impervious material in the reservoir basin. The dam would have the following the dimensions:

* 50 feet high,
* crest length of about 358 feet,
* crest width of 20 feet,
* 3.25H:1.0V upstream and 2.0H:1.0V downstream slopes
* 18 inch diameter outlet pipe,
* 15 foot wide spillway.

An 8 foot deep, 15 foot wide core trench would be excavated most of the length of the embankment and upstream of the centerline of the embankment.

Figure 3 shows the cross section of the dam at the outlet pipe. Figure 4 shows the front view of the embankment looking upstream from below the dam. Figure 5 shows a plan view of the dam, reservoir, and spillway.

There appears to be adequate impermeable material for the embankment available in the reservoir basin. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir. Table 2 shows the estimated volume of material required to construct the embankment. The material would be placed in one foot lifts and compacted to the appropriate density. Adequate testing will be required to monitor the compaction.

Rip rap is expected to be available near the county road about one half mile to the south.

A toe drain is included to control seepage through the embankment. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 200 feet long.

OUTLET PIPE: The outlet pipe size is suggested to be 18 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance and if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be thick walled steel, possibly lined with mortar or another material; CMP is not recommended.

SPILLWAY: The spillway will be sized to pass the PMF (probable maximum flood). Since the drainage basin is only 0.15 square miles the size of the flood will be very small. Bureau of Reclamation criteria for reconnaissance level design flood estimating gives 70 acre-feet for a 0.15 square mile drainage basin; a peak flood flow was not available. The surcharge capacity is 40 acre-feet so the spillway would need to pass about half the flood, during the flood. A spillway width of 15 feet with 1:1 side slopes, excavated on the east abutment, would pass about 450 cfs which is expected to be adequate.

The spillway would discharge into the channel below the dam as shown on Figure 5. A concrete cutoff wall perpendicular to the flow of water is included to stabilize the spillway section. The wall would be about 2 feet thick, at least 2 feet below the ground surface at any point along the wall, and be the desired shape of the spillway cross section (15 feet wide at the base and sloping up a 1:1 on either side).

TABLE 2
CURRIER DAM EMBANKMENT VOLUME ESTIMATE

2 foot Stripping Depth
3.25 :1 Upstream
2 :1 Downstream
20 foot Crest Width
7380 feet Crest Elevation

15 foot Key Trench Width
8 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
100	7380	2	51				
				334.5	533	22	555
143	7370	12	618				
				1165	1510	78	1588
178	7360	22	1711				
				2520	3733	178	3911
218	7350	32	3328				
				4400	7007	191	7198
261	7340	42	5471				
				6804.5	7561	133	7694
291	7330	52	8138				
				6805	7561	133	7694
321	7340	42	5471				
				4400	6356	173	6529
360	7350	32	3328				
				2519.5	3733	178	3911
400	7360	22	1711				
				1165	992	51	1043
423	7370	12	618				
				335	434	22	456
458	7380	2	51				

Total Embankment Volume (cubic yards) 40600

Total Cubic Yards of Excavation & Compacted Fill (30% compaction) 52800

Figure 3
Currier Dam and Reservoir
Cross Section at Dam Center Line
Looking Upstream

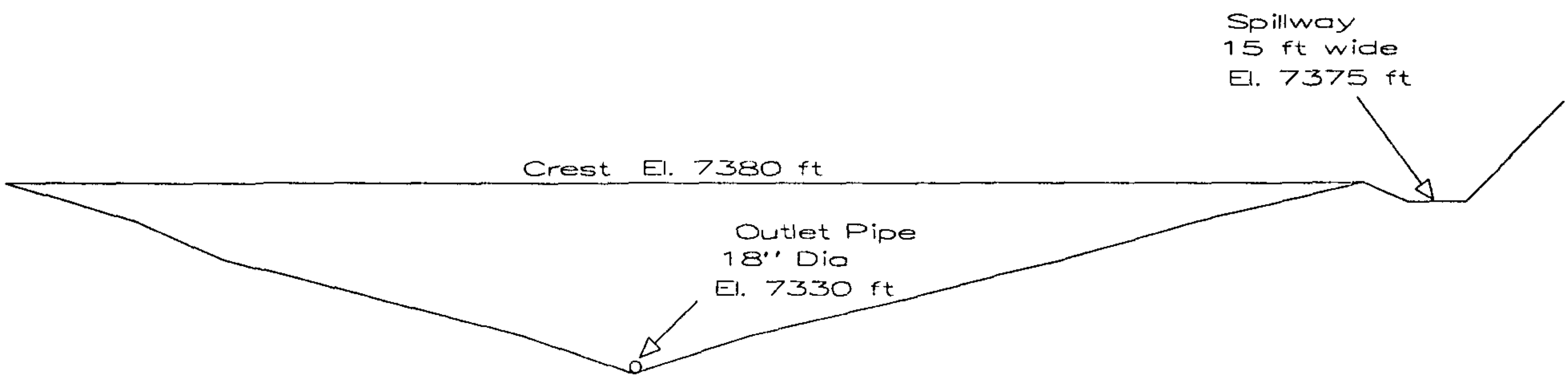
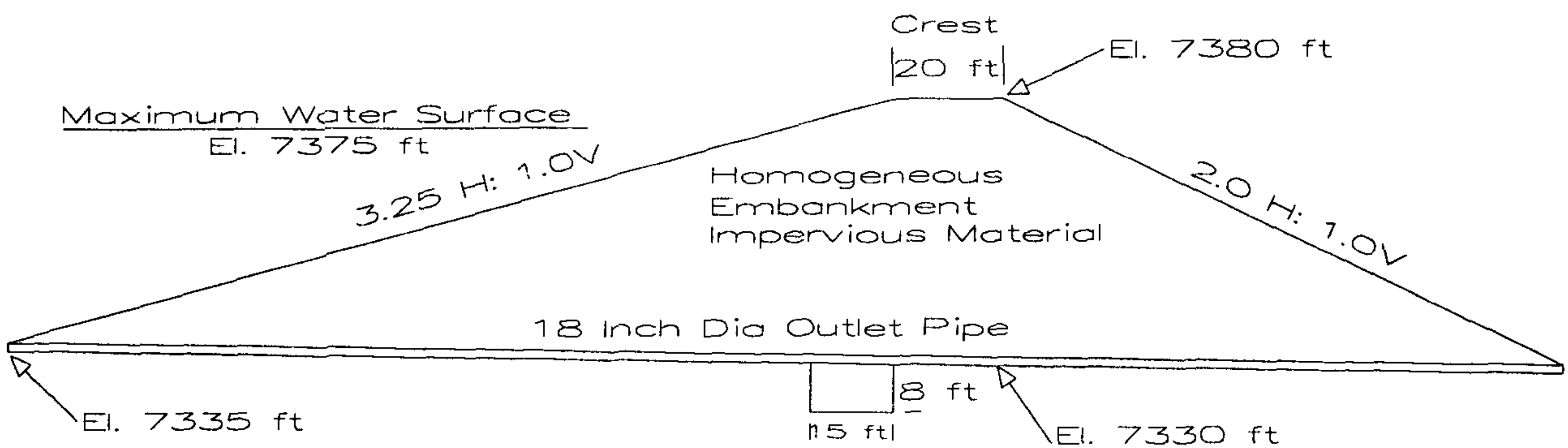


Figure 4
Currier Dam and Reservoir
Cross Section at Outlet Pipe



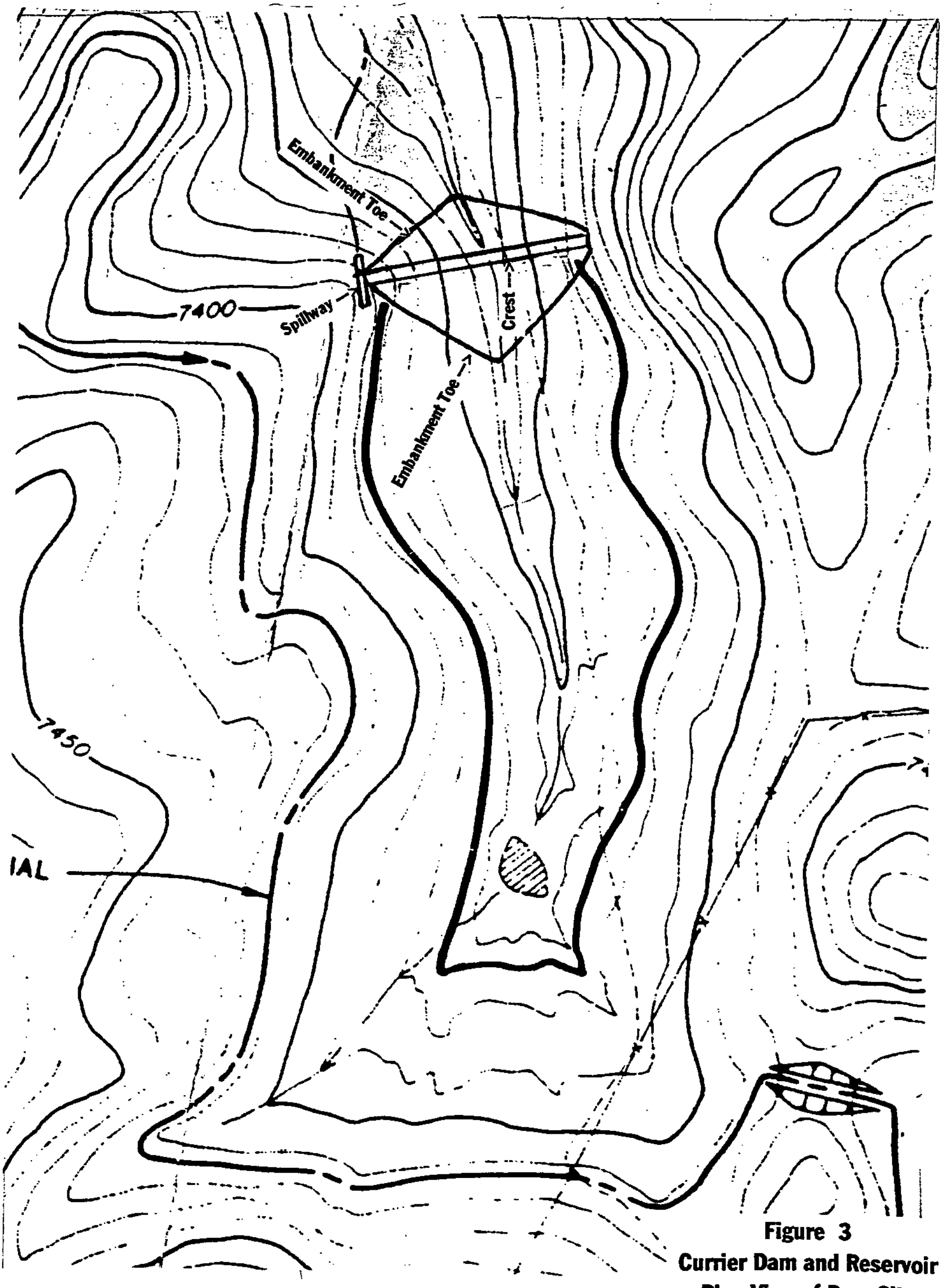


Figure 3
Currier Dam and Reservoir
Plan View of Dam Site

COST ESTIMATE

The estimated cost to construct the dam is shown in Table 3. The unit costs are based upon the BMWCD providing the equipment and some of the operators, so the usual cost of $4 per cubic yard to excavate and place the embankment material is reduced to $2. Other installation costs, not manufactured materials, are reduced similarly.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 5% based upon Ed Currier providing these services for free; which include preparation of plans and specifications and construction observation. The 5% will be used for soils evaluations and to collect data to obtain any necessary environmental permits, e.g. 404 permit, etc..

The dam and reservoir is on land owned by Ed Currier. He is agreeable to leasing the land to the BMWCD for a long period of time for a minimal amount.

FINANCING

The cost for this work will require financing. It is suggested that the BMWCD obtain preconstruction funds from the CWCB for soils evaluations and environmental compliance. Once the plans and specifications are approved and the permits are received construction funding would be needed. Table 4 shows several financing options assuming funds from the CWCB. Option 1 is the standard CWCB loan terms as of December, 1993; the terms change with national interest rates. As can be seen, even if Option 7 is assumed, a 1% interest rate for 40 years, the cost per acre-foot is still over $50.

RECOMMENDATIONS

Construction of Currier Dam and Reservoir does not appear to be financially feasible because the development costs are greater than the repayment ability of the irrigators. No further work is recommended on the dam.

TABLE 3
CURRIER DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$5,000
Embankment				
Exc. & Compacted Fill	cy	52800	$2.00	$105,600
Rip Rap	cy	1330	$20.00	$26,600
Toe Drain	lf	200	$20.00	$4,000
	Embankment Subtotal			$136,200
Outlet Works				
18" Outlet Pipe	lf	290	$40.00	$11,600
Gate	ls			$5,000
	Outlet Works Subtotal			$16,600
Spillway (30' Wide)				
Excavation	cy	740	$1.50	$1,100
Concrete Cutoff Wall	cy	10	$300.00	$3,000
	Spillway Subtotal			$4,100
	Total of Above Items			$156,900
	Contingency (30%)			$47,100
	Land Cost			$0
	Field Cost Subtotal			$204,000
	Engineering & Admin (5%)			$10,200
TOTAL ESTIMATED CONSTRUCTION COST				$214,000
Construction Cost per Acre-Foot of Yield				$1,860
Estimated Annual Reservoir Capacity/Yield in Acre-Feet				115

TABLE 4
CURRIER DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$214,000	4.0%	30	$12,376	$108
2	$214,000	4.0%	40	$10,812	$94
3	$214,000	3.5%	30	$11,635	$101
4	$214,000	3.0%	30	$10,918	$95
5	$214,000	3.0%	40	$9,258	$81
6	$214,000	2.0%	40	$7,823	$68
7	$214,000	1.0%	40	$6,517	$57

Volume of Reservoir Capacity/Annual Yield in Acre-Feet: 115

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

EAST LAKE CREEK DAM AND RESERVOIR
Sponsored By The Vail Valley Consolidated Water District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

UPPER EAGLE VALLEY CONSOLIDATED
SANITATION DISTRICT

846 FOREST ROAD • VAIL, COLORADO 81657
(303) 476-7480 • FAX (303) 476-4089

March 1, 1994

Mr. Steven C. Harris
Harris Water Engineering, Inc.
954 Second Avenue
Durango, CO 81301

Re: East Lake Creek Dam

Dear Mr. Harris:

I am writing regarding your report to the Colorado Water Conservation Board (CWCB) on the evaluation of East Lake Creek Dam and Reservoir.

As stated in your report, East Lake Creek was identified as a potential reservoir site in a report prepared by Tipton & Kalmbach, Inc. for the Vail Valley Consolidated Water District (District). At the present time however, the District has no plans to pursue water storage on East Lake Creek.

In December 1993, the Upper Eagle Regional Water Authority (Authority) filed for water storage rights on East Lake Creek in connect with its investigation of water management options. The Authority provides domestic water service to residents of the Eagle River Valley from the confluence of the Eagle River and Gore Creek to Squaw Creek.

The filing by the Authority has caused concern and some controversy among property owners and residents in the Lake Creek area. The District wants to be certain that it is not associated with this filing or the resulting controversy. Since your report identifies the District as the sponsor of a possible reservoir on East Lake Creek, we ask that you provide the Colorado Water Conservation Board with notice that the District is <u>not</u> the sponsor of such a reservoir nor does it intend to be in the future.

We would appreciate it if you would give such notice immediately and provided us with a copy of your correspondence to the CWCB.

We offer the following suggestions to correct a few errors of fact in your report and to remove references to the District.

Page 1:

Lake Creek enters the Eagle River about 15 miles east of the Town of Eagle. The Eagle River joins the Colorado River about 15 miles west of the Town of Eagle.

Also on Page 1:

If it were ever constructed, water from the reservoir would be used primarily for municipal purposes in communities located in the Eagle River Valley from the confluence with Gore Creek to the confluence with Squaw Creek.

Figure 1:

Your location map should show the proposed reservoir site just south of the community of Edwards.

Page 11:

Neither the District nor the Authority are in the wastewater treatment business, therefore, the 2nd and 3rd sentences of the 1st paragraph under the title Financing should be deleted.

All references to "Vail Valley Consolidated Water District" or "District" should be removed from the following locations in the text of your report.

Cover Page

Page 1: 2nd & 4th paragraphs

Page 4: 1st paragraph

Page 11: 5th & 6th paragraphs

Page 14: 1st paragraph & paragraph numbered 1.

We appreciate your cooperation. If you have any questions in connection with this request, please feel free to give me a call.

Sincerely,

Dennis Gelvin
Interim General Manger

DG:sld
\admin\gelv\sh-lkcrk.ltr

EAST LAKE CREEK DAM AND RESERVOIR

PLAN DESCRIPTION

East Lake Creek Dam and Reservoir would be a new structure located on East Lake Creek a tributary of Lake Creek which enters the Colorado River about 2 miles upstream from the Town of Eagle. Figure 1 shows the reservoir location in Colorado, Figure 2 is a copy of a USGS Quad map showing the reservoir site and drainage basin.

The sponsoring entity for the dam and the contact person are:

Vail Valley Consolidated Water District
Dennis Galvin, Manager 476-7480
846 Forest Road
Vail, Colorado 81657

The water would be used for municipal purposes in the Eagle - Vail area.

Tipton and Kalmbach prepared a report for the District in 1989, which surveyed 17 potential reservoir sites in the area. Based on that study, the East Lake Creek Reservoir was determined to be one of the best three sites, if not the best. Much of the technical information included herein is based upon the 1989 report, the embankment volume and construction cost estimate was redetermined herein.

This reconnaissance report describes the engineering issues, preliminary designs, and costs of constructing the dam.

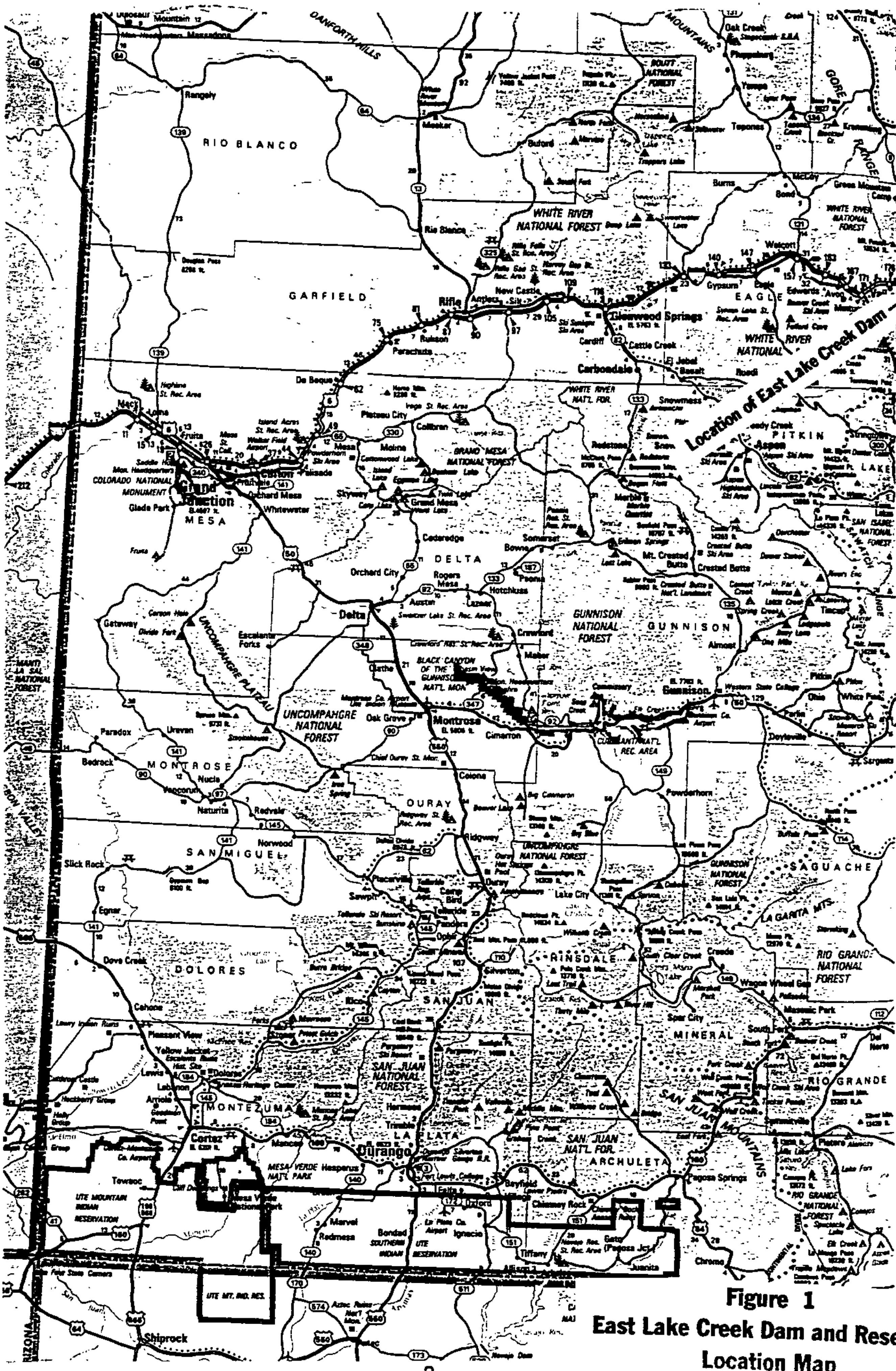
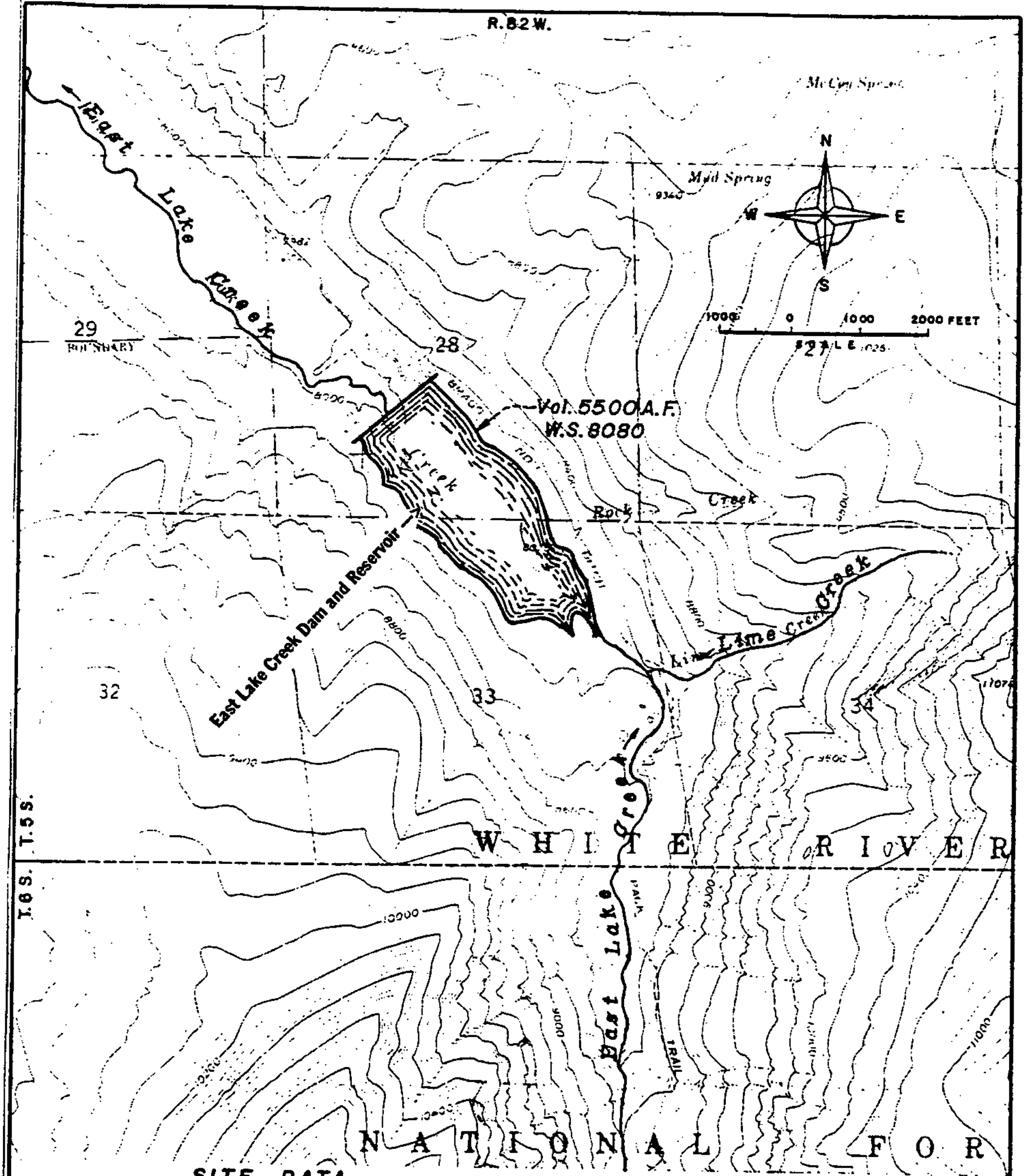


Figure 1
East Lake Creek Dam and Reservoir
Location Map



SITE DATA

RESERVOIR		DAM	
Storage (acre-feet)	W.S. Elev. (feet)	Height (feet)	Length (feet)
1000	8034	59	1020
5500	8080	105	1365

Figure 2
East Lake Creek Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The 1989 report estimated that a 5780 acre-foot reservoir would have a firm yield of about 5,400 acre-feet in the driest years. This is based upon bypasses to senior water rights including the Shoshone Power Plant. The District must obtain water rights for the site.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir. The area was developed from data in the 1989 report, which apparently used USGS Quad maps.

The crest of the dam is planned to be at elevation 8085 feet. The stream channel is at elevation 7975 feet. The height of the dam is therefore 110 feet with a water depth of 105 feet to allow 5 feet of freeboard. The capacity of the reservoir is estimated to be 5780 acre-feet at elevation 8080 feet. The outlet pipe will be near the bottom of the reservoir so essentially all of the capacity will be useable.

TABLE 1
EAST LAKE CREEK DAM & RESERVOIR
Elevation– Area–Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8084	134.1	6308	Top of Large Dam
8082	132.2	6042	
8080	129.5	5780	Spillway of Large Dam
8078	126.8	5524	
8076	124.1	5273	
8074	121.4	5028	
8072	118.7	4787	
8070	116	4553	
8068	113.3	4323	
8066	110.6	4100	
8064	107.9	3881	
8062	105.2	3668	
8060	102.5	3460	
8058	99.8	3258	
8056	97.1	3061	
8054	94.4	2870	
8052	91.7	2683	
8050	89	2503	
8048	86.3	2327	
8046	83.6	2158	
8044	80.9	1993	
8042	78.2	1834	
8040	75.5	1680	
8038	72.8	1532	
8036	70.1	1389	
8034	68	1251	
8032	64.2	1119	
8030	60.4	994	
8028	56.6	877	
8026	52.8	768	
8024	49	666	
8022	45.2	572	
8020	41.4	485	
8018	37.6	406	
8016	33.8	335	
8014	30	271	
8012	26.2	215	
8010	22.4	166	
8008	18.6	125	
8006	14.8	92	
8004	11	66	
8002	7.2	48	
8000	3	38	

DAM EMBANKMENT

The dam would be a jurisdictional dam requiring preparation of plans and specifications for approval by the State Engineer prior to construction. The dam is expected to be an intermediate Class I structure; there would probably be loss of life if the dam failed. The reconnaissance designs described herein are based upon the 1989 report described above.

The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, 25 feet maximum,
* a spillway capable of passing 100% of the PMP flood,
* upstream rip rap to protect the embankment,
* and complete soils investigation and analysis.

EMBANKMENT: The dam is expected to be a homogeneous earth embankment constructed from impervious material in the reservoir basin. The dam would have the following the dimensions:

* 110 feet high,
* crest length of about 1370 feet,
* crest width of 25 feet,
* 3.25H:1.0V upstream and 2.5H:1.0V downstream slopes
* 36 inch diameter outlet pipe,
* a spillway capable of passing 100% of the PMP.

A 20 foot deep, 75 foot wide core trench would be excavated most of the length of the embankment and upstream of the centerline of the embankment.

Figure 3 shows the cross section of the dam at the outlet pipe. Figure 4 shows the front elevation view of the embankment looking upstream from below the dam.

There is assumed to be adequate impermeable material for the embankment available in the reservoir basin. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir. Table 2 shows the estimated volume of material required to construct the embankment; 30% is added to this amount to allow for compaction. The material would be placed in and compacted to at least 95% Standard Proctor. Adequate testing will be required to monitor the compaction.

Rip rap is expected to be available near the reservoir.

A toe drain is included to control seepage through the embankment. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 500 feet long.

The cost of a roller compacted concrete dam was roughly evaluated and was significantly more costly but offered the advantage of a spillway. If the cost assumption herein for a spillway is not adequate, an RCC dam should be reconsidered.

OUTLET PIPE: The outlet pipe size is suggested to be 36 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance and if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be thick walled steel, possibly lined with mortar or another material; CMP is not recommended.

SPILLWAY: The spillway will be sized to pass the PMF (probable maximum flood). The PMF was estimated from Bureau of Reclamation reconnaissance level sizing criteria, which indicate that the 20 square mile drainage area would have a flood of about 14,000 cfs and 4,000 acre-feet of volume.

The location of the spillway is a problem because the valley is very narrow and the spillway cannot be placed on either abutment. Therefore the spillway must be incorporated in the embankment somehow, such as a chute on the downstream face of the dam or a drop structure. A specific plan for the spillway is not included but a large cost is included to allow various methods.

TABLE 2
EAST LAKE CREEK DAM – EMBANKMENT VOLUME ESTIMATE

2 foot Stripping Depth
3.25 :1 Upstream
2.5 :1 Downstream
25 foot Crest Width
8085 feet Crest Elevation

75 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
1000	8085	2	62				
				189	210	278	488
1030	8080	7	316				
				12126	188627	23333	211960
1450	8000	87	23936				
				31400	127926	6111	134037
1560	7975	112	38864				
				31400	302370	14444	316814
1820	8000	87	23936				
				12126	233538	28889	262427
2340	8080	7	316				
				189	210	0	210
2370	8085	2	62				

Total Embankment Volume (cubic yards) 925900

Total Cubic Yards of Excavation & Compacted Fill (30% compaction) 1203700

Figure 3
East Lake Creek Dam and Reservoir
Cross Section at Outlet Pipe

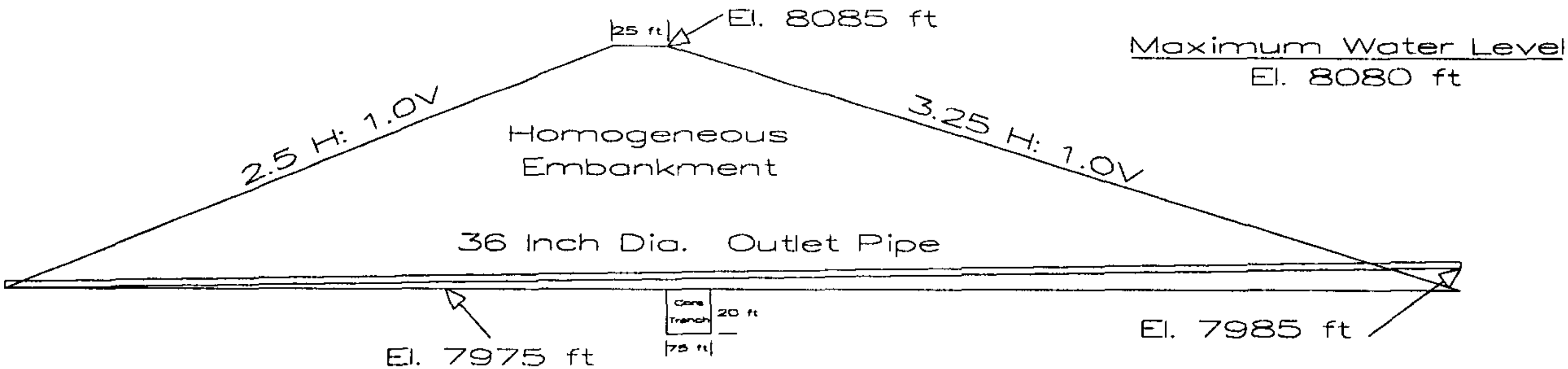
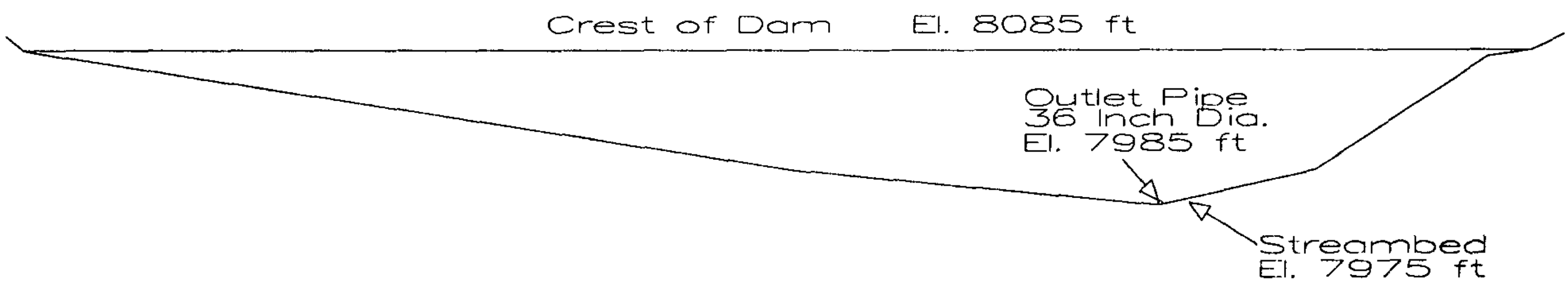


Figure 4

East Lake Creek Dam and Reservoir

Cross Section at Dam Center Line

Looking Upstreem



COST ESTIMATE

The estimated cost to construct the dam is shown in Table 3. The unit costs are based upon typical construction costs in rural areas. The spillway cost is estimated to be 50% of the embankment cost to include adequate funds for the type of spillway that is eventually selected.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

The dam and reservoir are on private land. The purchase price is estimated to be $4000 per acre for about 150 acres.

A 404 permit will be required which will trigger endangered species consultation and wetlands mitigation. The recent experience of the Colorado River Water Conservation District in obtaining permits and agreements to construct a reservoir near the Colorado River does not bode well for timely construction of dams.

FINANCING

The cost for this work will require financing. The District is currently in the process of attempting to finance and construct a $10 million wastewater treatment plant, which leaves little cash nor bonding ability for a large reservoir. For this reason, 100% financing of the reservoir is assumed.

Table 4 shows two financing options assuming 100% funding by the CWCB. Options 1 and 2 are standard CWCB loan terms as of December, 1993; the terms change with national interest rates. Either Option is recommended, the choice will be based upon the District's repayment ability.

TABLE 3
EAST LAKE CREEK DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$100,000
Embankment				
Exc. & Compacted Fill	cy	1203700	$4.00	$4,814,800
Rip Rap	cy	8670	$20.00	$173,400
Toe Drain	lf	500	$20.00	$10,000
	Embankment Subtotal			$4,998,200
Outlet Works				
36" Outlet Pipe	lf	590	$120.00	$70,800
Gate	ls			$50,000
	Outlet Works Subtotal			$120,800
Spillway				
Location and Type Undetermined -- Estimate 50% of Embankment				$2,499,100
	Spillway Subtotal			$2,499,100
	Total of Above Items			$7,718,100
	Contingency (30%)			$2,315,400
	Land Cost (150 acres)			$600,000
	Field Cost Subtotal			$10,633,500
	Engineering & Admin (15%)			$1,595,000
TOTAL ESTIMATED CONSTRUCTION COST				$12,230,000
Construction Cost per Acre-Foot of Storage				$2,120
Estimated Acre-Feet of Storage Capacity				5780

TABLE 4
EAST LAKE CREEK DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$12,230,000	4.0%	30	$707,262	$122
2	$12,230,000	3.5%	20	$860,516	$149

Volume of Reservoir Storage in Acre-Feet: 5780

RECOMMENDATIONS

This report recommends that the District pursue development of additional water storage but perform a feasibility study on 3 or 4 alternative storage methods before selecting the best site.

The costs and financing amounts described above give a general idea of the cost of water.

The specific development steps are described below:

1. The District must decide if it is ready to begin the 4 to 8 year process to construct a new reservoir. If there are no problems, the soonest the dam could be constructed is 1998; more likely the dam could not be constructed until 1999 or 2000, if the District diligently pursues development. Soonest winter 1994.

2. Request feasibility study funds from the CWCB to evaluate 3 or 4 of the best storage options. The evaluations would include: detailed evaluation of water requirements and supply, preliminary engineering designs, materials investigations, environmental permit requirements, and land acquisition. The capacity of the reservoir assumed in this report may be larger than can realistically be constructed and used. The study cost would probably be about $100,000 and require about 6 to 9 months to complete. Soonest fall 1994.

3. Based on the results of the feasibility study, assuming that East Lake Creek or another dam site are selected, the next step would be to request construction funding from the CWCB so that: (1) the plans and specifications for the dam can be prepared and submitted, (2) the environmental permits can be prepared and submitted, (3) other agreements can be negotiated and ratified, and (4) land can be acquired. The CWCB accepts construction funding requests in the fall of each year which must be approved by the State Legislature, so that funding is available the following summer. Soonest funds would be available is summer 1995.

4. The preconstruction activities would require at least two years for the permits and plan approvals. Soonest completion is summer 1997.

5. Allowing about 6 months for bidding and contractor selection, construction could begin in the spring of 1998, at the soonest.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

Water Storage Requirements of the City of Fort Morgan

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

CITY OF FORT MORGAN

PLAN DESCRIPTION

The City of Fort Morgan is participating in the "Southern Water Supply Project" which is a pipeline between Carter Lake and Broomfield being constructed by the Northern Colorado Water Conservancy District (NCWCD).

In order to serve Fort Morgan, an eastern pipeline will be constructed from about the midpoint of the Broomfield-Carter Lake pipeline to Fort Morgan; serving other communities along the way.

Presently Fort Morgan obtains all of its municipal water from wells, which are poor quality. With the pipeline, the City will receive raw water that must be treated and in order to minimize the size of the pipeline, a reservoir is needed near the City to supply peak demands.

Figure 1 shows the general location of the City of Fort Morgan.

The contacts for the City are:

Kevin Crago, Director of Utilities (867-3001)
City of Fort Morgan
710 E. Railroad Avenue
Fort Morgan, Colorado 80701

Jack Odor, City Engineer (Consulting) (867-5298)
219 E. Railroad Avenue
Fort Morgan, Colorado 80701

The construction of the pipeline from Broomfield to Carter Lake is scheduled for construction in 1994. The eastern pipeline is not yet scheduled but is still in the process of being planned and designed; the entities to receive water are still being determined.

In order to size the pipeline to serve Fort Morgan, the City needs to prepare a feasibility study which evaluates raw water reservoir and water treatment plant sites.

RECOMMENDATIONS

When appropriate, it is recommended that the City apply to the CWCB for feasibility study funds to evaluate reservoir sites relative to water treatment plant sites and for sizing the main pipeline.

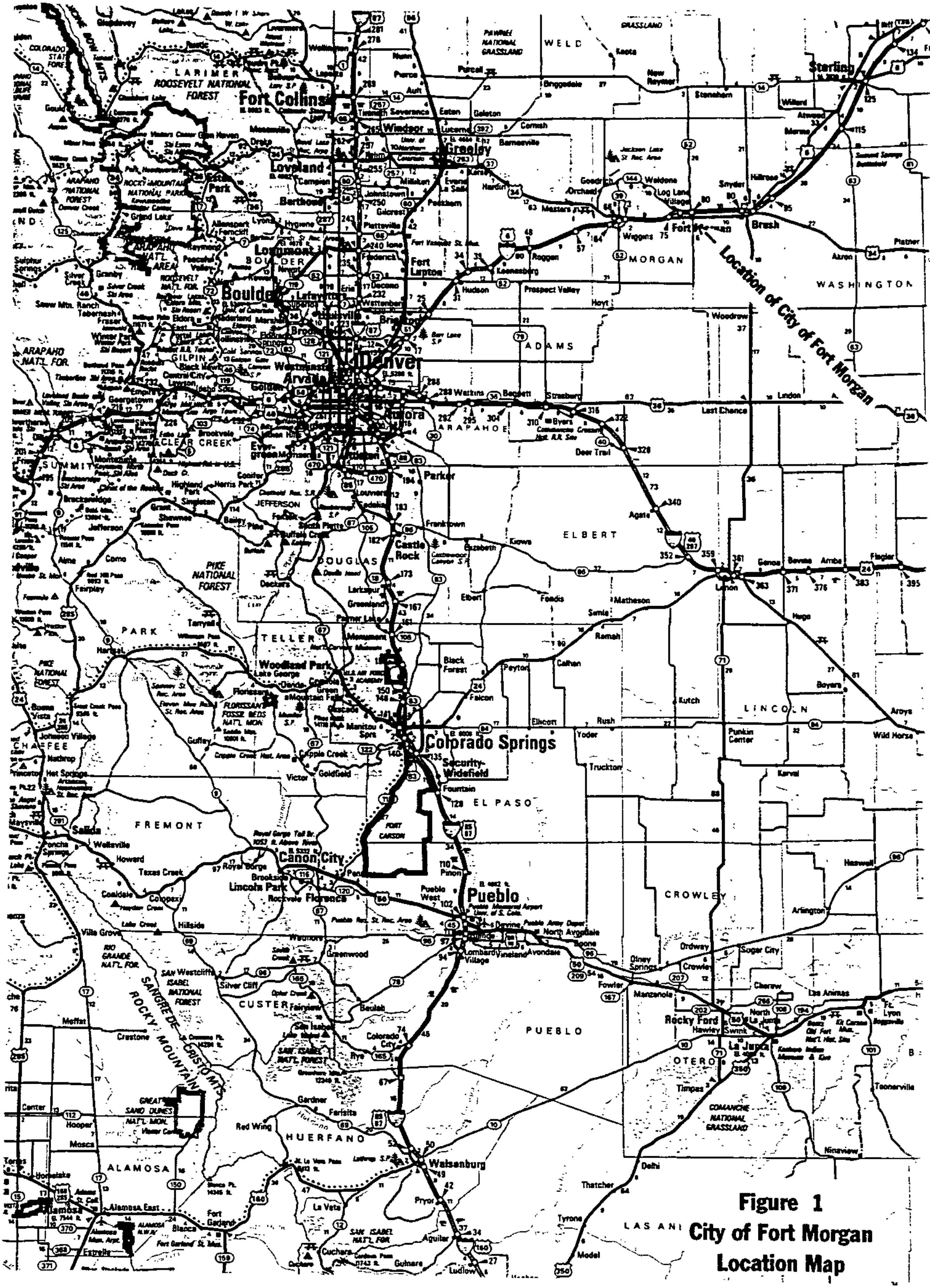


Figure 1
City of Fort Morgan
Location Map

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

GOULD DAM AND RESERVOIR
Sponsored By The Fruitland Mesa Water Conservancy District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

GOULD DAM AND RESERVOIR ENLARGEMENT

PLAN DESCRIPTION

Gould (aka Onion Valley) Dam and Reservoir is an existing structure located on Iron Creek in the North Fork of the Gunnison River drainage in western Colorado, about 15 miles south of the Town of Hotchkiss. Figure 1 shows the general reservoir location. The dam is owned by the Fruitland Irrigation Company but any enlargements of Gould Reservoir would be sponsored by the Fruitland Mesa Water Conservancy District. The District contact person is:

Don Meeks (921-5757)
82551 Highway 92
Maher, Colorado 81421

The purpose of enlarging the dam and reservoir is to store additional water for use by irrigators downstream of the reservoir.

The dam and reservoir were included in the Fruitland Mesa Project which is a participating project of the Colorado River Storage Project Act, but has not been constructed. The Bureau of Reclamation has studied the enlargement as part of an overall plan to divert and store additional water for the area. There is considerable information on the Gould enlargement at the Reclamation Grand Junction Projects Office.

The CWCB and the Fruitland Mesa WCD retained PRC (now ECI) Engineers in 1980 to prepare a feasibility study on the enlargement of Gould Reservoir. Where Reclamation had included Gould as one component of a larger project, the PRC report just investigated enlarging Gould Reservoir. The PRC report thoroughly investigated the technical and cost issues associated with enlargement of Gould Reservoir. The report determined that an enlarged Gould Reservoir, from about 8,300 acre-feet to 12,000 acre-feet, in conjunction with cooperative operation of the existing ditch water would increase the late season irrigation water supply considerably. The report, however, concluded that there was not sufficient irrigation repayment ability to repay the project costs even though the benefits exceeded the costs.

This report summarizes the findings and updates the cost estimates to determine if the project is feasible at today's financing terms.

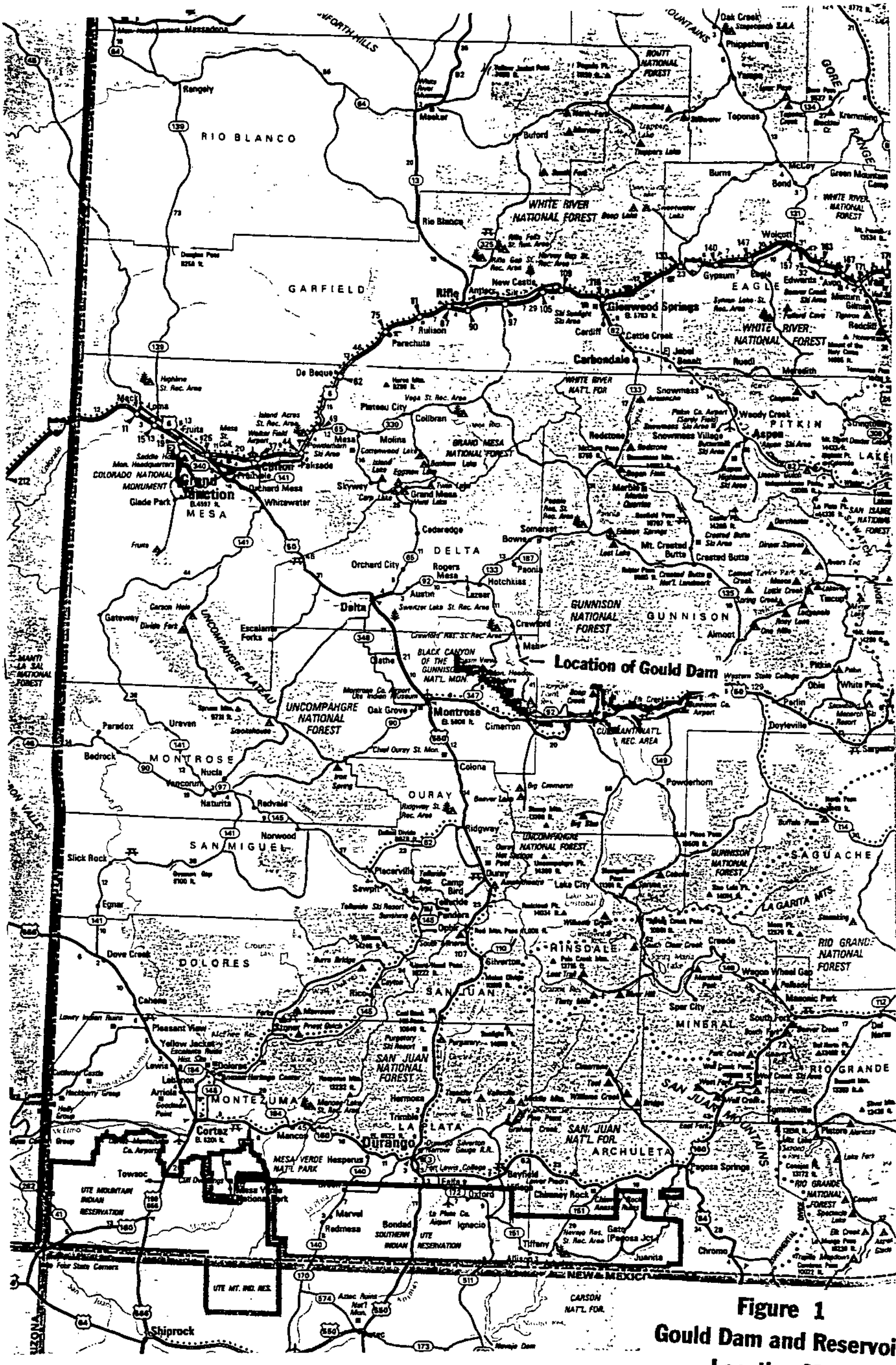


Figure 1
Gould Dam and Reservoir Location Map

WATER SUPPLY

The water source for Gould Reservoir is one of the key issues in determining the technical feasibility of the project. The project would require diversions from Crystal Creek, Onion Valley, and Iron Creek. Also, if possible, diversions from several small creeks on Black Mesa would be utilized.

The water diversions of the existing ditches would be changed so that irrigators diverted the ideal irrigation requirement in the early season. The excess early water would be stored in the enlarged Gould Reservoir for use later in the season. This re-operation of the existing ditches is a significant change in water usage patterns and will be difficult to achieve.

The PRC report thoroughly evaluated sources of runoff and methods of water allocation and determined that the best reservoir size would be 12,000 acre-feet, increased from 8,300 acre-feet currently. This size reservoir in conjunction with re-operation of ditch rights would decrease the water shortage to the 6,310 acres in the service area, from 4,030 acre-feet to 2,240 acre-feet. The additional water would allow a significant increase in the late season irrigation water supply.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir from the estimated bottom of 7270 feet to the proposed dam crest of 7335 feet. The table was developed from data obtained from the Bureau of Reclamation. The reservoir quantities suggested by PRC, based on Table 1, are an increase from 8404 acre-feet to 12,370 acre-feet, an increased storage volume of about 4,000 acre-feet.

TABLE 1
GOULD DAM & RESERVOIR
Elevation– Area–Capacity

Depth	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
7335	427	14400.0	Top of Enlarged Dam
7334	421.4	12370.0	
7333	415.8	12370.0	
7332	410.2	12370.0	
7331	404.6	12370.0	
7330	399	12370.0	Enlarged Spillway Crest
7329	391.7	12106.1	
7328	384.4	11842.2	
7327	377.1	11578.3	
7326	369.8	11314.4	
7325	362.5	11050.5	
7324	355.2	10786.6	
7323	347.9	10522.7	Existing Dam Crest
7322	340.6	10258.8	
7321	333.3	9994.9	
7320	326	9731.0	
7319	318.7	8404.0	Existing Spillway Crest
7318	311.4	8075.0	
7317	304.1	7762.0	
7316	296.8	7450.0	
7315	289.5	7145.0	
7314	282.2	6850.0	
7313	274.9	6559.0	
7312	267.6	6279.0	
7311	260.3	6001.0	
7310	253	5734.0	
7309	248.2	5472.0	
7308	243.4	5216.0	
7307	238.6	4964.0	
7306	233.8	4718.0	
7305	229	4476.0	
7304	224.2	4241.0	
7303	219.4	4012.0	
7302	214.6	3789.0	
7301	209.8	3574.0	
7300	205	3366.0	
7299	199.2	3163.0	
7298	193.4	2966.0	
7297	187.6	2775.0	
7296	181.8	2589.0	
7295	176	2409.0	
7294	170.2	2235.0	
7293	164.4	2067.0	
7292	158.6	1905.0	
7291	152.8	1750.0	
7290	147	1601.0	
7289	140.3	1458.0	
7288	133.6	1323.0	
7287	126.9	1195.0	
7286	120.2	1074.0	
7285	113.5	960.0	
7284	106.8	852.0	
7283	100.1	751.0	
7282	93.4	656.0	
7281	86.7	567.0	
7280	80	484.0	
7279	73.2	407	
7278	66.4	335	
7277	59.6	269	
7276	52.8	211	
7275	46	159	
7274	39.2	117	
7273	32.4	82	
7272	25.6	56	
7271	18.8	37	
7270	12	23.0	

DAM EMBANKMENT

The Gould Dam (aka Onion Valley Dam), is a large Class I structure. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, 25 feet maximum,
* a spillway capable of passing 100% PMP,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications.

EMBANKMENT: The existing Gould Dam consists of two embankments which are not connected. The dam is in relatively good condition and is not restricted though there are problems with the present spillway size and the condition of the outlet works. The dimensions for the existing primary dam embankment are:

* 55 feet high at a height of 7323 feet,
* crest length (both embankments) of about 1710 feet,
* crest width of 15 feet,
* 3.0H:1.0V upstream and 2.5H:1.0V downstream slopes,
* 36 inch diameter metal outlet pipe.

The proposed enlargement of the dam will involve raising the main dam embankment to a crest elevation of 7335 feet and raising the dike embankment to a crest elevation of 7336 feet. The upstream slope on the raised portion of the west embankment would be 3.0H:1.0V and the downstream slope will be 2.5H:1.0V with a 15 foot wide crest. The PRC report included soils tests and safety factor evaluations to recommend the embankment shape.

The maximum section of the enlarged primary dam will be an earth embankment with following the dimensions:

* 67 feet high at a height of 7335 feet,
* crest width of 18 feet,
* 3.0H:1.0V upstream and 2.5H:1.0V downstream slopes
* 135 foot extension of existing 36 inch diam. outlet pipe,
* a spillway crest 5 feet below the dam crest.

Refer to the PRC report for drawings of the embankment.

OUTLET PIPE: The outlet pipe at the dam would be extended about 135 feet through the new embankment. No other modifications are anticipated but necessary repairs to the existing outlet pipe and gate would be made concurrently with the enlargement.

A 4 foot diameter, 350 foot long outlet pipe would be installed on the dike to allow releases to the Cattlemen's Ditch on the south side of the reservoir. This is needed to re-operate the existing ditch water to optimize the water supply.

SPILLWAY: The spillway for the enlargement would be constructed at the same location as the existing spillway, with the crest raised to elevation 7330 feet; 5 feet below the dam crest. The PRC report includes a conceptual design of the spillway based on passing the probable maximum precipitation.

RELATED STRUCTURES: The PRC report included several related structures necessary to collect and release water for implementation of the plan, which include:

Black Mesa Conduit
Conveyance System
Drop of Cattleman's Ditch
Diversion Structure on Fruitland Mesa Ditch
Gould Canal
Cattleman's Ditch below Gould (pipe or relocate)
Additional Conveyance Capacity

COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 2, summarized from the PRC report. The costs are indexed up by 30%, approximately 2.5% per year from 1980.

PRC used an amount of 25% for contingencies and 10% for engineering and administration.

TABLE 2
GOULD DAM AND RESERVOIR
CONSTRUCTION COST ESTIMATE

Cost Item	PRC Report Cost Estimate
Dam and Dike (PRC Report)	$2,441,000
Outlet Works (PRC Report)	$32,000
Spillway (PRC Report)	$158,000
Conveyance System (PRC Report)	$54,000
Black Mesa Conduit (PRC Report)	$1,964,000
Dike Outlet Works (PRC Report)	$1,164,000
PRC Report Subtotal	$5,813,000
Index from 1980 to 1993 (30%)	$1,744,000
TOTAL ESTIMATED CONSTRUCTION COST	$7,557,000
Cost per Acre-foot of Additional Storage	$1,890
Volume of Additional Storage in Acre-Feet	4000

FINANCING

The cost for this work will require financing of nearly all, if not all, of the cost.

The financial analysis herein assumes that Gould Reservoir will be enlarged with a loan for the full amount from the CWCB. The enlargement would yield additional storage of about 4,000 acre-feet, with the assumption that the water users would pay the same amount each year regardless of whether the water is available in dry years. Repayment options are shown in Table 3, assuming a 100% loan; if the District can include some cash the loan amount would be reduced.

None of the loan Options result in a price per acre-foot that can be repaid. Even no interest for 40 years is nearly $50 per acre-foot. Roughly $30 per acre-foot is the maximum reasonable amount for irrigators in the area.

RECOMMENDATIONS

The cost for enlargement of Gould Dam and Reservoir appears to be greater than the irrigators ability to repay using today's financing scenarios, which confirms the findings described in the PRC report. Also, the cost does not address the probability of re-operating the ditch water, which may be difficult.

Based on the cost of the enlargement and the problems with re-operation of the existing water supplies, a financially feasible method to enlarge Gould Dam and Reservoir cannot be identified.

No further study is recommended.

If major rehabilitation of the Gould Dam is required in the future to maintain the existing storage, then an enlargement should be considered.

TABLE 3
GOULD DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$7,557,000	4.0%	30	$437,022	$109
2	$7,557,000	4.0%	40	$381,806	$95
3	$7,557,000	3.5%	40	$353,874	$88
4	$7,557,000	3.0%	40	$326,934	$82
5	$7,557,000	2.0%	40	$276,252	$69
6	$7,557,000	1.0%	40	$230,153	$58
7	$7,557,000	0.0%	40	$188,925	$47

Volume of Reservoir Enlargement in Acre–Feet: 4000

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

GRANBY #12 DAM AND RESERVOIR
Owned By The Granby Ditch and Reservoir Company

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

GRANBY DAM AND RESERVOIR #12

PLAN DESCRIPTION

Granby Dam and Reservoir #12 is an existing reservoir located in the Dirty George Creek drainage of the Gunnison River basin about 12 miles north of the Town of Cedaredge. The reservoir is in the Grand Mesa National Forest. Figure 1 is a location map showing the reservoir within Colorado and relative to the Town of Cedaredge. Figure 2 is a copy of a USGS Quad map showing the reservoir site.

The dam and reservoir are owned by the Granby Ditch and Reservoir Company. The contact person is listed below.

Ernie Buchhein, Board Member
Granby Ditch and Reservoir Company
1781 2075 Drive
Cedaredge, Colorado 81413
303-856-3932

The dam was constructed in the early part of the century with a height of about 25 feet. When full, the reservoir has a capacity of about 750 acre-feet at gage height 22; the reservoir has been restricted to gage height 17, about 523 acre-feet, since the early 1980's.

The restriction was imposed because of a small slide at the toe of the embankment northeast of the outlet pipe. The dam safety engineer estimates that the slide may have been a foundation failure at the toe. Apparently when the dam was built, the surface material was not stripped prior to placing the embankment, which over the years became saturated and slipped. The repair work would either involve installation of a toe drain or addition of material on the toe for stability.

The primary construction problem is that the reservoir is located in the Grand Mesa National Forest and the local Forest office has not allowed improvement to the access road for construction equipment. The present road is extremely rough and almost inaccessible. No outside materials, such as sand for a toe drain, could be hauled to the dam under present conditions.

Granby Reservoir is adjacent to Big Battlement Reservoir, owned by the City of Delta, see Figure 2. Big Battlement, as explained in the report for that dam, is in need of reconstruction. Due to the access difficulty, the work for Granby #12 is predicated on the construction work at both reservoirs being performed jointly. One engineer and one contractor are assumed to perform the work at both sites, and any other repairs that may be needed at other dams in the area.

The mobilization cost, to move equipment to the site is estimated at $100,000 which is assumed to be split between the two dams generally according to construction cost, so Granby #12 is allocated $20,000 of the mobilization. If this cost can be reduced through access arrangements with the Forest Service, the construction cost could be significantly reduced. Negotiations are being conducted with the Forest Service to improve the access.

Airlifting equipment to the dam sites was not considered, though it is possible. The cost is assumed to be as high or higher than the costs used herein, but this should be verified during preparation of plans and specifications.

If the access were significantly improved, Granby #12 repairs may not depend on reconstruction of Big Battlement. Reasonable access would significantly reduce the mobilization and material placement costs used herein.

This reconnaissance report describes the engineering issues, construction, and costs of repairing the Granby #12 Dam in conjunction with reconstruction of Big Battlement Dam.

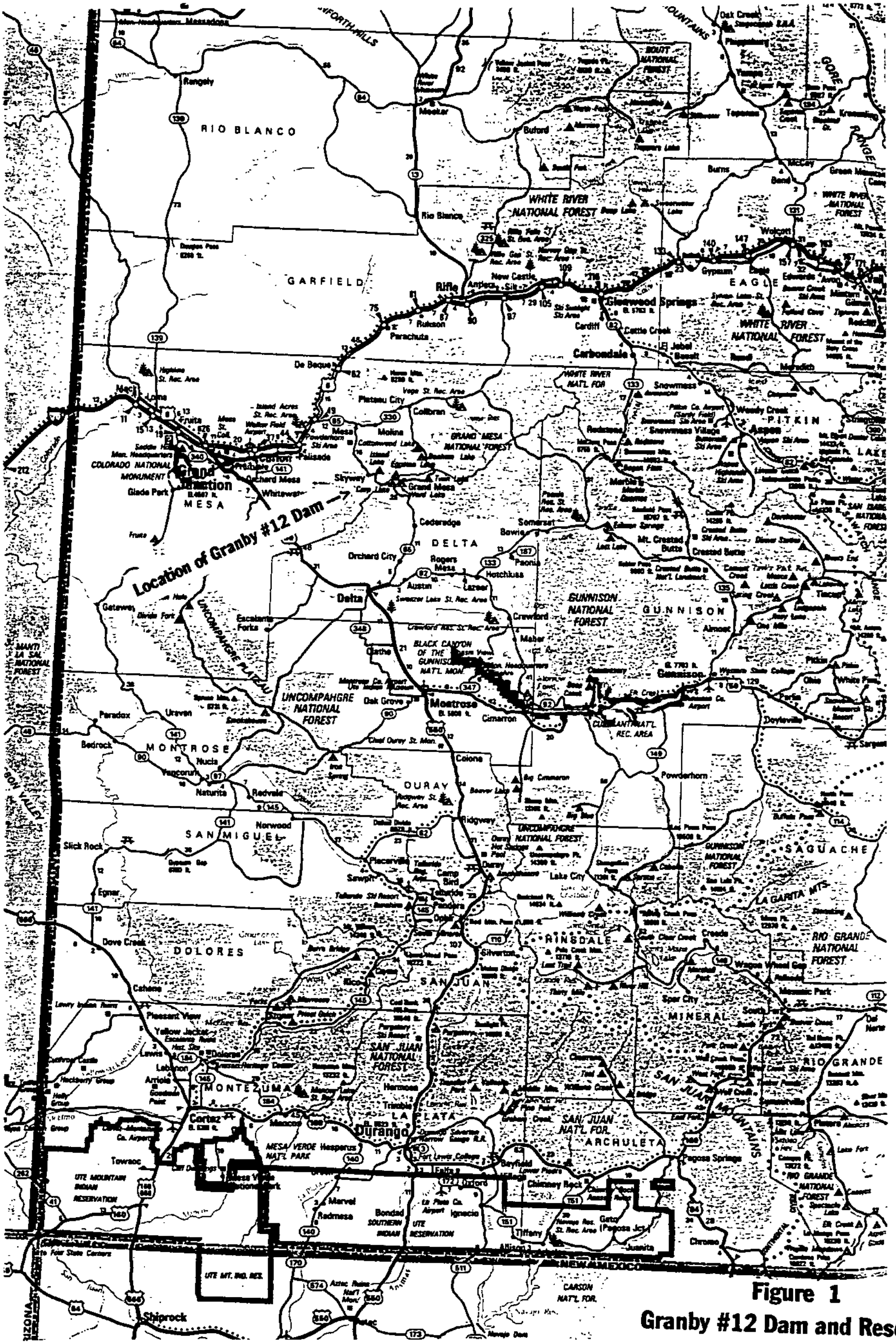


Figure 1
Granby #12 Dam and Reservoir
Location Map

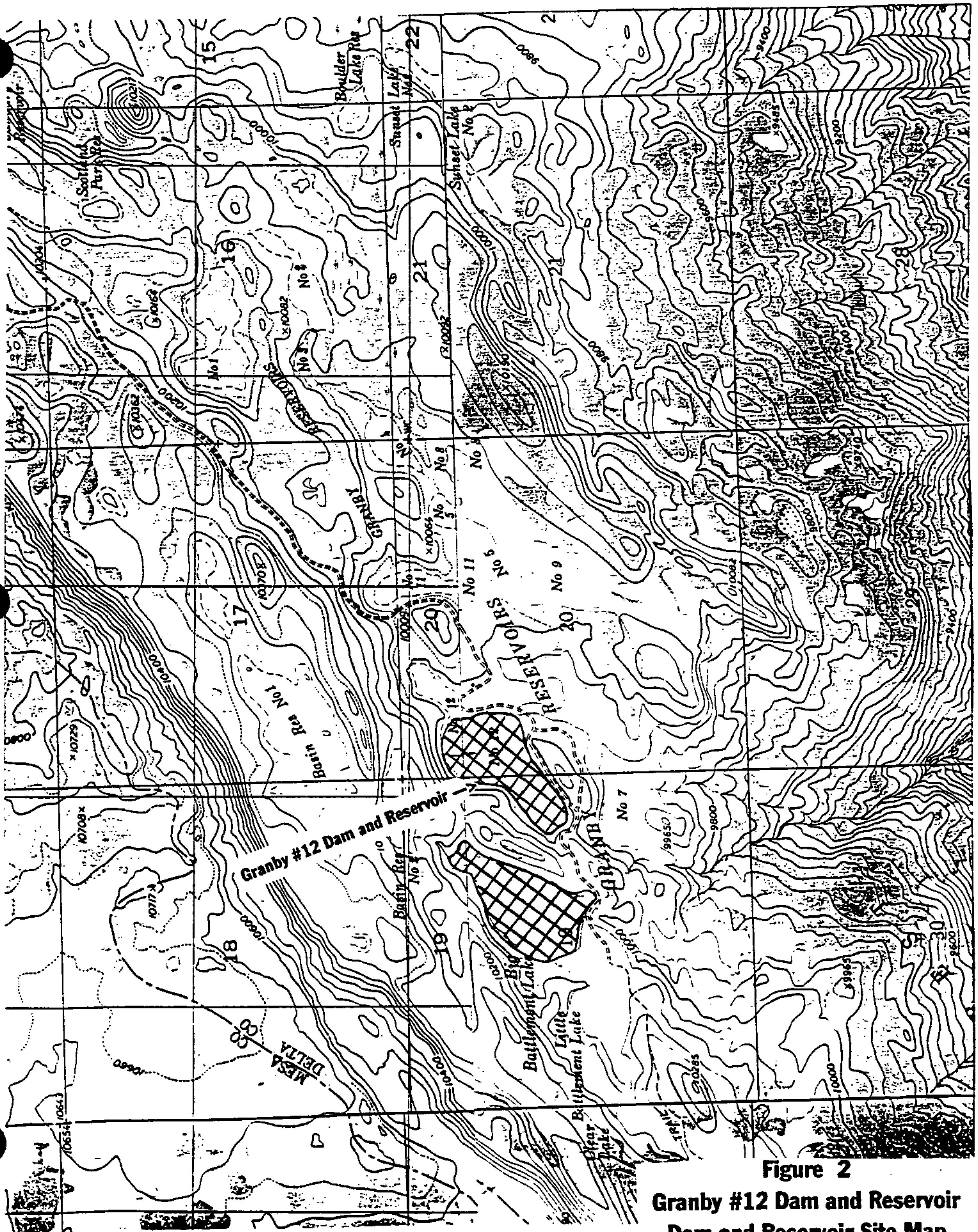


Figure 2
Granby #12 Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The Granby Ditch and Reservoir Company owns Granby #12 Reservoir and several other reservoirs in the area. There is essentially no drainage area above Granby #12, the reservoir basin is the drainage area. Granby #12 is filled with water conveyed from the other reservoirs upstream of Granby #12, through a system of ditches. All of the water collected is from snow melt, and for practical purposes there is no other water to collect.

All of the reservoirs in the system fill each year except in the driest periods. The 227 acre-feet of restricted volume (750 minus 523 acre-feet) is water that is being lost to the Ditch Company. There is sufficient runoff to fill Granby # 12 in most years if the dam were repaired.

RESERVOIR

An elevation-area-capacity table for the reservoir is not included. The area-capacity table used by the Water Commissioner shows that when the reservoir is full, at gage height 22 feet, the capacity is 750 acre-feet. The reservoir is restricted to gage height 17 feet, which is 523 acre-feet. There is no possibility of increasing the capacity of the reservoir concurrently with the repairs.

DAM EMBANKMENT

EMBANKMENT: The dam is an earth embankment with following the dimensions:

* 25 feet high,
* crest length of about 420 feet,
* crest width of 13 feet,
* about 2.0H:1.0V upstream and 2.4H:1.0V downstream slopes

The dam is jurisdictional and is rated small Class II. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources must be followed. The only issue in the restriction concerns the toe of the embankment so other aspects of the structure, such as spillway, outlet pipe, etc., are not addressed herein. However, if there are other needed repairs to Granby #12 or any other dams in the vicinity, those problems should be corrected while equipment is in place.

The plans suggested herein, are not proposed to be plans and specifications but preliminary designs subject to further detailed evaluations, e.g. soils test of the embankment and borrow material.

The failure of the embankment extends about 100 feet from the outlet pipe to the northeast abutment of the dam. The downstream slope of the embankment is 2.4H:1.0V then has an abrupt change to 1.5H:1.0V, followed by a flat slope, indicating the toe slipped. See Figure 3, which is a typical section of the downstream slope showing the apparent slide.

The repairs would normally involve excavation of the slide area, replacement with compacted fill, and installation of a sand filter toe drain along the entire length of the dam. Due to the inaccessibility of the dam, it is infeasible to haul the necessary amount of sand to the site; local materials must be used for the repairs.

Also, because of access problems, the entire 420 foot length of the toe should be repaired and not just the 130 foot section that has already slipped, while the equipment is available. The embankment southwest of the outlet pipe has the potential to slide because of foundation seepage.

The repair plan includes excavation of the entire toe beginning at about the midpoint of the downstream slope and stepped (2 foot horizontal, 2 foot vertical, etc.) to a depth about 5 or 6 feet below the existing embankment then horizontally away from the dam until "catching" the existing slope.

Once excavated, a geotextile would be placed over the cut slope. The geotextile would be selected to act as a filter, to screen out soil particles in the seepage, this is the most reasonable option to not being able to use sand for the filter.

Select compacted fill will then be placed over the geotextile. A drain pipe will be installed, with a geotextile "sock" to attempt to convey water safely from the toe. If gravel is available, the drain pipe may also be surrounded by a gravel border.

The fill will be placed in one foot lifts and compacted to at least 95% Standard Proctor. The new fill will be placed to form a finished slope of about 3.3H:1.0V, which will provide additional weight to the toe of the embankment for increased stability. About twice as much material will be needed than is excavated from the embankment, requiring that material be obtained from a borrow source. Approximately 3400 cubic yards of material will be required which includes a 30% increase for compaction.

The geotextile, drain pipe, and increased fill on the toe are expected to correct the problem in the area of the present slide and prevent slippage southwest of the outlet pipe. Evaluations, which must be performed by a register professional engineer, to verify this assumption would include: soils tests of the embankment and borrow material, availability of drain materials, review of geotextile materials, review of drain pipes with "socks", and possibly slope stability analysis assuming the finished slope.

The construction work will require equipment such as: a backhoe, loader, dump truck, and a sheepsfoot roller.

The US Forest Service access permit required for borrow areas, is potentially a serious impediment to repair of the dams and in fact hinders the repairs because the best equipment and materials cannot be used. To account for this, the planning and evaluation of available materials must be thorough and complete, the pre-construction cost may be higher because there is little room for change.

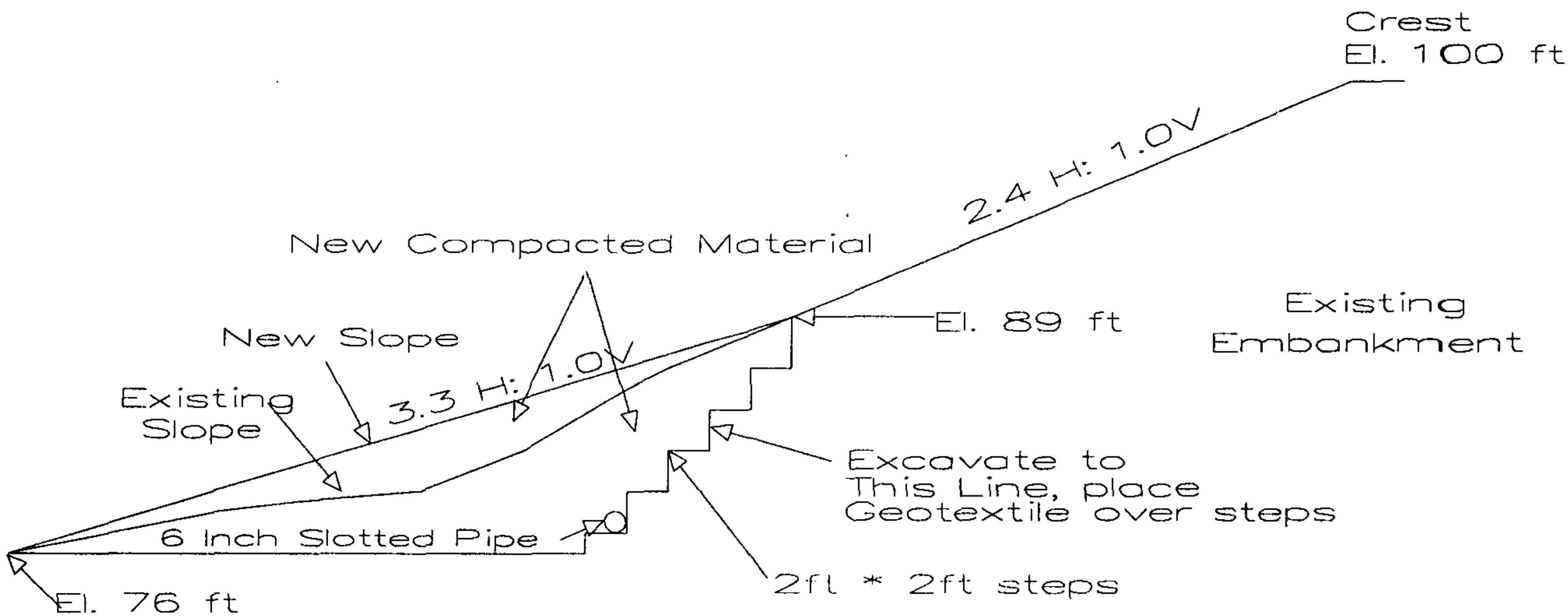
Coordination of this work with the reconstruction of Big Battlement Dam is necessary. The same engineer and contractor should be used for both repairs. The contractor should plan on entering the area as early as possible in the summer and completing both projects, as well as any other minor repairs.

Compared to the Big Battlement reconstruction, the Granby #12 repairs are minor. The repairs to Granby probably cannot be accomplished without coordination with the City of Delta who owns Big Battlement. In short, Granby must wait until, or if, the City of Delta proceeds with Big Battlement.

Figure 3

Granby #12 Dam and Reservoir

Cross Section at Toe Slide



COST ESTIMATE

The estimated costs to repair the dam are shown in Table 1. The unit costs are approximately 50% higher than normal costs because of the difficult access problems associated with getting equipment and materials to the site. For example, transport of fuel for the equipment will be very costly. The unit cost for toe drain pipe and geotextile were obtained from a manufacturer and approximately doubled to include installation.

A mobilization cost of $100,000 is assumed for both Granby #12 and Big Battlement dams. The amount was split approximately by the ratio of total construction costs, resulting in Granby #12 paying $20,000 for mobilization.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because of the access problems. Engineering and administration is estimated at 15% which includes: materials testing, preparation of plans and specifications and construction observation.

The land is owned by the US Forest Service but permitted to the Ditch Company so there is no land cost. However, permits to perform the work and excavate borrow material will be necessary, which will probably require an environmental assessment.

FINANCING

The cost for this work is large for the Granby Ditch and Reservoir Company and will definitely require financing. The Company has 700 shares of stock which are presently charged $4 per share per year, for a total of $2,800. Option #5 is recommended for financing which is better than the normal financing terms but will still require more than doubling the annual assessment.

Discussions with the Forest Service to improve the access would reduce the costs considerably (30% to 50% reduction) and should be aggressively pursued.

TABLE 1
GRANBY #12 DAM
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$20,000
Embankment				
Excavation	cy	1870	$3.00	$5,610
Compacted Fill	cy	3440	$6.00	$20,640
Geotextile	sq yd	1680	$2.50	$4,200
Toe Drain Pipe	lf	420	$4.00	$1,680
	Embankment Subtotal			$32,130
	Total of Above Items			$52,130
	Contingency (30%)			$15,600
	Land Cost			$0
	Field Cost Subtotal			$67,730
	Engineering & Admin (15%)			$10,200
TOTAL ESTIMATED CONSTRUCTION COST				$77,900
Construction Cost per Acre-foot of Storage				$340
Estimated Annual Reservoir Storage in Acre-Feet				227

TABLE 2
GRANBY #12 DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$77,900	3.5%	20	$5,481	$24
2	$77,900	4.0%	30	$4,505	$20
3	$77,900	4.0%	40	$3,936	$17
4	$77,900	3.5%	40	$3,648	$16
5	$77,900	3.0%	40	$3,370	$15

Volume of Reservoir Storage from Rehabilitation in Acre–Feet 227

RECOMMENDATIONS

Even though the repair costs are high, repairs to the dam should be planned because the restriction may be increased in future years if the Company does not attempt to make repairs. The Company may not have much choice but to make the repairs concurrently with Big Battlement reconstruction, no matter what the cost, or risk losing the storage capacity. Designs and plans developed in the following steps should be made with the idea to minimize the construction costs to the extent possible.

The followings steps are recommended to increase the water storage of Granby #12:

1. Coordinate with the Town of Delta to determine when the City will be ready to seriously pursue reconstruction of Big Battlement Dam. When the City is ready, jointly select a consulting engineer and contractor to perform the necessary work. Concurrently negotiate with the Forest Service to improve assess, if successful, joint construction with Delta may not be necessary. When one or the other possibility is determined, proceed with the best course. Soonest spring of 1994.

2. Perform necessary materials tests on the embankment and borrow area. In conjunction with the contractor and State Dam Safety Engineer, the Consulting Engineer will prepare plans, specifications, and a construction plan to repair the toe slide. If necessary, apply to the CWCB for feasibility study funds to prepare the plans and specifications. Soonest early summer of 1994.

3. Evaluate the estimated costs to assess that the project is still feasible. Initiate the CWCB construction financing process. Soonest late summer of 1994.

4. Apply for permits from the US Forest Service for borrow material. The permits would include Granby #12, Big Battlement and any other repairs needed at dams in the area. Soonest for permit applications is late summer of 1994; soonest permits are received is spring of 1995.

5. Construct the repairs. The work must begin as soon as snow and weather conditions allow because the work at the dam sites will require all or most of the summer season. Soonest is summer 1995.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

IDAHO SPRINGS DAM AND RESERVOIR
Owned By The City of Idaho Springs

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

IDAHO SPRINGS DAM AND RESERVOIR

PLAN DESCRIPTION

Idaho Springs Dam and Reservoir (sometimes called Chicago Creek Dam and Reservoir) is an existing reservoir located on Chicago Creek, a tributary to Clear Creek which is in the South Platte River drainage. Figure 1 shows the reservoir location in central Colorado and Figure 2 is a copy of a USGS Quad map showing the reservoir site location.

Idaho Springs Dam and Reservoir is owned by the City of Idaho Springs. The address and contact person is:

City of Idaho Springs
1711 Miner Street
Idaho Springs, Colorado 80452

Dennis Jorgensen, Public Works Director
303-567-4421

The dam has been under restriction by the Colorado State Engineer for many years because of safety problems associated with seepage through the embankment and an inadequate spillway. In conjunction with repairs, the City has plans to enlarge the reservoir considerably, from about 150 acre-feet to about 1550 acre-feet; a dam height increase of about 55 feet.

The reservoir is in a water short basin, that supplies water to many communities and the Coors Brewing Company; so there should be a good demand for water both for future growth in Idaho Springs and to sell within the basin. In fact, Wright Engineers has performed water supply and engineering studies at the site for Coors; the studies are not available to the public and could not be obtained for inclusion herein.

There have been other studies performed at the site including a 1976 geotechnical and hydrology report to rehabilitate the existing dam, prepared by Donald Sutherland Associates, Inc..

The drainage basin above the reservoir is 5.3 square miles in size. The basin is very steep with a drop from 13,842 feet to 10,617 at the reservoir. About half of the basin is above tree line and the other half has a good stand of trees and brush.

Enlargement of the dam essentially involves an entire new dam, covering the existing dam with the new crest upstream of the existing crest. This reconnaissance report describes the engineering issues, construction, and costs of enlarging the dam. The engineering plans are preliminary based upon available information, detailed studies may result in different designs.

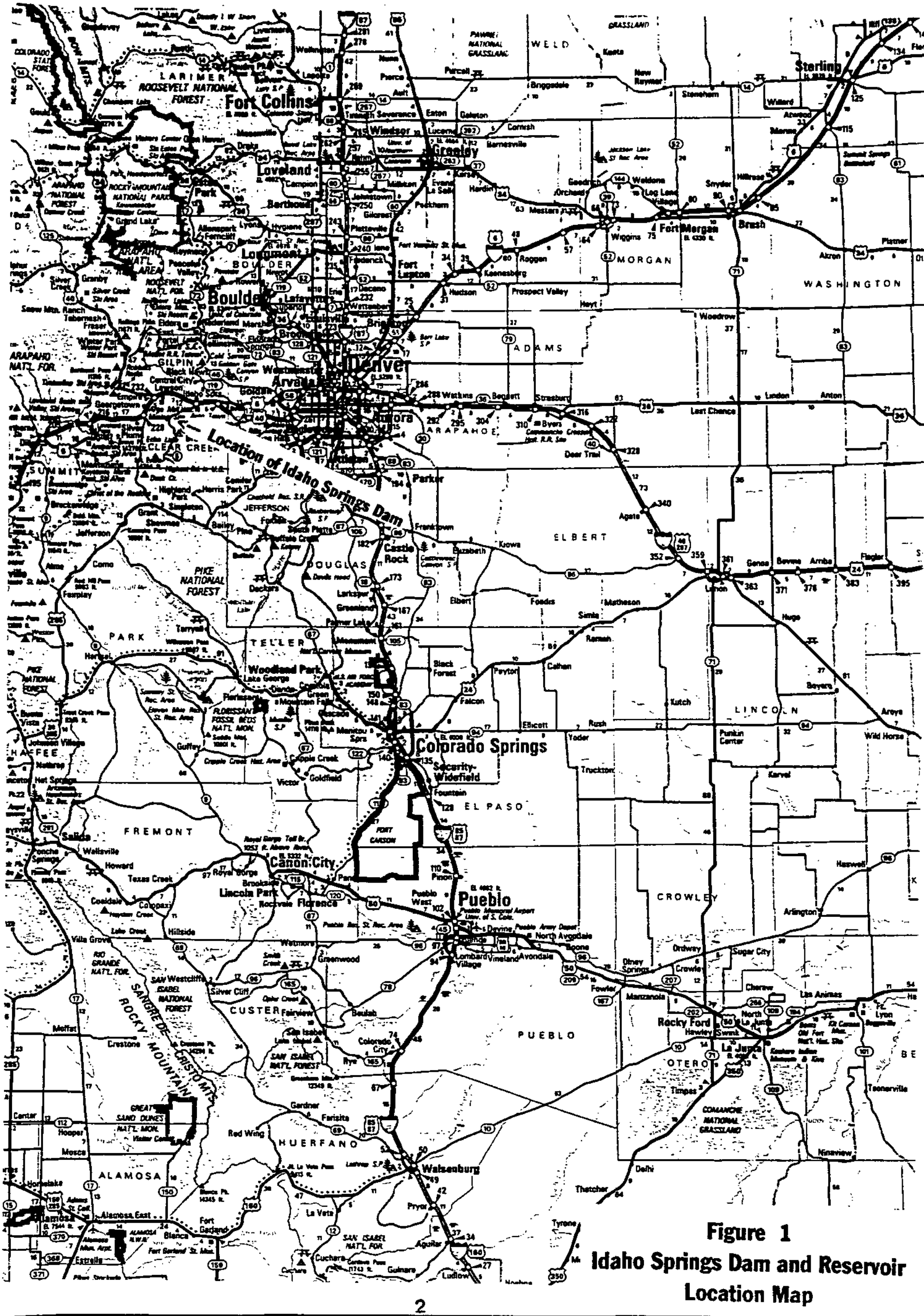


Figure 1
Idaho Springs Dam and Reservoir
Location Map

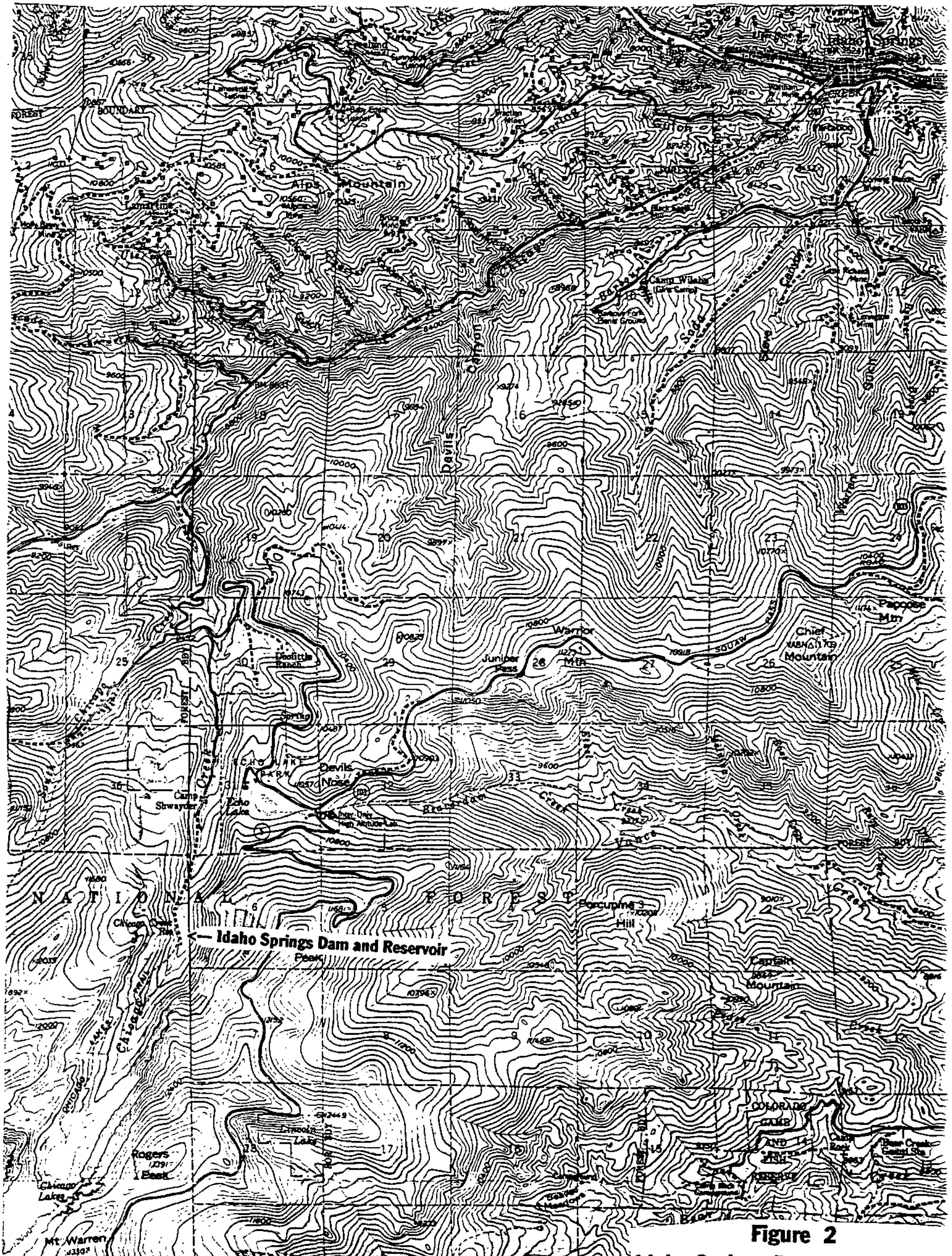


Figure 2
Idaho Springs Dam and Reservoi
Dam and Reservoir Site Map

WATER SUPPLY

The City of Idaho Springs has the water rights for the enlarged reservoir. Though the drainage area is not large, 5.3 square miles, it should be adequate to fill the enlarged capacity each year. The work performed by Wright Engineers undoubtedly evaluated the water supply at the reservoir in detail.

For purposes of this study, the storage capacity is assumed to be the annual yield of the reservoir.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir basin derived from maps that are 1 inch equals 100 feet with 10 foot contours. The existing capacity at 10,615 feet is about 155 acre-feet, the proposed enlarged capacity at elevation 10,673 feet is about 1549 acre-feet; an increase in capacity of 1400 acre-feet.

The dam would be reconstructed in approximately the same location as the present dam but the outlet pipe would be raised to about elevation 10,611 feet so that there would be about 105 acre-feet of inactive storage and about 1,440 acre-feet of active storage. Locating the outlet pipe at elevation 10,611 feet also minimizes the excavation into the existing embankment to install the pipe.

TABLE 1
IDAHO SPRINGS DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
10678	35.77	1690.2	Enlarged Top of Dam
10677	35.54	1654.5	
10676	35.31	1619.1	
10675	35.08	1583.9	
10674	34.85	1549.1	
10673	34.62	1549.0	Enlarged Spillway Crest
10672	34.39	1514.5	
10671	34.16	1480.2	
10670	33.93	1446.2	
10669	33.55	1412.4	
10668	33.17	1379.1	
10667	32.79	1346.1	
10666	32.41	1313.5	
10665	32.03	1281.3	
10664	31.65	1249.4	
10663	31.27	1218.0	
10662	30.89	1186.9	
10661	30.51	1156.2	
10660	30.13	1125.9	
10659	29.75	1095.9	
10658	29.37	1066.4	
10657	28.99	1037.2	
10656	28.61	1008.4	
10655	28.23	980.0	
10654	27.85	951.9	
10653	27.47	924.3	
10652	27.09	897.0	
10651	26.71	870.1	
10650	26.33	843.6	
10649	25.95	817.4	
10648	25.57	791.7	
10647	25.19	766.3	
10646	24.81	741.3	
10645	24.43	716.7	
10644	24.05	692.4	
10643	23.67	668.6	
10642	23.29	645.1	
10641	22.91	622.0	
10640	22.53	599.3	

TABLE 1
IDAHO SPRINGS DAM & RESERVOIR
Elevation– Area–Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
10639	22.15	576.9	
10638	21.77	555.0	
10637	21.39	533.4	
10636	21.01	512.2	
10635	20.63	491.4	
10634	20.25	470.9	
10633	19.87	450.9	
10632	19.49	431.2	
10631	19.11	411.9	
10630	18.73	393.0	
10629	18.35	374.4	
10628	17.97	356.3	
10627	17.59	338.5	
10626	17.21	321.1	
10625	16.83	304.1	
10624	16.45	287.4	
10623	16.07	271.2	
10622	15.69	255.3	
10621	15.31	239.8	
10620	14.93	224.7	
10619	14.55	209.9	Existing Top of Dam
10618	14.17	195.6	
10617	13.79	181.6	
10616	13.41	168.0	
10615	13.03	154.8	Existing Spillway Crest
10614	12.65	141.9	
10613	12.27	129.5	
10612	11.89	117.4	
10611	11.51	105.7	Enlarged Outlet Pipe El.
10610	11.2	94.3	
10609	10.64	83.4	
10608	10.08	73.1	
10607	9.52	63.3	
10606	8.96	54.0	
10605	8.4	45.3	
10604	7.84	37.2	
10603	7.28	29.7	
10602	6.72	22.7	
10601	6.16	16.2	
10600	5.6	10.3	
10599	5.04	5.0	
10598	5	0.0	

DAM EMBANKMENT

The dam, is jurisdictional and would be intermediate Class I when enlarged. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet but not to exceed 25 feet,
* a spillway capable of passing a PMP flood,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications; these tests have largely been performed in the past and should be reviewed prior to conducting new tests. The reconnaissance designs described herein are based upon a site inspection and review of available data; detailed engineering work may result in a different design.

EMBANKMENT: The existing Idaho Springs Dam and Reservoir dam is about 28 feet high with embankment slopes of 3.5:1 upstream and 2.0:1 downstream, a 12 foot crest with, and an outlet pipe. The dam is restricted to 4 feet below the spillway crest because of excessive seepage through the embankment. Major modifications would be necessary to correct the problems so reconstruction appears to be the best long term solution.

The reconstructed dam is expected to be an earth embankment with following the dimensions:

* 90 feet high,
* crest length of about 900 feet,
* crest width of 25 feet,
* 3.25H:1.0V upstream and 2.5H:1.0V downstream slopes
* 36 inch diameter outlet pipe,
* a 100 foot wide spillway on the embankment.

Figure 3 shows the cross section of the dam at the outlet pipe. Figure 4 shows the front view of the embankment looking upstream from below the dam.

The top 2 feet of the existing embankment would be removed and wasted because it is unsuitable for use in the new embankment; the majority of the embankment would be left in place as part of the new embankment.

The dam would be constructed on river deposits and fragmented rock foundation. Foundation seepage is expected to be problem so a core trench and grouting are included to attempt to reduce the seepage. An estimated 20 foot deep, 20 foot wide core trench would be excavated just upstream of the existing embankment and most of the length of the new embankment. Foundation grouting is included in an area 80 feet deep, 200 feet wide (upstream -downstream), 950 feet across (abutment to abutment) and assumes filling voids totalling 5% of the volume of the area.

Once the existing dam is stripped, the spillway removed, and the foundation prepared, the new embankment would be placed. The new outlet pipe is estimated to be placed at elevation 10,611 feet at the inlet and the discharge end placed at about 10,590 feet. The embankment would then be raised to elevation 10,678 feet. The core of the dam would be impervious material placed with slopes no steeper than 1.0H:1.0V and flatter if an adequate quantity of impervious material is available. A shell of pervious material would be placed on the upstream and downstream slopes to form the required slopes.

Embankment material would be obtained from the reservoir basin, probably upstream of the existing reservoir. There did not appear to be any suitable material downstream of the dam. Filter material for the toe drain and any filters in the embankment must be hauled to the site.

The quantity of embankment material was determined by estimating the volume of the existing embankment, Table 2, which was subtracted from the volume of the proposed embankment, Table 3. The difference of the two volumes plus an additional 30% for compaction, is estimated to be the volume of material to be placed.

The rock in and around the reservoir basin is expected to be usable for rip rap. The rock is very hard but may need to be the fractured to provide appropriate sizes for the estimated 2 foot rip rap layer.

A toe drain is included to control seepage through the embankment. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 600 feet long.

OUTLET PIPE: The outlet pipe size is suggested to be 36 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance and if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be thick walled steel, possibly lined with mortar or another material; CMP is not recommended.

SPILLWAY: The spillway will be sized to pass the PMP flood. The spillway is shown on Figure 5 which is a copy of a drawing of the dam prepared by Wright Engineers which was obtained from the City of Idaho Springs. The spillway opening is 100 feet, with a chute down the downstream face of the dam into a stilling basin. A HEC-1 analysis was not performed to verify the spillway capacity. The concrete in the spillway was estimated from the dimensions on Figure 5 and assuming 5 foot walls and 2 foot thick concrete.

TABLE 2
IDAHO SPRINGS DAM EMBANKMENT – EXISTING VOLUME ESTIMATE

0 foot Stripping Depth
3.5 :1 Upstream
2 :1 Downstream
12 foot Crest Width
10618 feet Crest Elevation

0 foot Key Trench Width
0 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
220	10620	0	0				
				136	121	0	121
250	10610	8	272				
				690	1917	0	1917
325	10600	18	1107				
				1107	5535	0	5535
460	10600	18	1107				
				1800	8667	0	8667
590	10590	28	2492				
				2492	5538	0	5538
650	10590	28	2492				
				1800	11667	0	11667
825	10600	18	1107				
				554	1939	0	1939
930	10620	0	0				

Total Volume of Existing Embankment (cubic yards) 35400

TABLE 3
IDAHO SPRINGS DAM EMBANKMENT – ENLARGEMENT VOLUME

2 foot Stripping Depth
3.25 :1 Upstream
2.5 :1 Downstream
25 foot Crest Width
10678 foot Crest Elevation

20 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
100	10683	0	0				
				269	153	0	153
125	10670	10	538				
				1938	1794	185	1979
150	10650	30	3338				
				5888	9813	667	10480
195	10630	50	8438				
				10144	9393	370	9763
220	10620	60	11850				
				13844	15382	444	15826
250	10610	70	15838				
				18119	50331	1111	51442
325	10600	80	20400				
				20400	102000	2000	104000
460	10600	80	20400				
				22969	110591	1926	112517
590	10590	90	25538				
				25538	56751	889	57640
650	10590	90	25538				
				22969	148873	2593	151466
825	10600	80	20400				
				18119	43620	963	44583
890	10610	70	15838				
				13844	20510	593	21103
930	10620	60	11850				
				10144	11271	444	11715
960	10630	50	8438				
				5888	7633	519	8152
995	10650	30	3338				
				2494	1847	148	1995
1015	10660	20	1650				
				825	1076	0	1076
1060	10683	0	0				

Total Volume of Enlarged Embankment (cubic yards) 603900

Figure 3
Idaho Springs Dam and Reservoir
Cross Section at Outlet

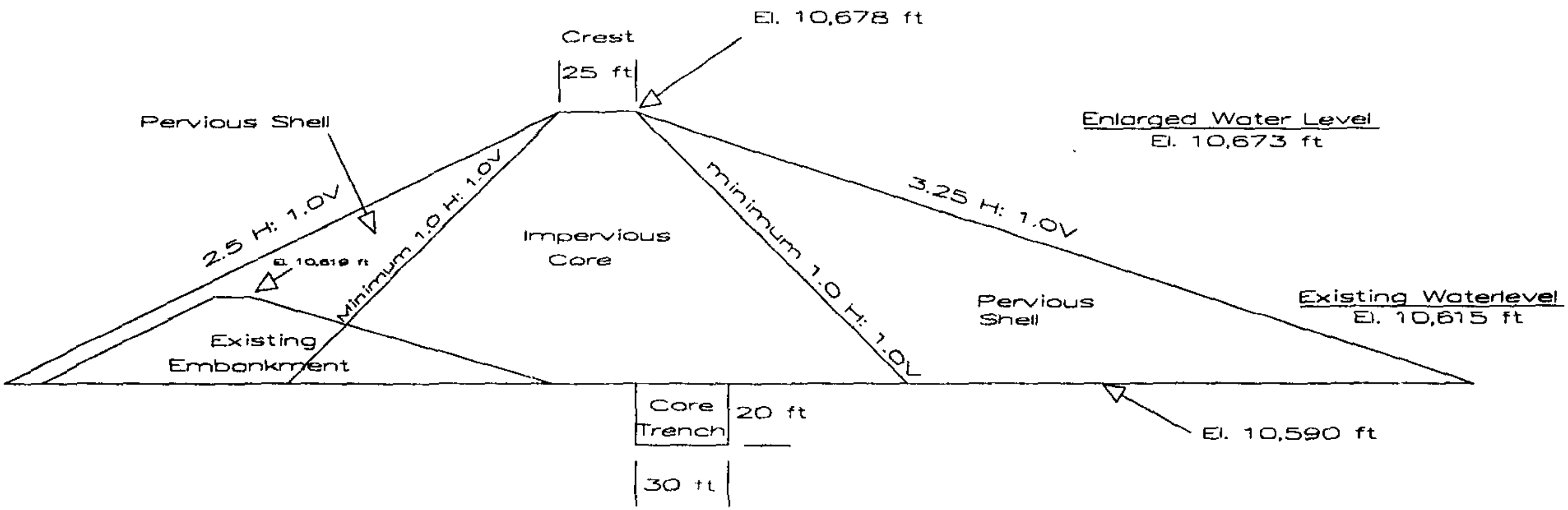
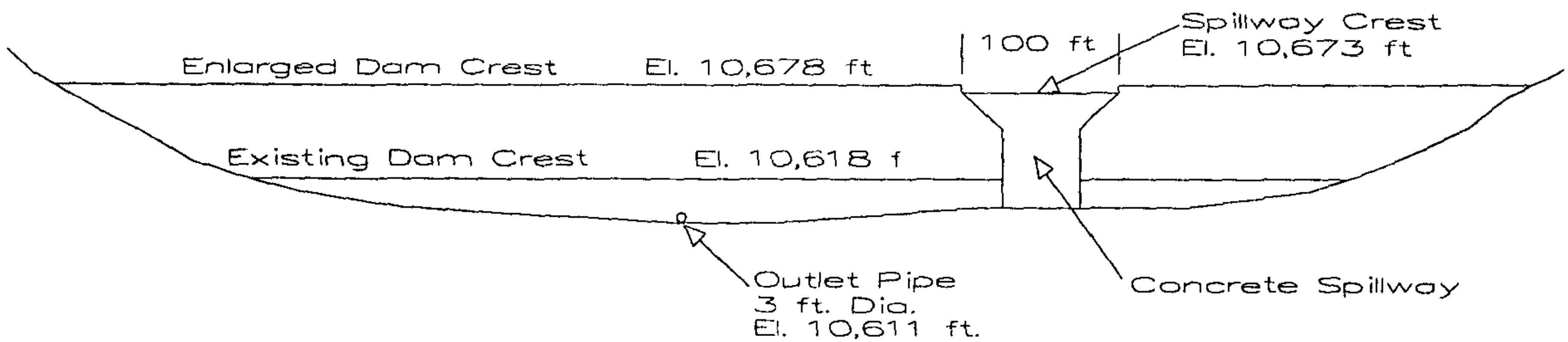


Figure 4
Idaho Springs Dam and Reservoir

Embankment Looking Upstream



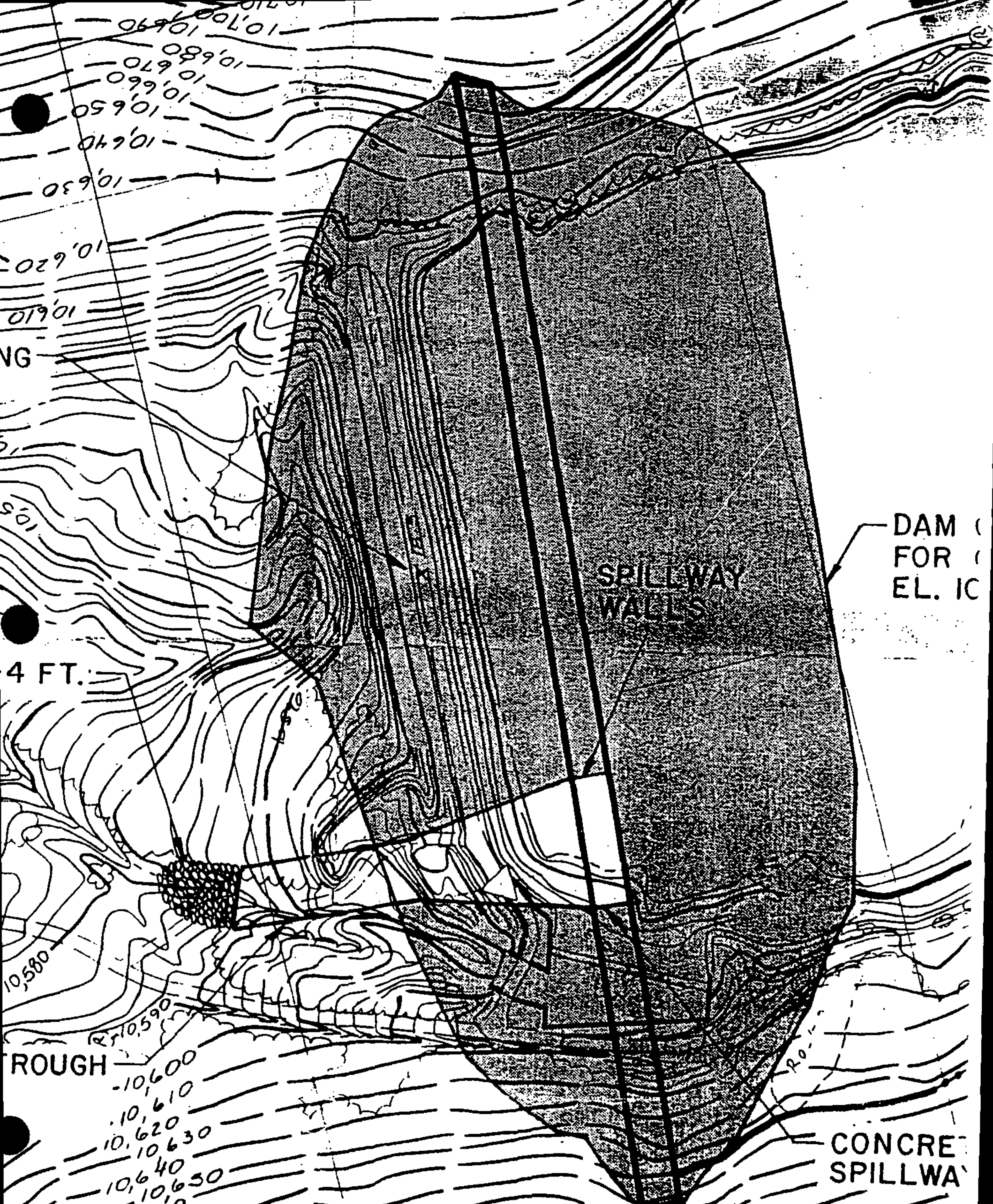


Figure 5
Idaho Springs Dam and Reservoir
Plan View of Dam Site

COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 4. The unit costs are rough estimates of costs found in non-urban areas of the state.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

Additional land will be required to enlarge the reservoir. About 20 acres of private land is required plus about 3 acres of U.S. Forest Service land. The 20 acres are estimated to cost $3,000 per acre. Acquiring the use of the USFS land will be time consuming to secure the necessary permits, which will in turn require at least an environmental assessment.

TABLE 4
IDAHO SPRINGS RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$30,000
<u>Embankment</u>				
Compacted Fill	cy	739100	$4.00	$2,956,400
Rip Rap	cy	10960	$20.00	$219,200
Foundation Grouting	cy	28150	$20.00	$563,000
Toe Drain	lf	600	$20.00	$12,000
	Embankment Subtotal			$3,750,600
<u>Outlet Works</u>				
Outlet Pipe, 3 ft	lf	480	$120.00	$57,600
Gate	ls			$15,000
	Outlet Works Subtotal			$72,600
<u>Spillway</u>				
Concrete	cy	2150	$300.00	$645,000
Stilling Basin Rip Rap	cy	440	$20.00	$8,800
	Spillway Subtotal			$653,800
	Total of Above Items			$4,477,000
	Contingency (30%)			$1,343,100
	Land Cost (20 acres)			$60,000
	Field Cost Subtotal			$5,880,100
	Engineering & Admin (15%)			$882,000
TOTAL ESTIMATED CONSTRUCTION COST				$6,760,000
Construction Cost per Acre-Foot of Additional Storage				$4,830
Additional Reservoir Storage in Acre-Feet				1400

FINANCING

The cost for this work will require financing. It is suggested that when the City of Idaho Springs is ready to prepare a feasibility study for the project that the City apply to the CWCB for funding. Feasibility study funding can be approved by the CWCB at any meeting of the Board. Depending on the results of the feasibility study, an application for construction funding may be made. The City would definitely need construction funding to enlarge Idaho Springs Dam.

Table 5 shows several financing options. Option 1 is the standard CWCB financing terms as of December, 1993. The other options are better terms but would require special action by the CWCB. All of the options indicate that the cost of water would be around $250 per acre-foot.

RECOMMENDATIONS

The followings steps are recommended to enlarge Idaho Springs Dam:

1. The City must identify potential buyers for the approximately 1,400 acre-feet of annual yield, including how much water is needed by the City. The City might consider combining this step with step 2, so that the feasibility study would also identify potential buyers. When this might occur is unknown.

2. Apply for funding for a feasibility study from the CWCB, in the range of $70,000 to $100,000. Select an engineering firm who would perform the study which would involve: development of better cost estimates for the enlargement, the cost of water to the potential buyers, the economic advantages to the City, 404 permitting requirements, process to acquire the 3 acres of US Forest Service land, and a recommendation of whether or not to proceed with the project. Within a year after step 1.

3. If feasible, and potential buyers have committed to the water, apply for construction funding from the CWCB in the fall of the year. Funds would be available the following summer. Soonest one year after completing step 2.

4. Prepare the plans and specifications and apply for the necessary environmental permits. Also negotiate with the Forest Service to use their land. This process will require about 2 years.

5. Construct the enlargement. About 2 years, because the construction season is short.

TABLE 5
IDAHO SPRINGS DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$6,760,000	4.0%	30	$390,931	$279
2	$6,760,000	4.0%	40	$341,539	$244
3	$6,760,000	3.5%	30	$367,550	$263
4	$6,760,000	3.5%	40	$316,552	$226
5	$6,760,000	3.0%	30	$344,890	$246
6	$6,760,000	3.0%	40	$292,454	$209

Volume of Reservoir Enlargement in Acre–Feet: 1400

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

Dams Owned by the Leroux Creek Water Users Association

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

LEROUX CREEK WATER USERS ASSOCIATION

PLAN DESCRIPTION

The Leroux Creek Water Users Association (Association) operates about 30 small dams and reservoirs on the south slope of the Grand Mesa in the Leroux Creek drainage. The reservoirs are generally a few hundred acre-feet in size, with Bailey Reservoir being about the largest at about 750 acre-feet.

Leroux Creek is a tributary to the North Fork of the Gunnison River, intersecting near the Town of Hotchkiss. The water is used to irrigate fruit orchards and pastures. Figure 1 shows the general location of Leroux Creek drainage.

The contacts for the Association are:

Thomas Alvey, President (872-3911)
P.O. Box 130
Hotchkiss, Colorado 81419

Joanne Fagan, Consulting Engineer for Association
P.O. Box 738 (874-5342)
Delta, Colorado 81416

There are some opportunities to enlarge reservoirs in the Association system, such as Bailey Reservoir. However, in the discussion with the Association President, his primary concern was maintaining the existing storage. With so many dams and reservoirs to operate, several always have problems. Also, the US Forest Service is attempting to restrict travel to the reservoirs so that the Association would have to obtain an access permit just to change gate openings.

Based on the primary concern of the Association President to maintain the existing storage capacities first and enlargement second, coupled with the large number of dams the Association operates; a comprehensive scope is proposed herein, rather than evaluation of one or two enlargements.

The Association is encouraged to apply to the CWCB for feasibility study funds to make an evaluation of all of the Association Dams and Reservoirs to assess the repair needs and secondly to determine if there is enlargement potential at any of the dams. Once the needs are itemized and cost estimates prepared, the Association would then apply to the CWCB for funds to construct the repairs and, if appropriate, enlargements.

This reconnaissance report describes the type of information that would be prepared during the feasibility study period and the process and timing to accomplish the work.

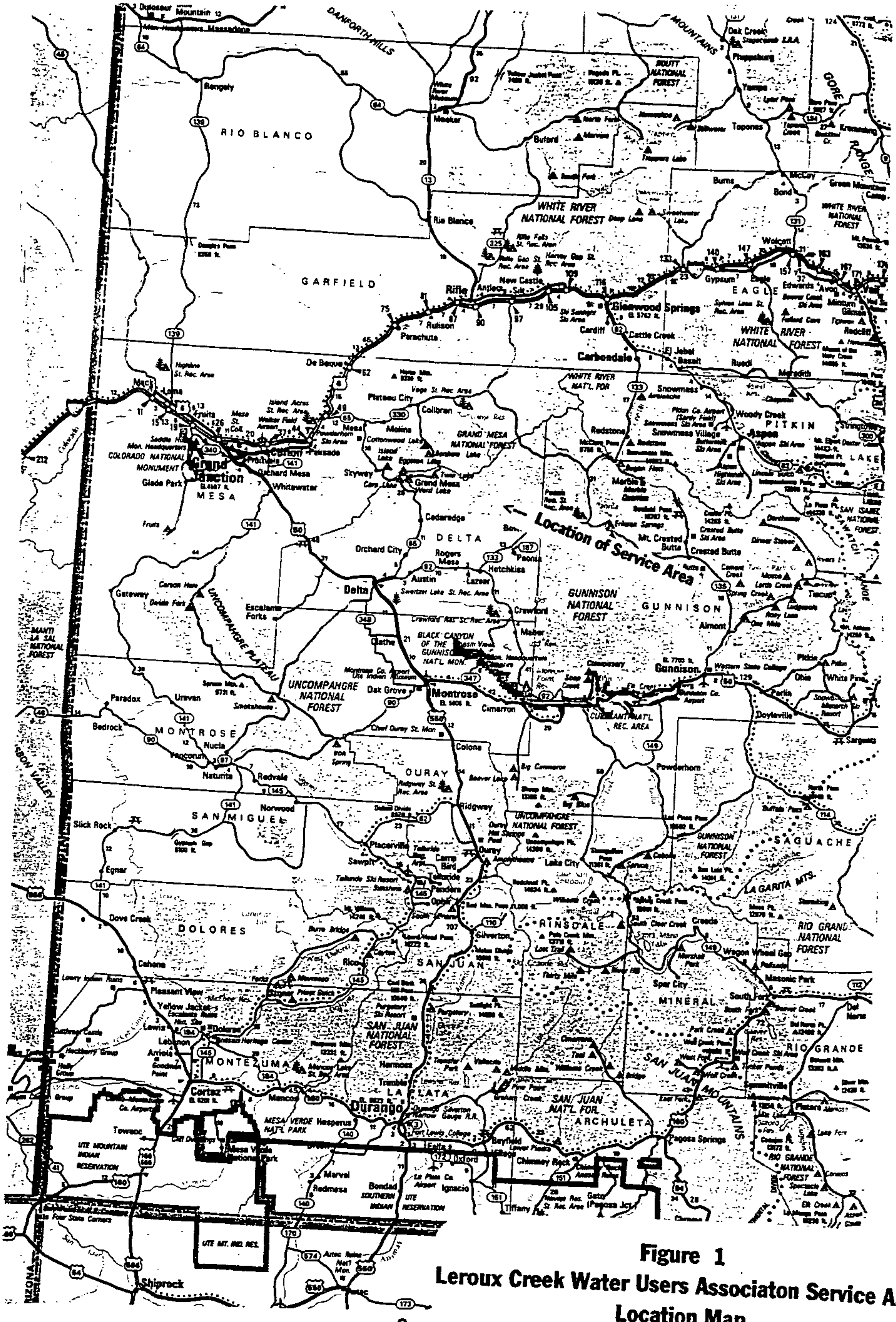


Figure 1
Leroux Creek Water Users Associaton Service Are
Location Map

WATER SUPPLY

The Association holds storage and direct flow water rights in the Leroux Creek drainage which can be managed to maximize the storage. The reservoirs are operated to store water during the runoff period for use in the late summer.

There is a regulation reservoir, on Leroux Creek, which collects releases from the upstream reservoirs to even out the flow pattern into the ditches that convey water to the fields. In short the Association has an efficient water collection system.

The Association has storage rights for about 5,400 acre-feet but only has storage capacity for about 4,000 acre-feet. There are 5400 shares in the Association based upon the acre-feet of potential storage rights.

The heart of the system are the nearly 30 small dams and reservoirs.

DAM AND RESERVOIRS

The work that would be performed during the proposed feasibility study to evaluate all of the reservoirs in the Association system is described in this section.

The Association would retain an engineer, assumed to be the present Association Engineer, to prepare a scope of work for the feasibility study. The suggestions for the scope of work described herein are based upon a one day site visit to three of the reservoirs and discussions with the Association Engineer and President. The suggestions herein should be modified to best reflect the needs of the Association.

The objective of the study would be to evaluate the condition of each dam and reservoir owned by the Association to: (1) determine what repairs are necessary to operate the dam for the next 20 to 30 years and (2) to determine if any of the dams can be enlarged. The two or three decade time period is suggested because the interest rates are presently the lowest in 20 years; in short, now is a good time to finance long term improvements.

The Dam Safety Engineer for the Colorado State Engineer would be involved with the dams that the State classifies as jurisdictional. The criteria stated in the "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources would apply to jurisdictional dams.

The evaluation process would generally include:

1. The Association should have their Engineer prepare a scope of work which, to the extent possible, specifically addresses the work to be performed and a not-to-exceed cost. The cost estimate should be on the high side because it is difficult to increase the CWCB amount after the initial application.

2. Apply to the CWCB for feasibility study funding. The CWCB will loan funds for at least half of the study cost. If the study results in construction, the amount is added to the construction loan. Feasibility Study funds can be applied for and received at any time during the year. John Van Sciver (866-3441) with the CWCB should be contacted to begin the process.

3. Assemble data for each dam and reservoir in the system such as: existing drawings, height, embankment slopes, reservoir capacity, outlet pipe size, jurisdictional or not, location, problems.

4. Perform a site inspection when the reservoirs are at maximum capacity. This would indicate any excessive seepage through the embankment. The outlet pipe and gate should be operated. Determine potential enlargement possibilities. Coordination with the State Dam Safety Engineer and the Rules and Regulations is suggested.

5. If existing topographic data is not adequate, perform surveys to determine embankment dimensions, water depth, reservoir size, enlargement potential, etc..

6. For each dam in the system, develop a list of repair needs (if any) and if appropriate, the enlargement potential. For each repair and enlargement a description, preliminary design, and cost estimate would be prepared.

7. Determine which, if not all, of the repairs and/or enlargements are cost effective and within the Association's ability to repay.

8. Once the work to be performed is determined and a cost estimate prepared, apply to the CWCB for construction funding. Construction funding applications must be submitted by about September first of each year for funding in late summer of the following year.

During the site visit, three possible dam improvements were reviewed.

* The Sheepsdrive Dam is presently breached because of safety problems, the cost to repair the dam to its original height appears to be exorbitantly large. The best idea is to repair the embankment to a non-jurisdictional height to retain some storage at a relatively small cost.

* Enlargement of Bailey Dam and Reservoir appears to be possible, even though it was enlarged about 20 years ago.

* The Doughty Dam and Reservoir could also be enlarged about 2 or 3 feet.

COST ESTIMATE and FINANCING

The cost for the feasibility study is estimated to be about $50,000 including some surveying costs for work at a few of the dams but no materials testing. The cost should be determined based on the scope of work prepared by the Association's Engineer. Assuming the CWCB funds $25,000, the Association would fund the other $25,000. The Association may request that the CWCB fund more than 50% of the cost. Geotechnical testing was not included in the study cost estimate but this may be necessary to adequately evaluate some of the embankments and should remain a possibility.

Since, an application for construction funding is a very likely result of the study, the Association should request that the feasibility study funds be added to the construction loan request; unless after the study a construction loan is not forthcoming.

RECOMMENDATIONS

This report recommends that the Association consider conducting a feasibility study to assess the repairs necessary to make their dams operational for at least 20 to 30 years and if appropriate evaluate potential enlargements to increase the water storage capacity.

The interest rates from the CWCB for long term debt are the lowest in 20 years so that now is a good time to make repairs and possibly enlargements.

In order to obtain construction funds in the summer of 1996, the feasibility study should begin this spring so that the work description and funding needs can be quantified by late summer of 1994, in time for an application for construction funds. The Colorado legislature must approve construction loans and does so in the CWCB Construction Fund Authorization bill passed each spring.

Construction funds would be available in the summer of 1995, so that plans and specifications (assuming that some of the improvements include jurisdictional dams) can be prepared in late 1995 for approval in early 1996, followed by construction in the summer of 1996.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

LILYLANDS DAM AND RESERVOIR
Owned By The Lilylands Canal and Reservoir Company

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

LILYLANDS DAM AND RESERVOIR

PLAN DESCRIPTION

Lilylands Dam and Reservoir is an existing structure located in the San Miguel River drainage in southwest Colorado, about 15 miles south of the Town of Norwood. The reservoir is located on a small tributary of West Naturita Creek. Figure 1 shows the reservoir location in Colorado, Figure 2 is a copy of a USGS Quad map showing the reservoir site and the drainage basin.

The dam is owned by the Lilylands Canal and Reservoir Company. The contact person is:

Bill Bray, President
Lilylands Canal and Reservoir Company
Redvale, Colorado   81431

The structure does not have any serious problems that has caused the dam to be restricted by the Colorado State Engineer; however, there is concern about the outlet pipe which should be lined in the near future. The Company would like to enlarge the reservoir to provide additional water to about 1500 acres in the Lilylands and Dry Creek Basin areas.

The drainage basin above the reservoir is about 1 square mile in size. The basin drains a gently sloping area, covered with pinion, pine and natural grass. Water to fill the enlarged reservoir must be diverted through the Lilylands Intake Ditch which collects runoff from the north slope of Lone Cone and conveys the water to Lilylands Reservoir. The Intake Ditch would be extended to collect additional water to fill the enlarged reservoir.

Enlargement of the dam would provide about 1686 acre-feet of additional storage; 2176 acre-feet total enlarged storage minus the existing storage of about 490 acre-feet. The additional annual yield is estimated to be the increased reservoir capacity; however, in dry years the reservoir will probably not fill.

The Lilylands system has been included in numerous studies by the Bureau of Reclamation in conjunction with the San Miguel Project (which is a participating project of the Colorado River Storage Project) and was the subject of two studies funded by the CWCB, one performed by Western Engineer (Grand Junction) and the second by Boyle Engineers (Denver). In all instances the repayment ability of the irrigators compared to the cost of the facilities was not adequate.

There is some discrepancy in the reservoir capacity between the reports described above and the volume determined for this report. Verification of the reservoir capacity resulting from the enlargement of the dam is suggested.

This reconnaissance report describes the engineering issues, construction, and costs of enlarging the Lilylands Dam. The plans described herein are preliminary based upon existing information; the plans may change as detailed plans and specifications are prepared.

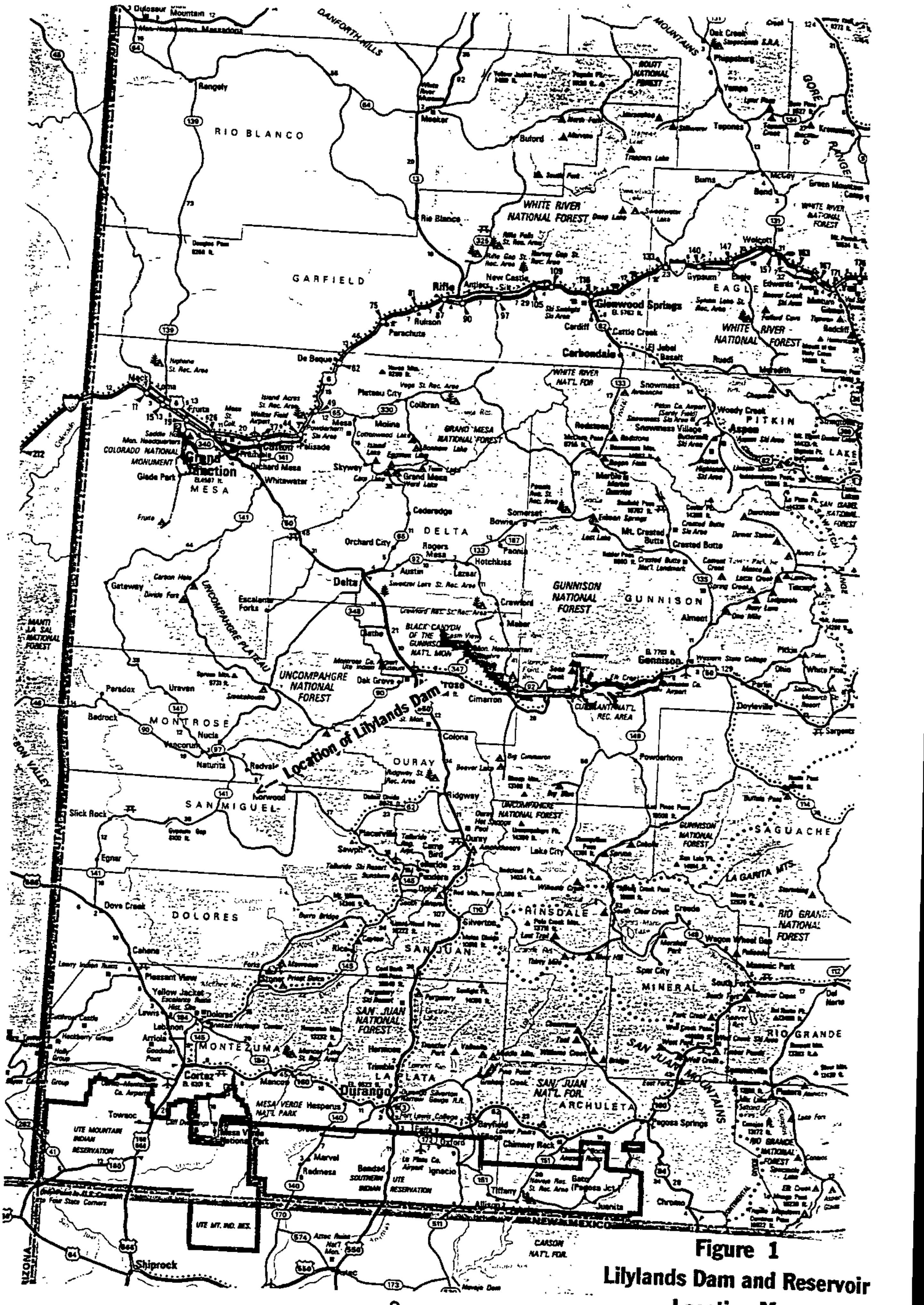


Figure 1

Lilylands Dam and Reservoir

Location Map

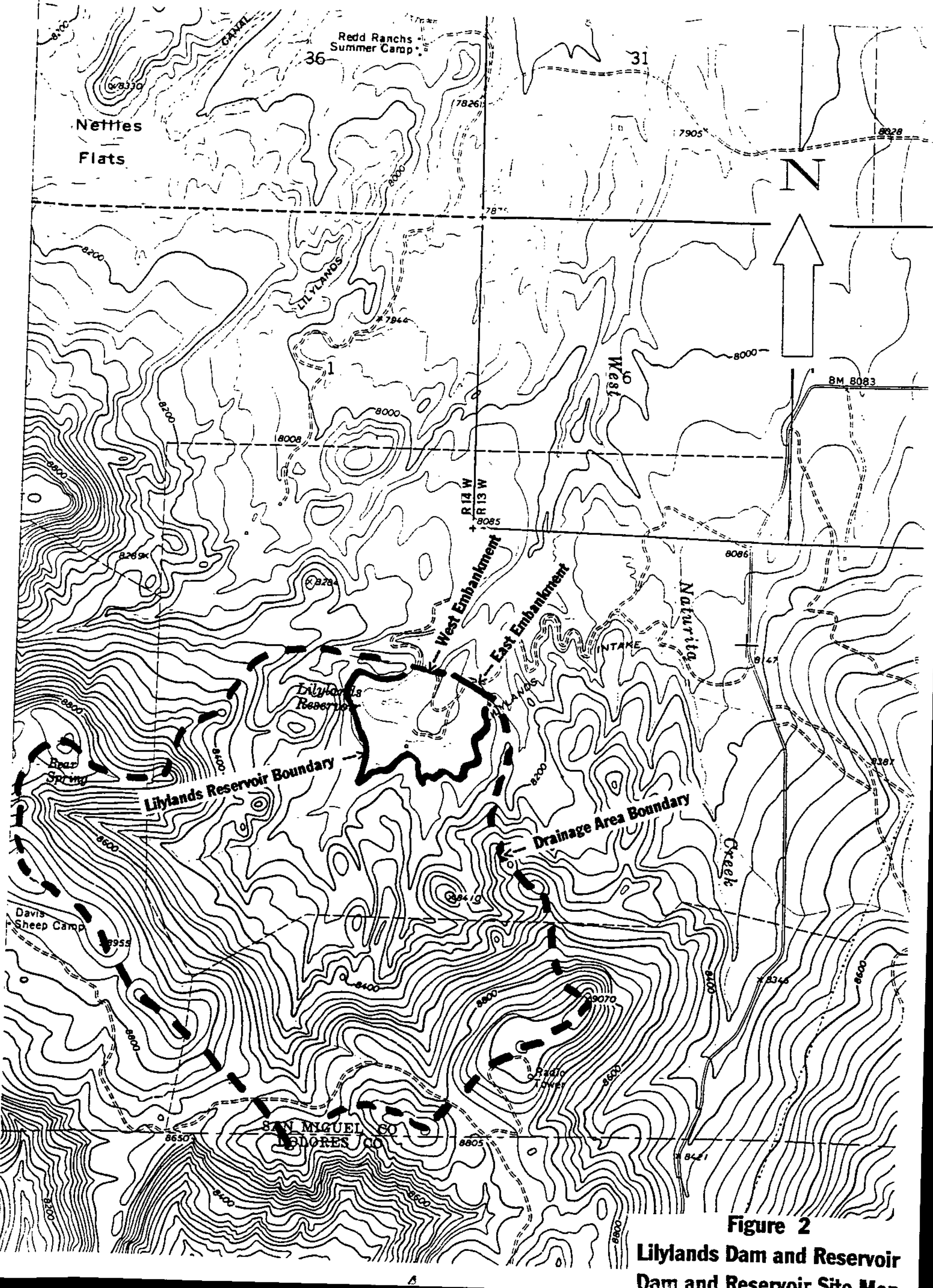


Figure 2
Lilylands Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The Lilylands Canal and Reservoir Company has 489 acre-feet of absolute storage rights and 99 cfs of absolute diversion rights for the Lilylands Intake Ditch. In addition the Company had 702 acre-feet of conditional storage rights and 14 cfs of conditional diversion rights, which have apparently been lost for lack of diligence. With enlargement of the reservoir the Company should apply for storage rights for the additional 1700 acre-feet of capacity.

The increased reservoir capacity would be used for late summer irrigation. The irrigators in Dry Creek Basin have installed center pivot sprinklers to maximize the water supply but are still only able to get one good cutting of hay. The enlarged reservoir would allow sufficient water for two cuttings.

The enlarged reservoir would not fill every year but even in dry years the water availability would be increased because some water is not collected or is passed through the reservoir which could be stored. The quantification of the water presently collected and potentially collectable has been studied intermittently for 30 years but is very difficult to estimate because of the numerous small streams that must be monitored to determine the runoff amounts. The Boyle Engineers report determined that an additional 1500 acre-feet of water could be developed each year with system improvements and a 1400 acre-foot Lilylands Reservoir; and an increase of 4600 acre-feet could be obtained with a 6500 acre-foot Lilylands Reservoir.

The assumption herein is that an additional 1686 acre-feet could be developed with a corresponding increase in storage capacity. Based on the Boyle Report, this should usually be the case. The reservoir intake ditch which collects runoff from Lone Cone must be extended and enlarged to convey additional water to the reservoir.

There is no potential for municipal water sales from the reservoir.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir from the estimated bottom of 8050 feet to the proposed dam crest of 8130 feet. The table was developed from areas measured from a 1 inch = 100 feet, 5 foot contour topographic map prepared by the Bureau of Reclamation. The capacities and areas do not correspond to the reservoir capacities and areas contained in the Boyle Report; for reasons that could not be determined the Boyle Report shows significantly more reservoir capacity at given dam heights.

The elevation-area-capacity for the reservoir should be verified in detail. See recommendations.

TABLE 1
LILYLANDS DAM & RESERVOIR
Elevation – Area – Capacity

Gage Height (feet)	Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
85	8135	92.2	3022.2	
84	8134	90.68	2930.7	
83	8133	89.16	2840.8	
82	8132	87.64	2752.4	
81	8131	86.12	2665.5	
80	8130	84.6	2580.2	Enlarged Dam Crest
79	8129	83.08	2496.3	
78	8128	81.56	2414.0	
77	8127	80.04	2333.2	
76	8126	78.52	2253.9	
75	8125	77	2176.2	Enlarged Water Surface
74	8124	73.2	2101.1	
73	8123	69.4	2029.8	
72	8122	65.6	1962.3	
71	8121	61.8	1898.6	
70	8120	58	1838.7	
69	8119	57.4	1781.0	
68	8118	56.8	1723.9	
67	8117	56.2	1667.4	
66	8116	55.6	1611.5	
65	8115	55	1556.2	
64	8114	54.4	1501.5	
63	8113	53.8	1447.4	
62	8112	53.2	1393.9	
61	8111	52.6	1341.0	
60	8110	52	1288.7	
59	8109	51.4	1237.0	
58	8108	50.8	1185.9	
57	8107	50.2	1135.4	
56	8106	49.6	1085.5	
55	8105	49	1036.2	
54	8104	48.4	987.5	
53	8103	47.8	939.4	
52	8102	47.2	891.9	
51	8101	46.6	845.0	
50	8100	46	798.7	

TABLE 1
LILYLANDS DAM & RESERVOIR
Elevation – Area – Capacity

Gage Height (feet)	Elevation (feet)	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
49	8099	42.5	754.4	
48	8098	39	713.7	Existing Dam Crest
47	8097	35.5	676.4	
46	8096	32	642.7	
45	8095	28.5	612.4	
44	8094	25	585.7	
43	8093	24.4	561.0	
42	8092	23.8	536.9	
41	8091	23.2	513.4	
40	8090	22.6	490.5	Existing Spillway Crest
39	8089	22	468.2	
38	8088	21.4	446.5	
37	8087	20.8	425.4	
36	8086	20.2	404.9	
35	8085	19.6	385.0	
34	8084	19	365.7	
33	8083	18.4	347.0	
32	8082	17.8	328.9	
31	8081	17.2	311.4	
30	8080	16.6	294.5	
29	8079	16	278.2	
28	8078	15.79	262.3	
27	8077	15.58	246.6	
26	8076	15.37	231.1	
25	8075	15.16	215.8	
24	8074	14.95	200.8	
23	8073	14.74	185.9	
22	8072	14.53	171.3	
21	8071	14.32	156.9	
20	8070	14.11	142.6	
19	8069	13.9	128.6	
18	8068	13.69	114.8	
17	8067	13.48	101.2	
16	8066	13.27	87.9	
15	8065	13.06	74.7	
14	8064	12.85	61.7	
13	8063	12.64	49.0	
12	8062	12.43	36.4	
11	8061	12.22	24.1	Outlet Pipe Level
10	8060	12	12.0	

DAM EMBANKMENT

The Lilylands Dam, is a jurisdictional intermediate Class III structure, with the enlargement the dam may be upgraded to a Class II. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days, suggested but not required,
* a crest width equal to the vertical height divided by 5 plus 10 feet, 25 feet maximum,
* a spillway capable of passing a 100 year flood, unless changed to a Class II rating which requires 50% PMP,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications. The reconnaissance designs described herein are based upon a review of available data; more detailed engineering work may result in a different design.

EMBANKMENT: The existing Lilylands Dam consists of two embankments which are not connected. The west embankment is the main dam and contains the outlet pipe to the Lilylands Canal; the dam is about 50 feet high with slopes of 4H:1V upstream and 2H:1V downstream, a 20 foot crest width, and a 3 foot diameter outlet pipe. The east embankment is a smaller dam about 12 feet high with slopes of 2.5H:1V upstream and 2H:1V downstream, and a 10 foot crest. The spillway is near the east dam. The dam is in relatively good condition and is not restricted or imminently facing a restriction.

The proposed enlargement of the dam will involve raising the west embankment to a crest elevation of 8130 feet and constructing a new east embankment also with a crest elevation of 8130 feet. The upstream slope on the raised portion of the west embankment would be 4.0H:1.0V and the downstream slope will be 2.0H:1.0V with a 25 foot wide crest. The rather flat upstream slope was maintained to match the existing slope.

Two alignments were investigated for the east embankment, a shorter alignment and a longer alignment; the longer alignment results in about 25 acre-feet of additional capacity. The shorter alignment was selected because it had about 65% of the volume of the longer alignment. The new east embankment will have slopes of 3.25H:1.0V upstream and the downstream slope will be 2.5H:1.0V with a 18 foot wide crest.

The maximum section of the proposed enlarged west dam will be an earth embankment with following the dimensions:

* 75 feet high at a height of 8130 feet,
* crest length (both embankments) of about 1300 feet,
* crest width of 25 feet and 5 feet of freeboard,
* 4.0H:1.0V upstream and 2.0H:1.0V downstream slopes
* extension of existing 36 inch diameter outlet pipe,
* a spillway bottom width of 20 feet.

Figure 4 shows the maximum cross section of the dam. Figure 5 shows the front elevation view of the larger west embankment looking upstream from below the dam.

The top 2 feet of the existing embankment and the area below the toe of the existing embankment would be removed and wasted because it contains humus and rocks. The material to raise the embankment will be placed on the downstream slope. A core trench is assumed at the downstream toe of the existing embankment that is 20 foot deep and 20 feet wide and under the highest section of the embankment. Though the core trench is downstream of the crest, it is included to impede foundation water seepage.

A sand filter toe drain is included on the downstream toe of both embankments to collect seepage. The filter would be 2 feet wide, 5 feet deep and the length of the toe of the east and west embankments. The sand would meet ASTM C-33 specifications and a drain pipe with 1/16th inch slots would be installed in the filter to convey water out of the filter.

No other drainage system is included in this preliminary design because the existing dam is apparently in good condition without serious seepage. Also, the enlargement includes the placement of a large mass of material on the downstream slope with a thick 25 foot crest width. In short, embankment material is readily available and drainage material is not; so the embankment slopes have been flattened rather than including expensive chimney drains.

The Bureau of Reclamation conducted test pits and bore holes in the reservoir basin to evaluate materials availability. Their tests indicated that there is a substantial amount of lean clay material which appears to be suitable for embankment material. Very little filter material was found, so the embankment design is suggested to be homogenous impervious material with a minimum of filters. If the designs and specification process indicates potential seepage problems, the best solution is probably to flatten the embankment slopes. The material would be placed in lifts and compacted to 95% Standard Proctor. Adequate testing will be required to monitor the compaction.

Rock for rip rap does not appear to be available immediately around the reservoir and must be hauled from a site assumed to be within 5 miles.

The volume of material to be placed in order to enlarge the dam was quantified by estimating the volume of the existing embankment, shown in Table 2. The volume of the enlarged embankment was also estimated, the west embankment is shown in Table 3 and the east embankment in Table 4. The existing embankment volume is subtracted from the total of the two enlarged embankments and the result is increased by 30% for compaction losses.

OUTLET PIPE: The existing outlet pipe would be lined with a thin layer of steel or another suitable material. The outlet pipe would be extended about 260 feet through the new embankment. No other modifications are anticipated.

SPILLWAY: The 1 square mile drainage area above the dam would have a flood from the probable maximum precipitation of about 6,000 cfs but only 300 acre-feet in volume; based on Bureau of Reclamation reconnaissance study design flood estimating procedures. The reservoir surcharge capacity is 400 acre-feet so the maximum flood can be stored in the reservoir. The spillway width is 20 feet to allow the flood flows to drain. The requirement to pass a 100 year or 50% PMP floods, depending on the dam classification, can be easily met, with the proposed surcharge and spillway.

The spillway would be constructed on the east abutment of the east embankment. The east abutment would be excavated to allow a 20 foot wide spillway with 1:1 side slopes. The 20 foot spillway was estimated based on the small drainage area; if a final HEC-1 analysis shows additional capacity is needed the spillway can be easily widened.

A concrete cutoff wall will be installed across the spillway to maintain the spillway crest. The wall would be the shape and width of the spillway channel with concrete about 2 feet thick and at least 2 feet deep along the length of the wall. Rip rap may be needed downstream of the cutoff wall to control potential erosion.

TABLE 2
LILYLANDS DAM EMBANKMENT – EXISTING VOLUME ESTIMATE

0 foot Stripping Depth
4 :1 Upstream
2 :1 Downstream
20 foot Crest Width
8098 feet Crest Elevation

0 foot Key Trench Width
0 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
210	8100	0	0				
				1023.5	1674	0	1674
258	8075	23	2047				
				4227	6575	0	6575
300	8055	43	6407				
				6407	33221	0	33221
440	8055	43	6407				
				4227	17221	0	17221
550	8075	23	2047				
				1024	1849	0	1849
603	8100	0	0				

Total Volume of Existing Embankment (cubic yards) 60500

TABLE 3
LILYLANDS DAM EMBANKMENT – WEST DAM ENLARGED VOLUME

2 foot Stripping Depth
4 :1 Upstream
2 :1 Downstream
25 foot Crest Width
8130 foot Crest Elevation

20 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
52	8130	2	62				
				397	1220	615	1835
135	8120	12	732				
				1012	937	185	1122
160	8115	17	1292				
				1647	1220	148	1368
180	8110	22	2002				
				2937	3263	444	3707
210	8100	32	3872				
				7522	13372	711	14083
258	8075	57	11172				
				15442	24021	622	24643
300	8055	77	19712				
				19712	102210	2074	104284
440	8055	77	19712				
				15442	62912	1630	64542
550	8075	57	11172				
				7522	14765	785	15550
603	8100	32	3872				
				2582	2486	193	2679
629	8115	17	1292				
				1012	262	52	314
636	8120	12	732				
				397	382	74	456
662	8130	2	62				

Total Volume of Enlarged West Embankment (cubic yards) 234600

TABLE 4
LILYLANDS DAM EMBANKMENT – EAST DAM ENLARGED VOLUME

2 foot Stripping Depth
3.25 :1 Upstream
2.5 :1 Downstream
18 foot Crest Width
8130 foot Crest Elevation

20 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
64	8130	2	48				
				339	603	356	959
112	8120	12	630				
				884	262	59	321
120	8115	17	1137				
				1859.5	2066	222	2288
150	8105	27	2582				
				3051	2260	296	2556
170	8100	32	3520				
				4061	2707	267	2974
188	8095	37	4602				
				5215	10430	800	11230
242	8090	42	5828				
				5828	57848	3970	61818
510	8090	42	5828				
				5215	9657	741	10398
560	8095	37	4602				
				4061	4061	400	4461
587	8100	32	3520				
				3051	2712	178	2890
611	8105	27	2582				
				1606	3926	489	4415
677	8120	12	630				
				339	477	74	551
715	8130	2	48				

Total Volume of Enlarged East Embankment (cubic yards) 104900

Figure 3

Lilylands (West Embankment) Dam and Reservoir

Cross Section at Outlet Pipe

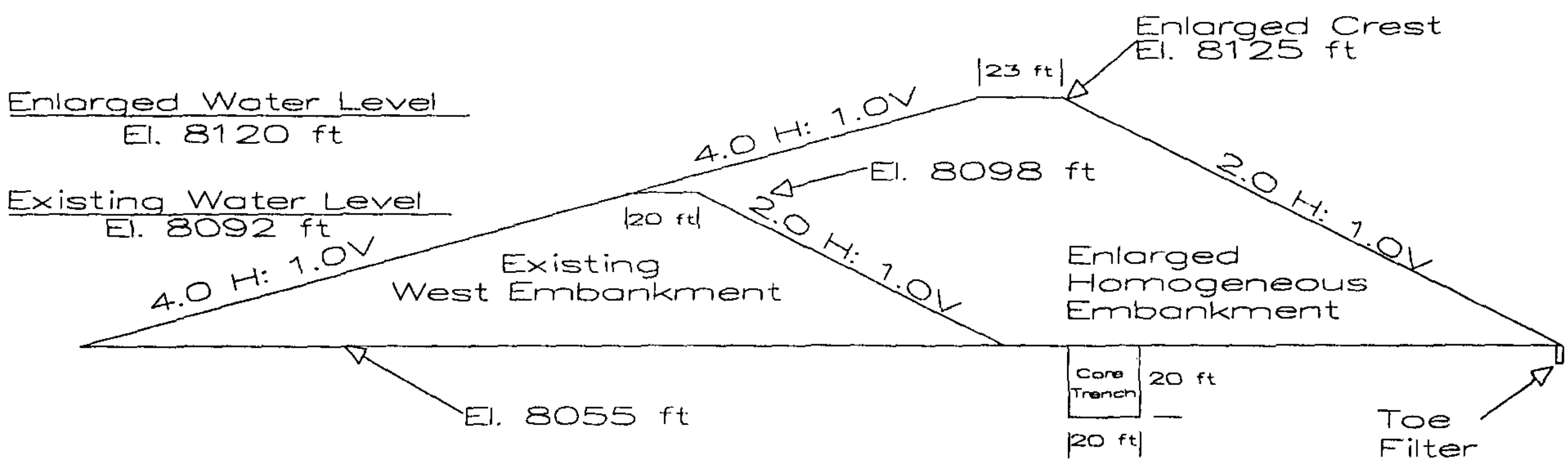
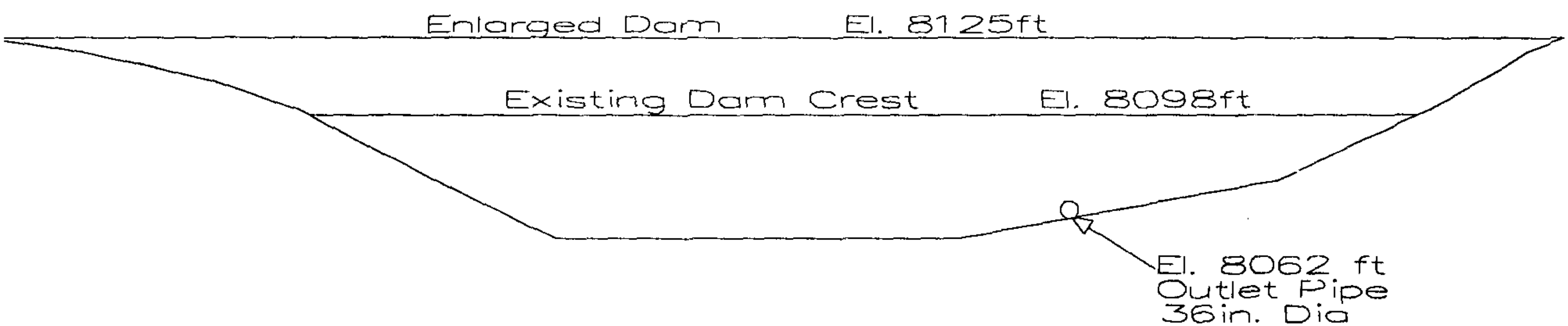


Figure 4
Lilylands (West Embanknment) Dam and Reservoir
Embankment Looking Upstream



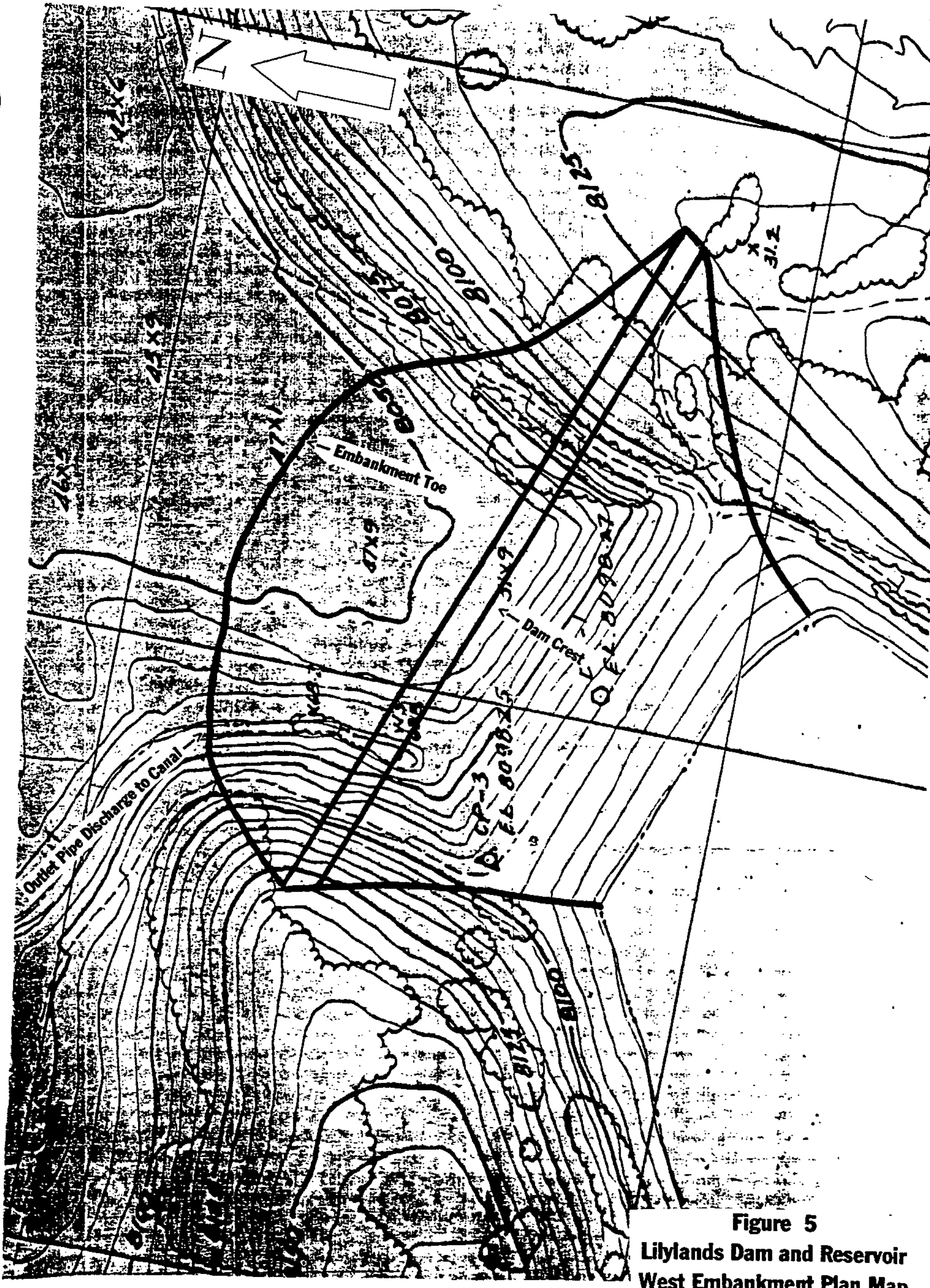


Figure 5
Lilylands Dam and Reservoir
West Embankment Plan Map

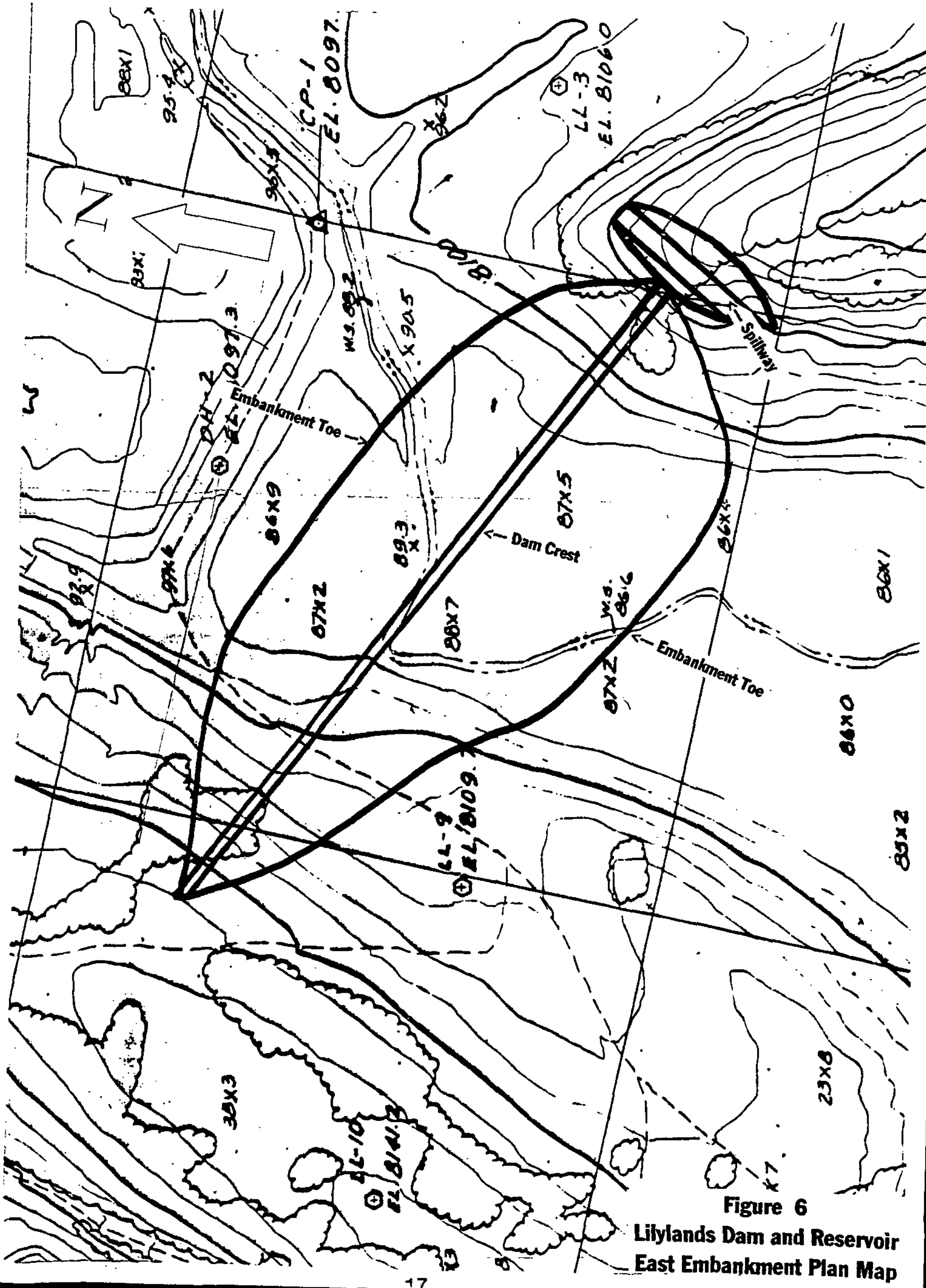


Figure 6
Lilylands Dam and Reservoir
East Embankment Plan Map

COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 5. The unit costs for placement of the embankment material was obtained from the Lilylands Canal and Reservoir Company representatives who have received estimates from local contractors for $1.50 to $2 per cubic yard. The outlet lining cost is assumed to be half the cost of new pipe. The outlet extension cost is double the cost of the pipe.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 12% which includes: testing for designs, preparation of plans and specifications, construction observation, CWCB financing costs, and any necessary permitting. Since Reclamation has already performed a significant amount of materials testing, there should not be much additional materials testing.

The cost of the Lilylands Intake Ditch extension is 50% of the Boyle Report cost based on the assumption that the Canal Company would perform the work at a reduced cost.

FINANCING

The cost for this work will require financing. The Reservoir Company would need to finance the entire cost.

The financial analysis herein assumes that Lilylands will be enlarged with a loan from the CWCB. The enlargement would yield addition storage of about 1,686 acre-feet. The repayment is based on the assumption that the water users would pay for 1868 acre-feet each year regardless of whether the water is available in dry years. Repayment options are shown in Table 6, assuming a 100% loan; if the District can include some cash the amounts would be reduced.

Options 6 or 7 are the only options that would allow the water to be priced below $30 per acre-foot which is marginally affordable irrigation water. The other financing options are not considered possible.

TABLE 5
LILYLANDS RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$10,000
Embankment				
Compacted Fill	cy	362700	$2.00	$725,400
Rip Rap	cy	4150	$20.00	$83,000
Intake Ditch Extension	ls			$70,000
Toe Drain	lf	700	$25.00	$17,500
	Embankment Subtotal			$895,900
Outlet Works				
Outlet Pipe Extension	lf	260	$300	$78,000
Line Existing Pipe	lf	180	$150	$27,000
	Outlet Works Subtotal			$105,000
Spillway				
Excavation	cy	2920	$2.00	$5,800
Concrete Control Section	cy	10	$300.00	$3,000
	Spillway Subtotal			$8,800
	Total of Above Items			$1,009,700
	Contingency (30%)			$302,900
	Land Cost			$0
	Field Cost Subtotal			$1,312,600
	Engineering & Admin (12%)			$157,500
TOTAL ESTIMATED CONSTRUCTION COST				$1,470,000
Construction Cost per Acre–Foot of Additional Storage				$870
Additional Reservoir Storage in Acre–Feet				1686

TABLE 6
LILYLANDS DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$1,470,000	4.0%	30	$85,010	$50
2	$1,470,000	4.0%	40	$74,270	$44
3	$1,470,000	3.5%	40	$68,836	$41
4	$1,470,000	3.0%	40	$63,596	$38
5	$1,470,000	2.0%	40	$53,737	$32
6	$1,470,000	1.5%	40	$49,138	$29
7	$1,470,000	1.0%	40	$44,770	$27

Volume of Reservoir Enlargement in Acre-Feet: 1686

RECOMMENDATIONS

The recommended financing option in order to allow reasonable repayment by the Company is Option #6 or #7, which would repay the loan amount at 1.5% or 1% interest over 40 years. These terms are about as much as the Company could afford.

The key to enlargement of Lilylands Reservoir is the estimated $2 per cubic yard to place material; this amount is lower than normal contractors but possible given that the Company plans to perform some of the general contracting responsibilities to reduce the cost.

The other primary assumption is that the water users in the Company can pay the annual cost of $45,000 to $50,000 regardless of whether the water is available, because in dry years the amount will be reduced. Due to the high cost per acre-foot and the fairly low repayment ability of the irrigators, there does not appear to be a feasible method to enlarge the dam which can be repaid with the standard CWCB financing terms.

Specific recommendations in sequential order.

1. The Lilylands Canal and Reservoir Company must: (1) decide if the recommended financing option is realistic for them and (2) carefully evaluate the proposed arrangement with local contractors to place the material for $2 per cubic yard or less. If not, discontinue work, if yes begin step 2. Suggest that the decisions be made by early spring of 1994.

2. Concurrently with step 1, request that Reclamation make a detailed determination of the elevation-area-capacity of the enlarged reservoir to elevation 8150 feet. It may be necessary to obtain additional topographic data on the upper portion of the reservoir. If the result is greater capacity than determined herein, then the project would be more feasible, or the embankment could be lowered for the same capacity. If the result is less capacity, the project may become infeasible (e.g. not repayable). Soonest by early spring 1994.

3. If after evaluation of the above two items, the Company wants to proceed, the Company should request feasibility study funds from the CWCB to prepare plans and specifications for submittal to the State Engineer. The plans and specifications will also include a detailed cost estimate which would be significantly more accurate than the estimate herein, the Company would have an opportunity to stop the work if necessary. The CWCB should agree to the general terms of the financing plan described above before providing the feasibility funds; there is no point in preparing the plans and specifications if the CWCB will require a higher interest rate. Apply for feasibility funds as soon as possible.

4. Prepare the plans and specifications during the late spring, summer, and early fall of 1994. The Bureau of Reclamation has a considerable amount of soils information, topography, and related information which will significantly reduce the amount of field work necessary.

5. Apply for CWCB construction funds by September of 1994 using the best available cost estimate if the final estimate, based on the final plans and specifications, is not completed. Provide the final cost estimate in time for inclusion in the FY 1996 CWCB Construction Fund bill.

6. Assuming construction funds are available finalize the contract with the CWCB and begin construction as soon as possible in the summer of 1996.

Interest rates are the lowest in 20 years, so the CWCB would be most willing to consider a 1.5% or 1% interest loan. The Company is encouraged to act quickly on steps 1 and 2. Submitting a construction loan request in the fall of 1994 may be critical because if this deadline is missed, a year will be lost and interest rates could increase.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

MATTIE DAM AND RESERVOIR
Owned By The City of Idaho Springs

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

MATTIE DAM AND RESERVOIR

PLAN DESCRIPTION

Mattie Dam and Reservoir would be a new dam and reservoir near the site of an old (nearly non-existent) mining dam. The facility would be used as a settling pond and diversion to the water treatment plant for the City of Idaho Springs; the reservoir site is not large enough to provide storage. The dam site is very small so rather than have a dam slightly greater than 10 feet the new dam would be less that 10 feet high so that it would be non-jurisdictional.

Mattie Dam and Reservoir would be owned by the City of Idaho Springs. The address and contact person is:

City of Idaho Springs
1711 Miner Street
Idaho Springs, Colorado 80452

Dennis Jorgensen, Public Works Director
303-567-4421

The reservoir would be located on Chicago Creek, a tributary to Clear Creek which is in the South Platte River drainage. Figure 1 shows the reservoir relative to the City of Idaho Springs. Figure 2 is a copy of a USGS Quad map showing the reservoir site location.

A field inspection was conducted on October 13, 1993, at which time a cross section of the dam site was surveyed; the area of the potential reservoir basin was roughly estimated. The City of Idaho Springs owns the original dam and the associated water rights but there is a discrepancy in the ownership boundaries that may require the purchase of additional land for the reservoir.

The drainage basin above the reservoir is very large, nearly 100 square miles in size. Much of the basin is above tree line with steep rocky slopes. The area below tree line has a good stand of trees and brush.

This report describes a preliminary plan for the construction of a non-jurisdictional dam near the old Mattie dam site; criteria for non-jurisdictional dams will apply. The evaluation is primarily based upon the survey made during the field inspection; there is no other data. The plans assume an earth embankment; however, because of the large drainage area, a concrete dam with the crest as a spillway should be considered prior to making a final decision. The concrete dam is more expensive but will have less damage from large floods.

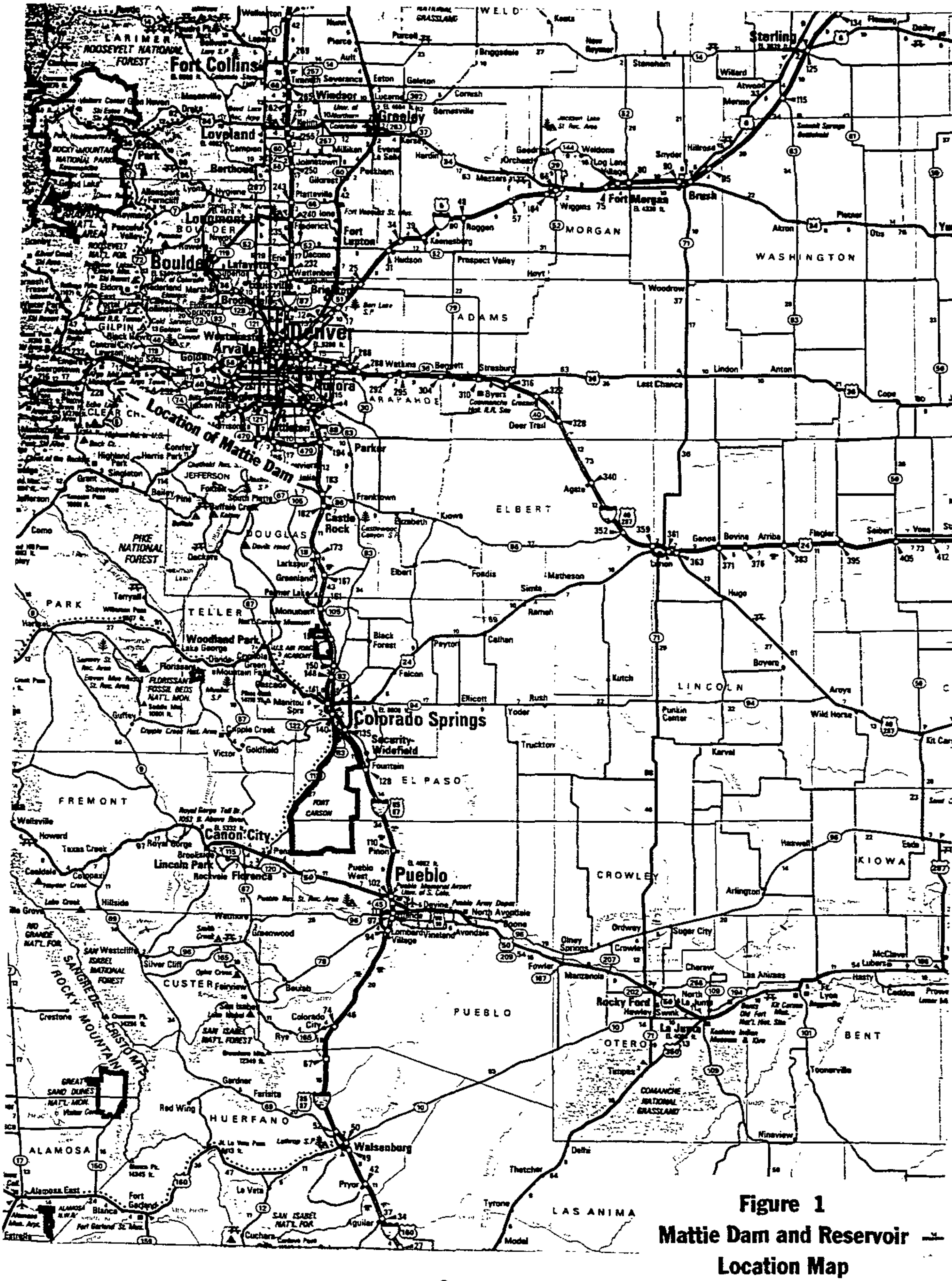


Figure 1

Mattie Dam and Reservoir Location Map

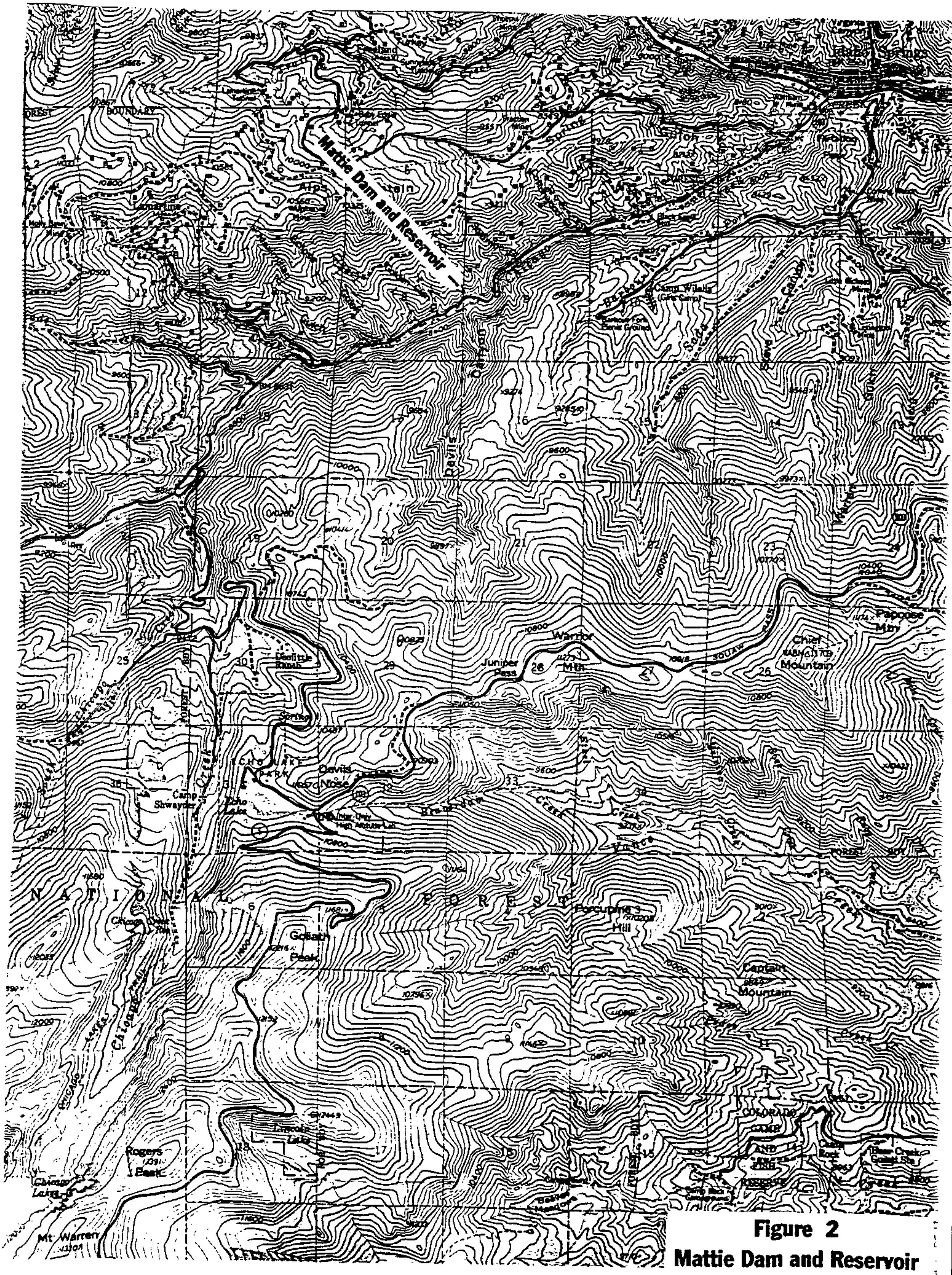


Figure 2
Mattie Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The City of Idaho Springs has water rights on Chicago Creek which are presently diverted from the creek near the proposed dam site, into a pipeline that conveys water to the treatment plant. The proposed reservoir essentially has no storage volume but would be used to settle some of the sediment load. There would be a slight change in the diversion location, of less than 100 feet; otherwise the present water supply will be the same.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir. The values in the table are very rough estimates based upon field observations of the reservoir area during the field inspection. A topographic survey of the dam site and reservoir basin should be performed prior to finalizing construction plans.

The field observations indicate that the reservoir would have a surface area of about one third of an acre and a capacity of about 1.5 acre-feet. A detailed estimate of the detention time was not made because the flow is widely variable during the year; during the spring runoff there will be minimal detention time. Once the topographic survey is completed, the reservoir capacity should be compared to the spring runoff flows to estimate the potential detention time, to determine if there will be enough detention to settle any sediment.

For instance, assuming 1.5 acre-feet and a spring flow of 100 cfs, the detention time would be about 11 minutes. A flow of 200 cfs would allow half the detention time and so on. There will be little settling of sediment for flows above 200 cfs.

TABLE 1
MATTIE DAM AND RESERVOIR
Reservoir Area-Capacity

Elevation	Area (acres)	Accumulative Volume (Ac-Ft)	Description
100	0.59	4.37	Top of Dam
99	0.55	3.8	
98	0.51	3.27	
97	0.47	2.78	
96	0.43	2.33	
95	0.39	1.92	
94	0.35	1.55	Crest of Spillway
93	0.31	1.22	
92	0.27	0.93	
91	0.23	0.68	
90	0.19	0.47	
89	0.15	0.3	
88	0.11	0.17	
87	0.07	0.08	
86	0.03	0.03	
85	0.01	0.01	
84	0		Intake to Outlet Pipe

DAM EMBANKMENT

The water depth behind the dam would be less than 10 feet and therefore non-jurisdictional, and would not have to comply with the "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources. In short an engineer is not needed to design the dam and the only State Engineer permit is a notification form. There may be other permits such as a Corp of Engineers 404 Permit. The City may want to retain an engineer to evaluate the detention time relative to the sediment load.

EMBANKMENT: The dam is assumed to be an earth embankment with following the dimensions:

* 16 feet high (water depth 10 feet),
* crest length of about 120 feet,
* crest width of 10 feet,
* 3.0H:1.0V upstream and 2.5H:1.0V downstream slopes
* 18 inch diameter outlet pipe,
* 20 foot wide spillway.

Figure 4 shows the cross section of the dam at the outlet pipe. Figure 5 shows the front elevation view of the embankment looking upstream from below the dam.

The embankment would be constructed of impervious (e.g. clay) material to reduce seepage. The material must be hauled to the site from the nearest borrow area (assumed to be within 5 miles). The foundation appears to be significantly different on the east and west abutments. The east abutment is stream sediment and cobble which is very flat extending over 100 feet to the highway. The west abutment is fragmented rock and very steep, nearly vertical. The east side of the dam will require a cutoff trench while the west side will be excavated into rock. The spillway will be located on the east side of the dam because of adequate area.

There is a large drainage area above the dam which will cause problems to any type of dam constructed at the site. The earth dam suggested herein includes a wide spillway (20 feet) and 6 feet of freeboard in the reservoir which will pass about 730 cfs, in an attempt to route the medium size floods through the reservoir. Unfortunately, given the size of the drainage area the dam will be overtopped during larger floods, requiring repairs.

A concrete dam, which will suffer little or no damage during a flood, was evaluated to roughly determine the volume of concrete; which showed that concrete would cost about three times the earth embankment (compare Tables 3 and 4).

The cost of concrete, including forms, rebar, and placement is estimated to be $300 per cubic yard; a concrete dam should be considered if the City can place concrete for less than $300 per cubic yard or is willing to spend more money for a more reliable dam.

The City should also investigate a roller compacted concrete dam. The concrete is placed, without rebar, with normal earthmoving equipment and in large dams the cost per cubic yard is about $50. However, this is a very small dam which will increase the cost considerably and does not appear to be a viable option.

Since an engineer is not needed for construction, the City has considerable flexibility to construct the facility with materials and personnel which can perform the work most efficiently. The type of construction that the City can best perform should be a prime consideration when selecting a type of dam.

Rip rap on the upstream face does not appear to be necessary because of the very small reservoir area and being a non-jurisdictional dam; however, if the City finds that erosion is a problem some rip rap may be placed at a later time.

The sediment which would accumulate in the reservoir basin must be removed with loaders and trucked away, when necessary. Flushing of the sediment will probably not be allowed into the stream.

OUTLET PIPE: The outlet pipe is suggested to be an 18 inch diameter, thick walled (e.g. 200 psi) PVC pipe with a slide gate operated by a gate stem and gate wheel at the dam crest. The pipe size is extra large to allow large releases through the dam, rather than over the spillway. A trash rack will be necessary over the gate mechanism to screen out large objects from entering and possibly plugging the pipe.

SPILLWAY: The 20 foot spillway in combination with 6 feet of freeboard is included to bypass about 730 cfs plus the outlet pipe. The spillway would be on the east abutment between the dam embankment and the highway property line. The spillway would be on natural ground with a concrete cutoff wall constructed to maintain the spillway shape.

The concrete cutoff wall will be perpendicular to the flow of water which is included to stabilize the spillway section. The wall would be about 2 feet thick, at least 2 feet below the ground surface at any point along the wall, and be the desired shape of the spillway cross section (roughly 20 wide at the base and sloping up a 1:1 on either side).

Rip rap should be placed downstream of the wall to reduce erosion.

TABLE 2
MATTIE DAM EMBANKMENT – VOLUME ESTIMATE

2	feet Stripping Depth
3	:1 Upstream
2.5	:1 Downstream
10	foot Crest Width
100	foot Crest Elevation
8	foot Key Trench Width
3	foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Earthwork (cy)
122	100	0	0				
				79.5	27	0	27
131	96	6	159				
				182	94	6	100
145	95	7	205				
				231	163	17	180
164	94	8	256				
				560	249	11	260
176	86	16	864				
				967.5	573	14	587
192	84	18	1071				
				1071	317	7	324
200	84	18	1071				
				1071	674	15	689
217	84	18	1071				
				1018	415	10	425
228	85	17	965				
				780	318	5	323
239	89	13	595				
				313	35	0	35
242	100	2	31				

Total Earthwork Volume (cubic yards) 2900

Earthwork Volume plus 30% for Compaction (cubic yards) 3800

Figure 3
Mattie Dam and Reservoir
Cross Section at Outlet Pipe

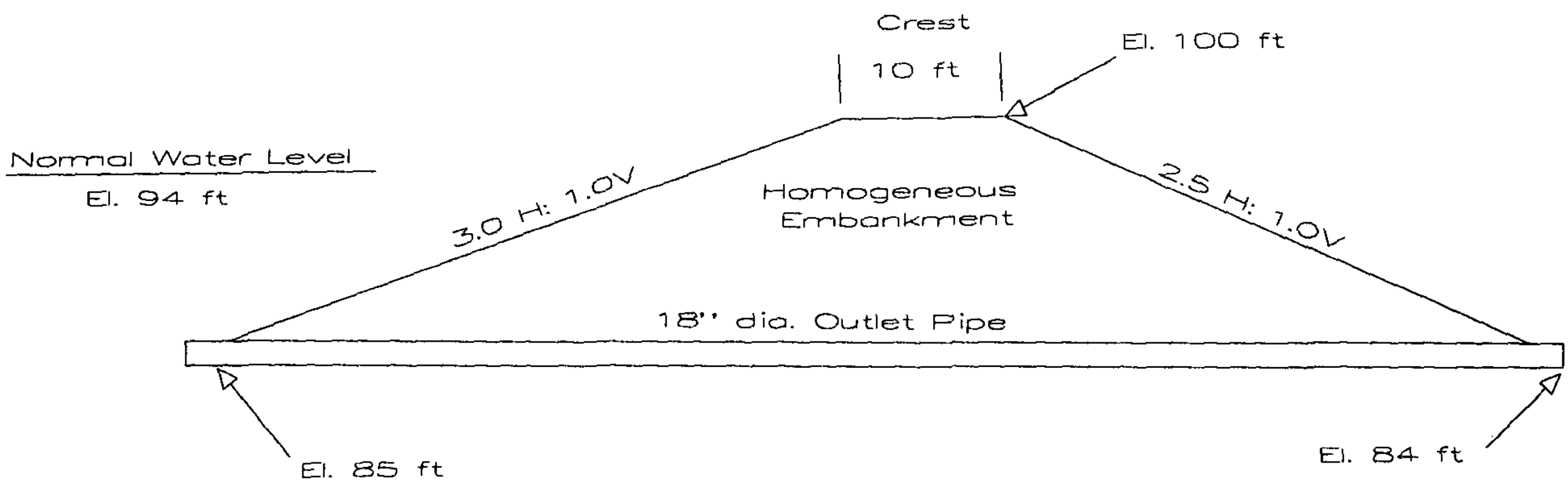
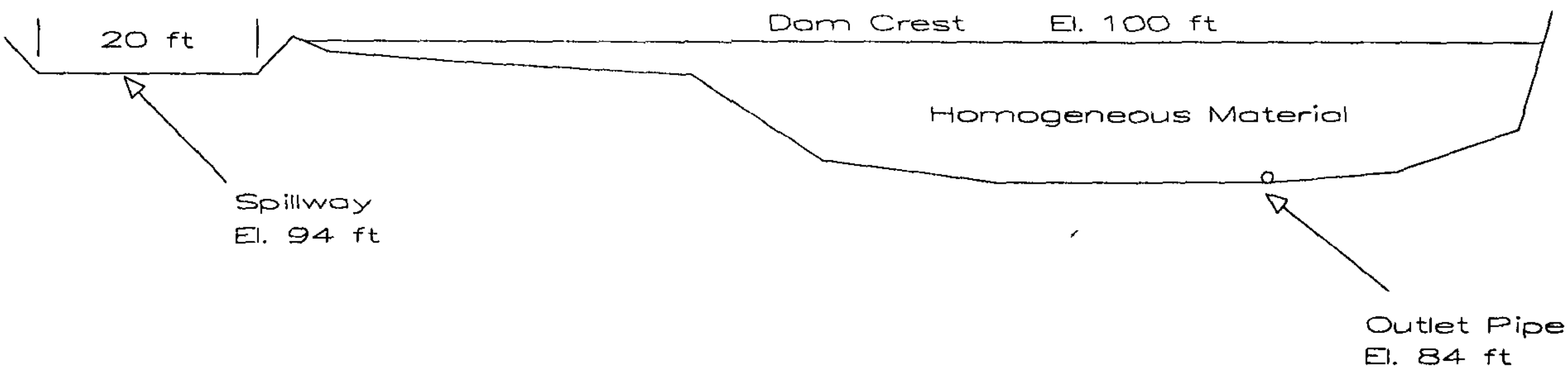


Figure 4
Mattie Dam and Reservoir
Embankment Looking Upstream



COST ESTIMATE

The estimated cost to raise the water level is shown in Table 2. The unit costs are rough estimates of costs found in non-urban areas of the state. The compacted fill cost of $5 per cubic yard includes 5 miles of hauling and placement with a sheepsfoot roller.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 10% which includes evaluation of options, surveying of the reservoir basin, and application for a 404 permit. There are many 404 permit exemptions which should be investigated.

The land is assumed to be owned by the Town so there is no land cost; however, there may be a question of whether the City owns all of the land necessary in which case an additional land cost may be necessary.

Table 3 is the cost estimate for an earth embankment. Table 4 is included to show the cost estimate for a concrete gravity dam.

TABLE 3
MATTIE DAM AND RESERVOIR
ESTIMATED EARTH DAM CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$1,000
Embankment				
Compacted Fill	cy	3800	$5.00	$19,000
Rip Rap	cy	0	$20.00	$0
Toe Drain	lf	0	$0.00	$0
	Embankment Subtotal			$19,000
Outlet Works				
18 Inch Outlet Pipe	lf	70	$60.00	$4,200
Gate	ls			$5,000
	Outlet Works Subtotal			$9,200
Spillway				
Excavation	cy	130	$3.00	$400
Concrete Control Section	cy	10	$300.00	$3,000
	Spillway Subtotal			$3,400
	Total of Above Items			$31,600
	Contingency (30%)			$9,500
	Land Cost			$0
	Field Cost Subtotal			$41,100
	Engineering & Admin (10%)			$4,100
TOTAL ESTIMATED CONSTRUCTION COST				$45,200

TABLE 4
MATTIE DAM AND RESERVOIR
ESTIMATED CONCRETE DAM CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$1,000
Concrete Dam				
Concrete	cy	290	$300.00	$87,000
	Embankment Subtotal			$87,000
Outlet Works				
18 Inch Outlet Pipe	lf	70	$60.00	$4,200
Gate	ls			$3,000
	Outlet Works Subtotal			$7,200
	Total of Above Items			$94,200
	Contingency (25%)			$23,600
	Land Cost			$0
	Field Cost Subtotal			$117,800
	Engineering & Admin (5%)			$5,900
TOTAL ESTIMATED CONSTRUCTION COST				$123,700

FINANCING

The cost for this work is not large and may not require financing, unless the City of Idaho Springs decides that a concrete dam would be the best option. The City may be able to fund the work from revenues; if not, a small loan from the CWCB may be appropriate for 10 years at 3.5%. There may be some difficulty with a CWCB loan for an earth dam which may be destroyed from large floods; additional flood analysis may be appropriate to determine the flood frequency the earth dam would pass.

RECOMMENDATIONS

The followings steps are recommended to evaluate and possibly construct the Mattie Dam and Reservoir:

1. Survey the reservoir basin and ownership boundaries to determine the capacity of the reservoir and if the dam and reservoir is on City land. Soonest is early spring 1994.

2. Based on the reservoir capacity determine if there is adequate detention time to reduce the sediment load. Concurrently, the City should ask for estimates from contractors for earth, concrete and roller compacted concrete dams. Based on the contractor estimates determine the best type of structure. Determine what, if any type of 404 permit is necessary and obtain permit. Soonest summer of 1994.

3. If necessary, apply to CWCB for construction funds. Apply summer of 1994; funds available summer of 1995.

4. Construct the modifications.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

ORLANDO DAM AND RESERVOIR
Sponsored By The Welton Ditch Company

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

ORLANDO DAM AND RESERVOIR

PLAN DESCRIPTION

The Orlando Dam and Reservoir is an off stream structure in the Huerfano River basin, located about 11 miles north of Walsenburg and 1.5 miles east of Interstate 25. The reservoir has about 2966 acre-feet of active capacity and is filled by a diversion ditch from Huerfano Creek. Figure 1 shows the general location in Colorado and Figure 2 shows location on the appropriate Quad map.

The dam and reservoir are presently owned by Preferred Equities an out of state company who has subdivided land around the reservoir and is selling acreages. The reservoir, inlet ditch and the corresponding water rights are presently operated in an inefficient manner because the present owners are not irrigators.

The Welton Ditch Company presently purchases water from Orlando Reservoir when available but would like to purchase the entire reservoir from Preferred Equities.

The contact for the Welton Ditch Company is:

John Singletary (719-542-5656)
201 W. 8th Street
Pueblo, Colorado 81003

Purchase of the reservoir offers two advantages. First the water continues to be used for agricultural production in the Arkansas River basin rather than nonuse. Secondly, the stable water supply will increase the crop production of irrigators under the Welton Ditch.

This reconnaissance report describes how the reservoir might be purchased.

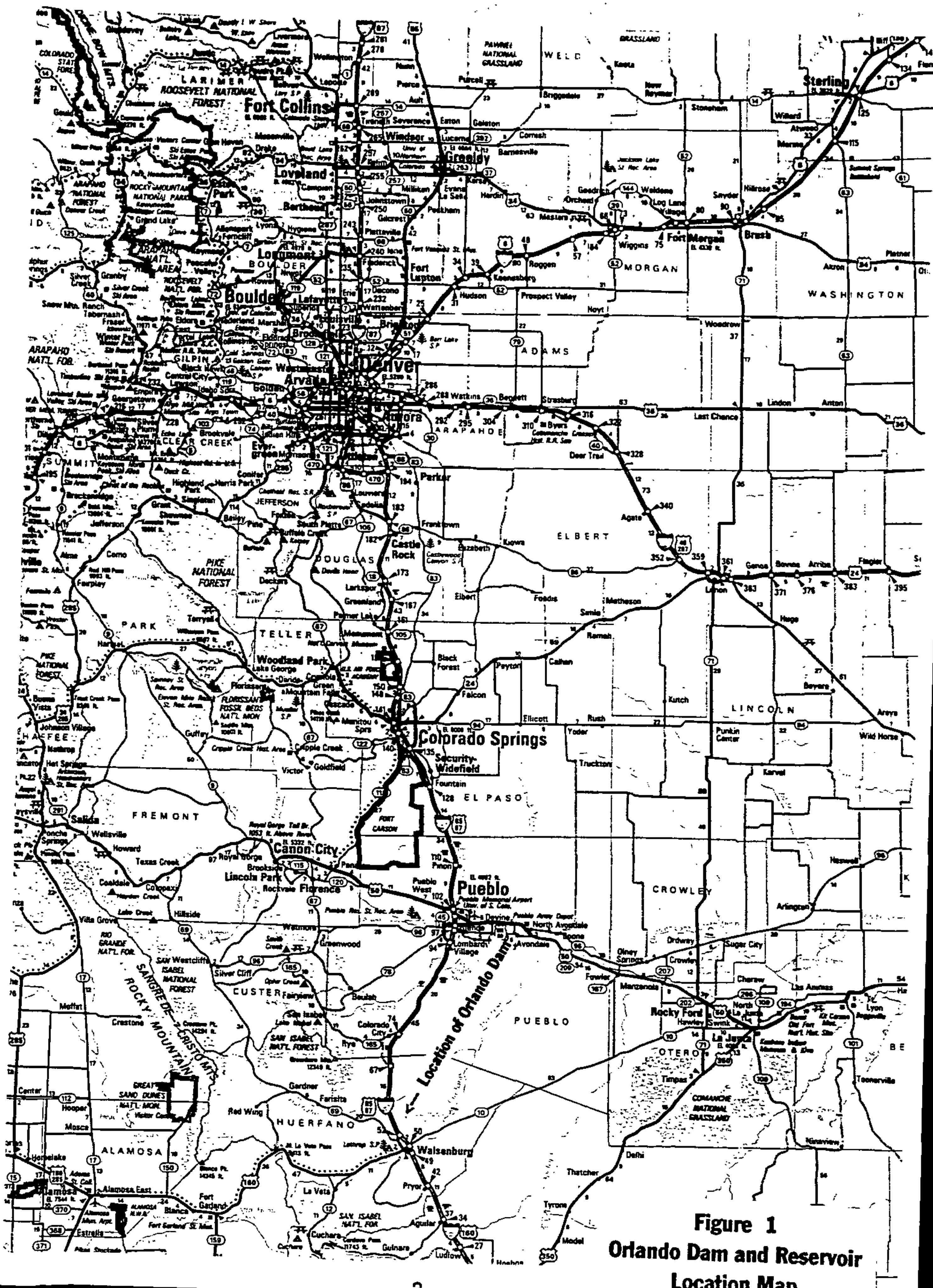


Figure 1
Orlando Dam and Reservoir
Location Map

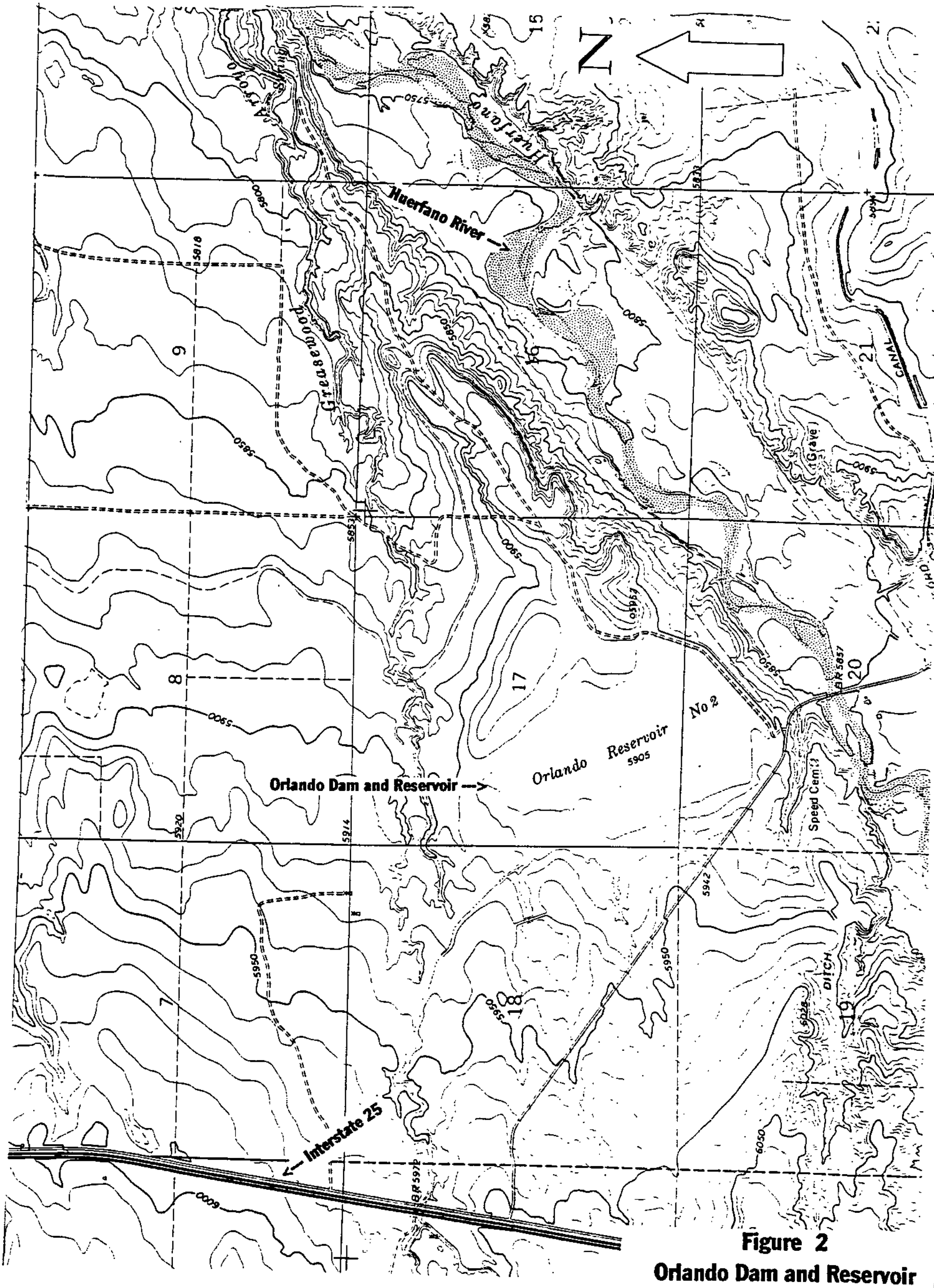


Figure 2

Orlando Dam and Reservoir

Dam and Reservoir Site Map

WATER SUPPLY

The Orlando Reservoir has about 2966 acre-feet of active capacity with about 3400 acre-feet of decreed storage, the reservoir has about 614 acre-feet of silt which decreases the storage. The reservoir is filled by the Orlando Ditch which diverts water from the Huerfano River and has a direct diversion decree of about 172 cfs.

The reservoir is normally in priority to store a substantial amount of water in the winter and early spring, which would fill the reservoir in most years. However, prior to purchase, an evaluation of the water yield should be performed to verify this rough analysis.

RESERVOIR

Table 1 shows the estimated capacity as given in the 1972 plans, the bottom 8 feet of the reservoir was determined to filled with silt in 1972. The reservoir has a capacity of about 3580 acre-feet, estimated from the 1905 original plans and a 1972 enlargement, but silt decreases the active capacity to about 2966 acre-feet.

The drainage area above the dam is 5350 acres of range and sagebrush. ,

TABLE 1
ORLANDO DAM & RESERVOIR
Elevation – Area – Capacity

Depth	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
30	719	6409.3	Top of Dam
29	666.3	5716.7	
28	613.6	5076.7	
27	560.9	4489.5	
26	508.2	3954.9	
25	240	3580.8	Spillway Crest
24	230.4	3345.6	
23	220.8	3120.0	
22	211.2	2904.0	
21	201.6	2697.6	
20	192	2500.8	
19	182.4	2313.6	
18	172.8	2136.0	
17	163.2	1968.0	
16	153.6	1809.6	
15	144	1660.8	
14	134.4	1521.6	
13	124.8	1392.0	
12	115.2	1272.0	
11	105.6	1161.6	
10	96	960.0	
9	86.4	777.6	
8	76.8	614.4	Silt Level
7	67.2	470.4	
6	57.6	345.6	
5	48	240.0	
4	38.4	153.6	
3	28.8	86.4	
2	19.2	38.4	
1	9.6	9.6	
0	0	0.0	

DAM EMBANKMENT

The dam is not, nor is it about to be, restricted.

The Orlando Dam, is an intermediate Class III structure. The dam meets the criteria in the "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources.

EMBANKMENT: The existing dam is an earth embankment with following the dimensions:

* 30 feet high,
* freeboard of 5 feet,
* crest length of about 3,285 feet,
* crest width of 12 feet,
* 2.5H:1.0V upstream and 2.5H:1.0V downstream slopes
* 36 inch diameter outlet pipe,
* spillway width of 400 feet.

The only problem with the dam is foundation seepage of about 3 to 4 cfs under the south half of the dam at a full reservoir; the seepage is considerably less at lower water levels. This is not a major problem because the dam is Class III and the seepage has not caused any structural problems. Presently the water is not collected and included as a release from the reservoir.

OUTLET PIPE: The outlet pipe is 120 long and is 36 inch diameter CMP. The inlet box to the pipe was repaired in 1993 due to damage from ice and silt.

SPILLWAY: The spillway is 400 feet long with a concrete cutoff wall to maintain the spillway crest and shape. There are no problems with the spillway. The 100 year flood is used for the spillway design which has a discharge of 5460 cfs; the spillway is adequate to pass the required flood.

COST ESTIMATE

The estimated cost to purchase the reservoir, a few hundred acres around the reservoir, and the water rights is $1,500,000. This is based upon experience by Mr. Singletary who is a real estate broker in addition to a past Board member of the Welton Ditch Company. Recently, the reservoir and adjacent land was almost sold for that amount. Mr. Singletary estimates that the land price has probably changed very little.

If the reservoir is purchased with a few hundred acres, the land could be resold and the funds used to reduce the cost. Discussions should also be held with the Colorado Division of Wildlife to determine if a minimum pool in the reservoir might be worth partial funding by that agency.

FINANCING

The cost to purchase the reservoir will require financing. The Ditch Company would need to finance nearly the entire cost of $1,500,000.

The financial analysis herein assumes that Orlando will be purchased with a 100% loan from the CWCB. The purchase would yield additional storage of about 2966 acre-feet to the Company, with the same average annual yield. Repayment options are shown in Table 2, assuming a 100% loan from the CWCB; if the District can include some cash the amounts would be reduced.

There are 4000 shares of stock in the Welton Ditch Company. The present assessment is $7.50 per share. Options 2, 3 or 4 are about the same and are recommended herein as financial plans that would be barely affordable to the Ditch Company. The assessment would be increased to about $27.50 plus a small amount for operation and maintenance. The highest amounts in the area are presently about $20. The Company can discuss the possibility of Options 5 or 6 with the CWCB.

The Company might investigate funding from DOW for a minimum pool or if possible, resell some land around the reservoir. There is dead storage in the reservoir that currently provides a minimum pool that does not normally evaporate.

TABLE 2
ORLANDO DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$1,500,000	4.0%	30	$86,745	$29
2	$1,500,000	4.0%	40	$75,785	$26
3	$1,500,000	3.5%	30	$81,557	$27
4	$1,500,000	3.0%	30	$76,529	$26
5	$1,500,000	2.0%	30	$66,975	$23
6	$1,500,000	1.0%	30	$58,122	$20

Volume of Reservoir Capacity/Annual Yield in Acre-Feet: 2966

RECOMMENDATIONS

The advantages to local irrigators of purchasing the reservoir could be substantial, so this report recommends that the purchase of Orlando Reservoir be pursued by the Welton Ditch Company, and others as may be appropriate. The steps are generally listed below but will change to meet the actual needs of the negotiation process.

1. The Welton Ditch Company, Board must officially begin the process to purchase the reservoir and assign a person (assumed to be Mr. Singletary) to coordinate the effort. The Company must also understand and generally agree that the annual assessment could nearly quadruple to repay the reservoir, but realizing that a firm financial commitment is not necessary at the present time. The Company may apply for a CWCB feasibility study loan to perform the work to purchase the reservoir.

2. The CWCB, in considering funds for the feasibility study activities, must consider whether to support the concept of purchasing Orlando Reservoir with Construction Fund monies, subject to agreement of the final terms, and provide a reduction in the standard financing terms. If the CWCB is not agreeable to either issue, then there is no reason to provide feasibility study funds.

3. The Company should contact the present owners to negotiate purchase of at least the reservoir and water rights. This assumes that the present owners are interested in selling the reservoir, if not the process ends. The Company should also use some of the feasibility study funds to have an engineer evaluate the water supply to verify that the reservoir will fill in most, if not all, years.

4. Negotiate with the Colorado Division of Wildlife and other entities who might be interested in using the reservoir and who may be able to provide funds to repay the costs.

5. Assuming that the previous steps have positive results, apply for funds from the CWCB Construction Fund to purchase the reservoir. The timing of the availability of funds may be important and should be considered in the negotiations. Applications for construction funds are processed in the fall of each year, funds are not available until after authorization by the legislature in July of the next year. For instance, the earliest that funds to purchase the reservoir could be available is July of 1995.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

PALISADE #1 DAM AND RESERVOIR
Owned By The Town of Palisade

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

PALISADE RESERVOIR #1

PLAN DESCRIPTION

Palisade Reservoir #1 is an existing reservoir located in the Colorado River drainage about 5 miles southeast of the Town of Palisade. Figure 1 shows the reservoir relative to the Town of Palisade and the Colorado River. Figure 2 is a copy of a USGS Quad map showing the reservoir site.

The dam and reservoir are owned by the Town of Palisade, which owns about 3,000 acres around the reservoir for a watershed. The persons to contact at the Town are:

Town of Palisade
Town Hall
175 East Third St.
Palisade, Colorado 81526

Larry Cleaver, Town Administrator 303-464-5602
Rick McKay, Public Works Foreman

The dam was reconstructed a few years ago to a height of 20 feet but the spillway was excavated 10 feet below the crest so the dam is nonjurisdictional (water depth is 10 feet or less). The reservoir capacity at 10 feet is about 11 acre-feet. Increasing the water depth to 15 feet would increase the storage capacity to about 23 acre-feet; which would require that the dam meet the requirements of a jurisdictional dam. This reconnaissance report describes the engineering issues, construction, and costs of changing the dam to a jurisdictional structure.

The drainage basin above the reservoir is 0.72 square miles in size. The basin is very steep with a vertical drop coming off the north face of Grand Mesa. The area has a good stand of trees, brush and grasses.

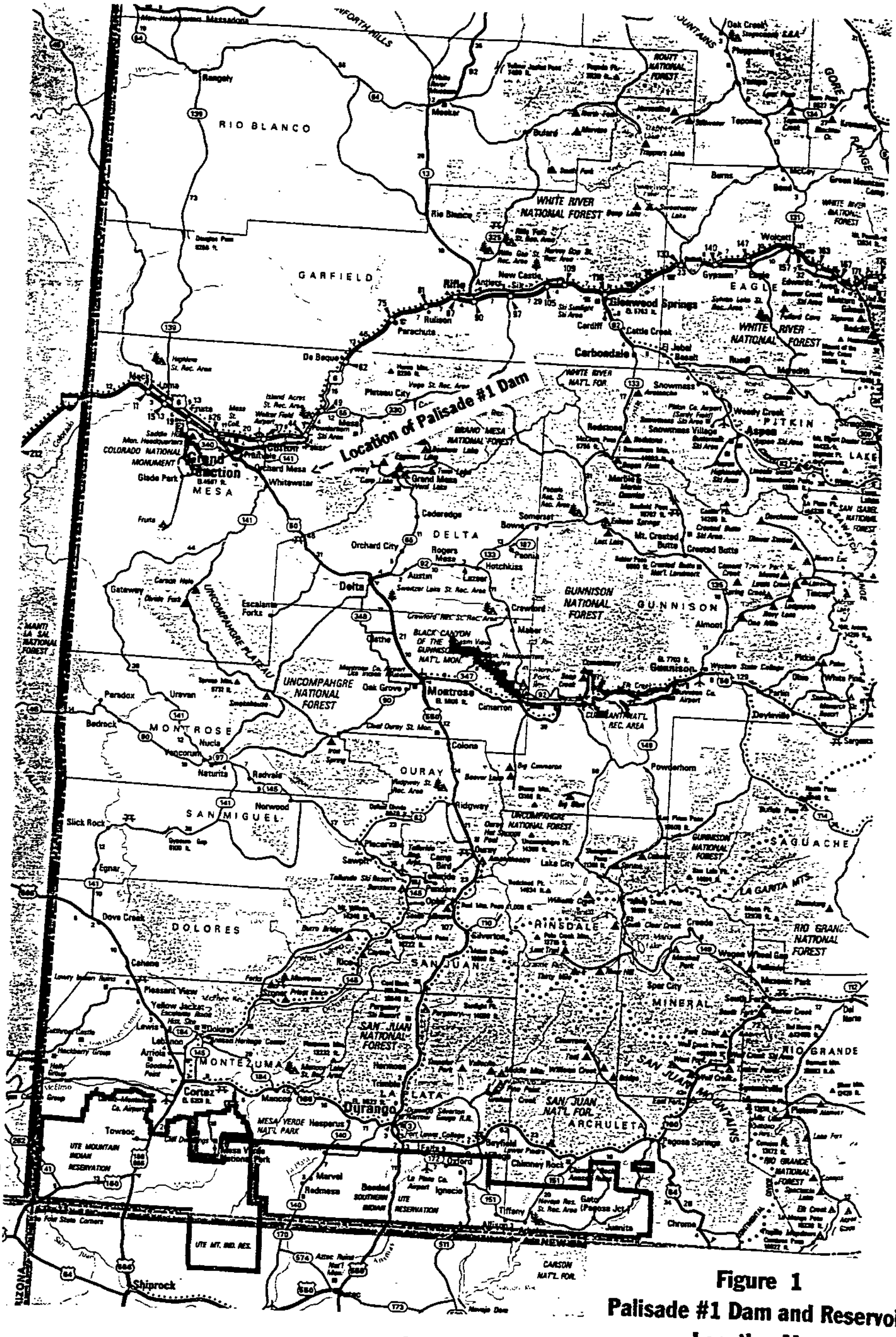


Figure 1
Palisade #1 Dam and Reservoir
Location Map

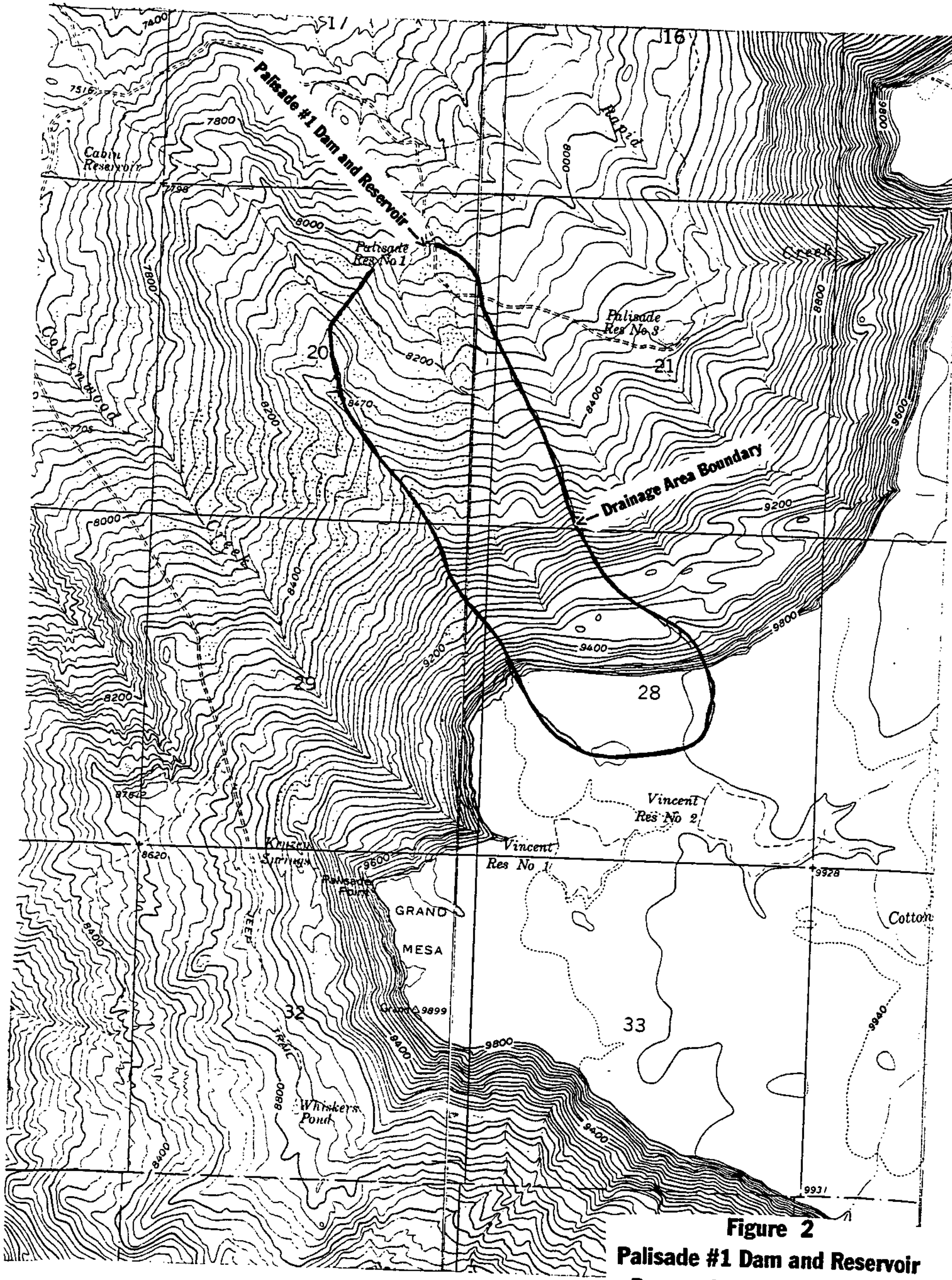


Figure 2
Palisade #1 Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The Town of Palisade owns a 3,000 acre watershed southeast of the Town from which the Town's water supply is obtained. The watershed is on the north side of the Grand Mesa.

A report prepared by Henningson, Durham, & Richardson (HDR) in 1979 entitled "Updated Engineering Report, Palisade Water System" included a water supply appendix (a copy of the report is included in the CWCB files). The appendix was prepared by Leonard Rice Engineers and evaluated the average and dry year runoff. The result was an estimated water supply of 1690 acre-feet in average years and 1150 acre-feet in dry years; including both surface runoff and springs.

The report recommended that Palisade enlarge Cabin Reservoir, which was accomplished a few years ago, and repair and enlarge the other reservoirs in the watershed, which has not been done. The report also stated that the Town has adequate water rights for its diversions and storage needs. As is typical in Colorado, the main water supply problem is storing the spring runoff for use in the late summer and fall.

Palisade Reservoir #1 dam was reconstructed a few years ago to a greater height but the reservoir capacity was not increased in order to maintain the dam as nonjurisdictional. As was mentioned above and will be described in detail in the following sections, by raising the spillway crest 5 feet an additional 12 acre-feet of storage can be accomplished. There is sufficient runoff and springs above the reservoir to provide the additional 12 acre-feet annually.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir. The present water level is about 7989 feet, 1.92 acres, 10.91 acre-feet. Raising the spillway crest to 9794 feet will result in a 2.85 acre surface area and 22.88 acre-feet of capacity. These values were determined from topographic maps of the reservoir prior to the reconstruction of the dam and may be slightly low. The material for the embankment was excavated from the basin which may have made the storage volume larger.

There is no opportunity to enlarge the embankment other than the proposed 5 foot increase in the spillway elevation.

TABLE 1
PALISADE #1 DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
7999	3.92	39.69	Top of Dam
7998	3.69	35.88	
7997	3.46	32.3	
7996	3.23	28.95	
7995	3.03	25.82	
7994	2.85	22.88	Raised Spillway Crest
7993	2.67	20.12	
7992	2.49	17.54	
7991	2.31	15.14	
7990	2.11	12.93	
7989	1.92	10.91	Existing Spillway Crest
7988	1.73	9.08	
7987	1.54	7.44	
7986	1.35	5.99	
7985	1.18	4.72	
7984	1.05	3.6	
7983	0.92	2.61	
7982	0.79	1.75	
7981	0.66	1.02	Intake to Outlet Pipe
7980	0.51	0.43	
7979	0.34	0	

DAM EMBANKMENT

EMBANKMENT: The dam is an earth embankment with following the dimensions:

* 20 feet high,
* crest length of about 400 feet,
* crest width of 13 feet,
* 3.0H:1.0V upstream and 2.5H:1.0V downstream slopes
* 6 inch diameter outlet pipe,
* 10 foot wide spillway.

Figure 4 shows the cross section of the dam at the outlet pipe. Figure 5 shows the front elevation view of the embankment looking upstream from below the dam.

The plan to increase the reservoir storage involves increasing the reservoir water level from 10 feet to 15 feet; this will allow about 12 acre-feet additional storage capacity. Raising the spillway crest 5 feet would allow the additional storage. The dam must be changed from a non-jurisdictional to a jurisdictional classification.

The dam, if jurisdictional would be minor Class III. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days, though not required it is recommended,
* a crest width equal to the vertical height divided by 5 plus 10 feet,
* a spillway capable of passing a 50 year flood,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

The crest width is 13 feet, the criteria suggest 14 feet (20 feet divided by 5 plus 10). A waiver of the 14 foot crest width to 13 feet would be requested, subject to appropriate evaluations.

The rip rap on the upstream face presently is 10 feet below the crest. Additional rip must be placed, near the dam crest elevation. There is a significant amount of rock near the reservoir which can be used for rip rap.

The most difficult issue is the possible need for soils investigations and possibly a toe drain to control seepage. Preliminary discussions with the dam safety engineer for Water Division 5, indicate that the best course of action would be to fill the reservoir to the current 10 foot level and have the dam safety engineer look at the dam.

If the embankment appears to be in good condition then no additional work may be required; if not, either soils tests, a toe drain, or some other activity may be necessary. Assuming that the dam appears to be safe at the current storage level, without soils tests or a toe drain, the spillway crest would be raised 5 feet. With the reservoir filled to the enlarged level, the dam would again be inspected and if necessary repair work would be implemented.

The installation of a toe drain is assumed for purposes of the cost estimate. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and 200 feet long.

The plan to increase the reservoir storage would increase the water level 5 feet, which would still allow 5 feet of freeboard.

OUTLET PIPE: The outlet pipe is 6 inch diameter which is capable of releasing 1.6 cfs at 10 feet of head and 2.0 cfs at 15 feet of head, see Table 2. Assuming an average release of 1.8 cfs for the top 5 feet of storage, the outlet pipe would drain the top 12 acre-feet in 3.5 days, well within the criteria of 5 days. A trash rack will be necessary over the gate mechanism to screen out large objects from entering and possibly plugging the pipe.

SPILLWAY: The spillway in combination with 15 acre-feet of storage above the spillway crest is adequate to pass the 100 year flood. A HEC1 analysis was performed (call Harris Water Engineering for a copy) which showed that the spillway could pass one half the PMP which is greater than the required 50 year PMP.

A concrete cutoff wall perpendicular to the flow of water is included to stabilize the spillway section. The wall would be about 2 feet thick, at least 2 feet below the existing ground surface at any point along the wall, and be the desired shape of the spillway cross section (roughly 10 wide at the base and sloping up a 1:1 on either side). The concrete wall may require wing walls for support depending upon the channel and wall design.

TABLE 2
PALISADE #1 DAM
OUTLET PIPE DISCHARGE

Reservoir Water Level (feet)	Depth Above Outlet Pipe Entrance (feet)	Outlet Pipe Discharge (cfs)	Notes
7980	0	0	Elevation of Pipe Entrance
7981	1	0.5	
7982	2	0.7	
7983	3	0.9	
7984	4	1	
7985	5	1.2	
7986	6	1.3	
7987	7	1.4	
7988	8	1.5	
7989	9	1.6	
7990	10	1.7	
7991	11	1.7	
7992	12	1.8	
7993	13	1.9	
7994	14	2	Crest of Spillway
7995	15	2	
7996	16	2.1	
7997	17	2.2	
7998	18	2.2	
7999	19	2.3	Crest of Dam

Outlet Discharge Equation: Q=A*(2G*H/sum of losses) ^.5

Outlet Pipe Diameter:	0.5 feet
Outlet Pipe Area (A):	0.196 square feet
2G is:	64.4
H is:	depth of water above outlet pipe entrance
Sum of losses is:	9 Empirically Derived

Figure 3
Palisade #1 Dam and Reservoir
Cross Section at Outlet Pipe

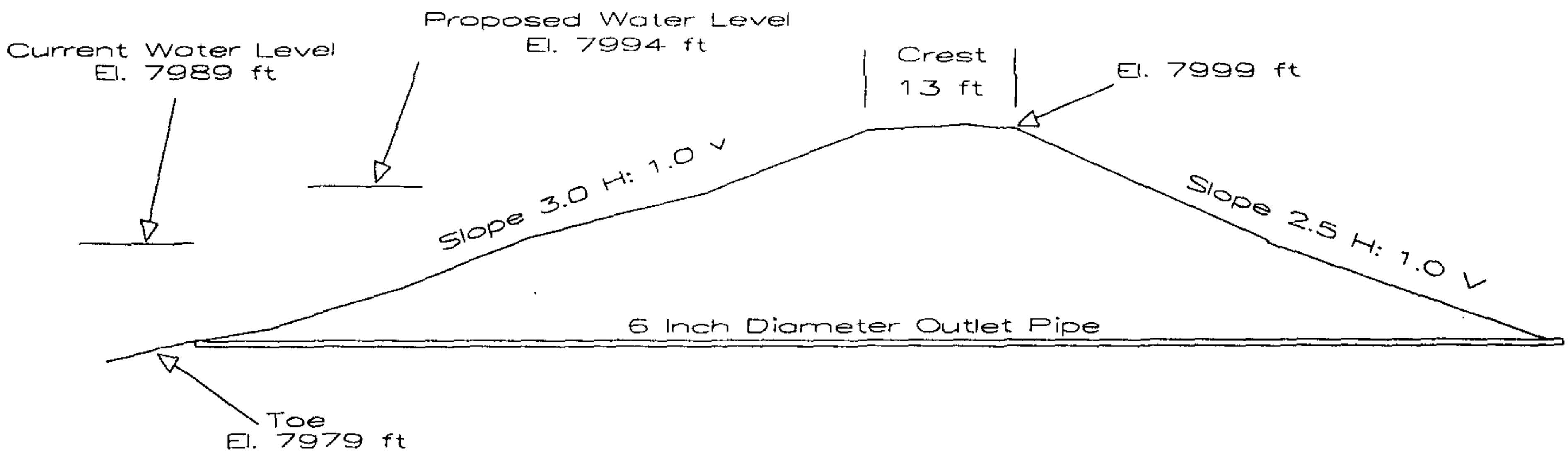
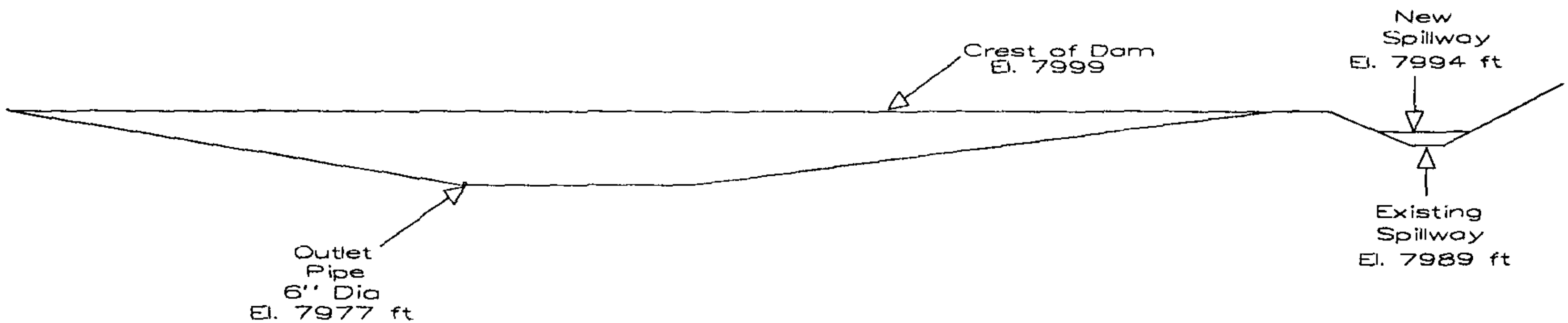


Figure 4
Palisade #1 Dam and Reservoir
Cross Section at Dam Center Lin



COST ESTIMATE

The estimated cost to raise the water level is shown in Table 2. The unit costs are rough estimates of costs found in non-urban areas of the state. Costs for earthwork vary by area and by contractor.

The total cost assumes the worst case where a toe drain will be needed to control seepage and soils tests will be needed to provide stability. If this work is not required the construction cost would be reduced considerably.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

The land is owned by the Town so there is no land cost.

Since the dam is constructed, there would not be any permits required, other than the State Engineer. In short there are no environmental compliance requirements.

TABLE 3
PALISADE #1 DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$2,000
Embankment				
Test Drill Holes	each	3	$1,500	$4,500
Compacted Fill	cy	0	$0.00	$0
Rip Rap	cy	220	$20.00	$4,400
Toe Drain	lf	200	$20.00	$4,000
	Embankment Subtotal			$12,900
Outlet Works				
Trashrack	ls			$500
	Outlet Works Subtotal			$500
Spillway				
Rip Rap	cy	90	$20.00	$1,800
Concrete Cutoff Wall	cy	10	$300.00	$3,000
	Spillway Subtotal			$4,800
	Total of Above Items			$18,200
	Contingency (30%)			$5,500
	Land Cost			$0
	Field Cost Subtotal			$23,700
	Engineering & Admin (15%)			$3,600
TOTAL ESTIMATED CONSTRUCTION COST				$27,300
Construction Cost per Acre-Foot of Yield				$2,482
Estimated Additional Annual Reservoir Yield in Acre-Feet				11

FINANCING

The cost for this work is not large and should not require financing. The Town of Palisade is assumed to be able to fund the work from revenues; if not, a small loan from the CWCB may be appropriate.

RECOMMENDATIONS

The followings steps are recommended to increase the water storage of Palisade Reservoir #1:

1. Fill the reservoir next spring and before it is drawn down, arrange for the State Dam Safety Engineer to inspect the embankment. Soonest spring of 1994.

2. Based on the condition of the dam when full, determine between the Town and the Dam Safety Engineer what modifications are needed to increase the storage capacity. As a minimum, raising the spillway, installation of a trashrack, and placing additional rip rap will be required; if there are seepage problems, soils testing and/or a toe drain may be required. If designs are needed, retain an engineer to prepare the designs. Soonest summer of 1994.

3. Construct the modifications determined in step 2. Soonest late summer of 1994. Assumes that CWCB financing is not needed.

4. Fill the enlarged reservoir and determine if additional modifications are needed for safety reasons. Soonest summer of 1995.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

PALISADE #3 DAM AND RESERVOIR
Owned By The Town of Palisade

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

PALISADE RESERVOIR #3

PLAN DESCRIPTION

Palisade Reservoir #3 is an existing reservoir located in the Colorado River drainage about 5 miles southeast of the Town of Palisade. Figure 1 shows the general location of the reservoir; Figure 2 is a copy of a USGS Quad map showing the reservoir site and drainage basin.

The dam and reservoir are owned by the Town of Palisade, which owns about 3,000 acres around the reservoir for a watershed. The persons to contact at the Town are:

Town of Palisade
Town Hall
175 East Third St.
Palisade, Colorado 81526

Larry Cleaver, Town Administrator 303-464-5602
Rick McKay, Public Works Foreman

The dam has been under restriction by the Colorado State Engineer for many years because of safety problems associated with seepage through the embankment. Due to those problems which are primarily caused by steep slopes and a very narrow crest width, reconstruction of the embankment is believed to be the best method to secure storage in the reservoir for future water use.

The drainage basin above the reservoir is 1.62 square miles in size. The basin is very steep with a vertical drop coming off the north face of Grand Mesa. About half of the basin is on the Grand Mesa and the half nearest the dam is below the vertical drop from the mesa. The area has a good stand of trees, brush and grasses.

Reconstruction of the dam would provide about 42 acre-feet of storage.

This reconnaissance report describes the engineering issues, construction, and costs of reconstruction of the dam to its historical water level.

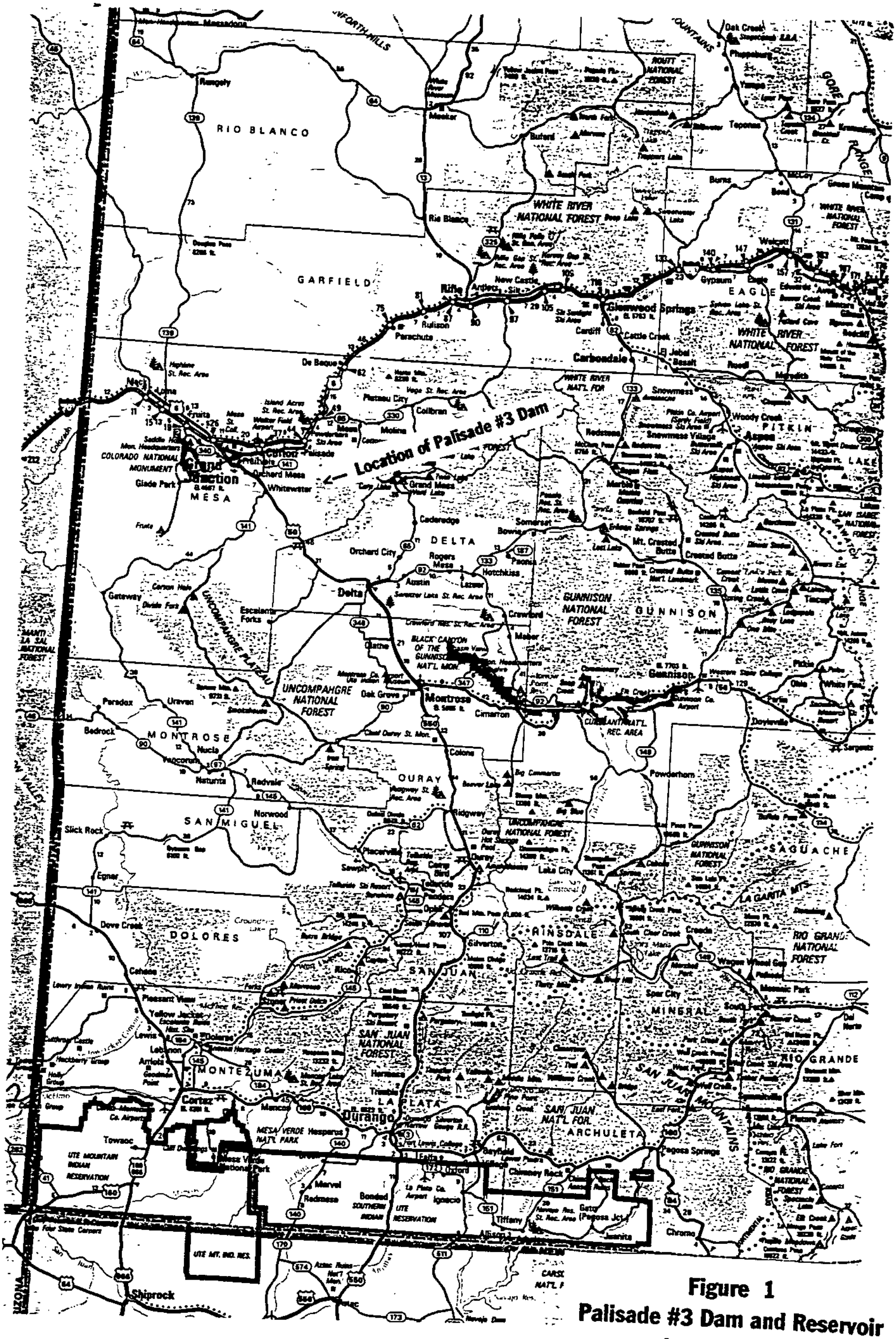


Figure 1
Palisade #3 Dam and Reservoir
Location Map

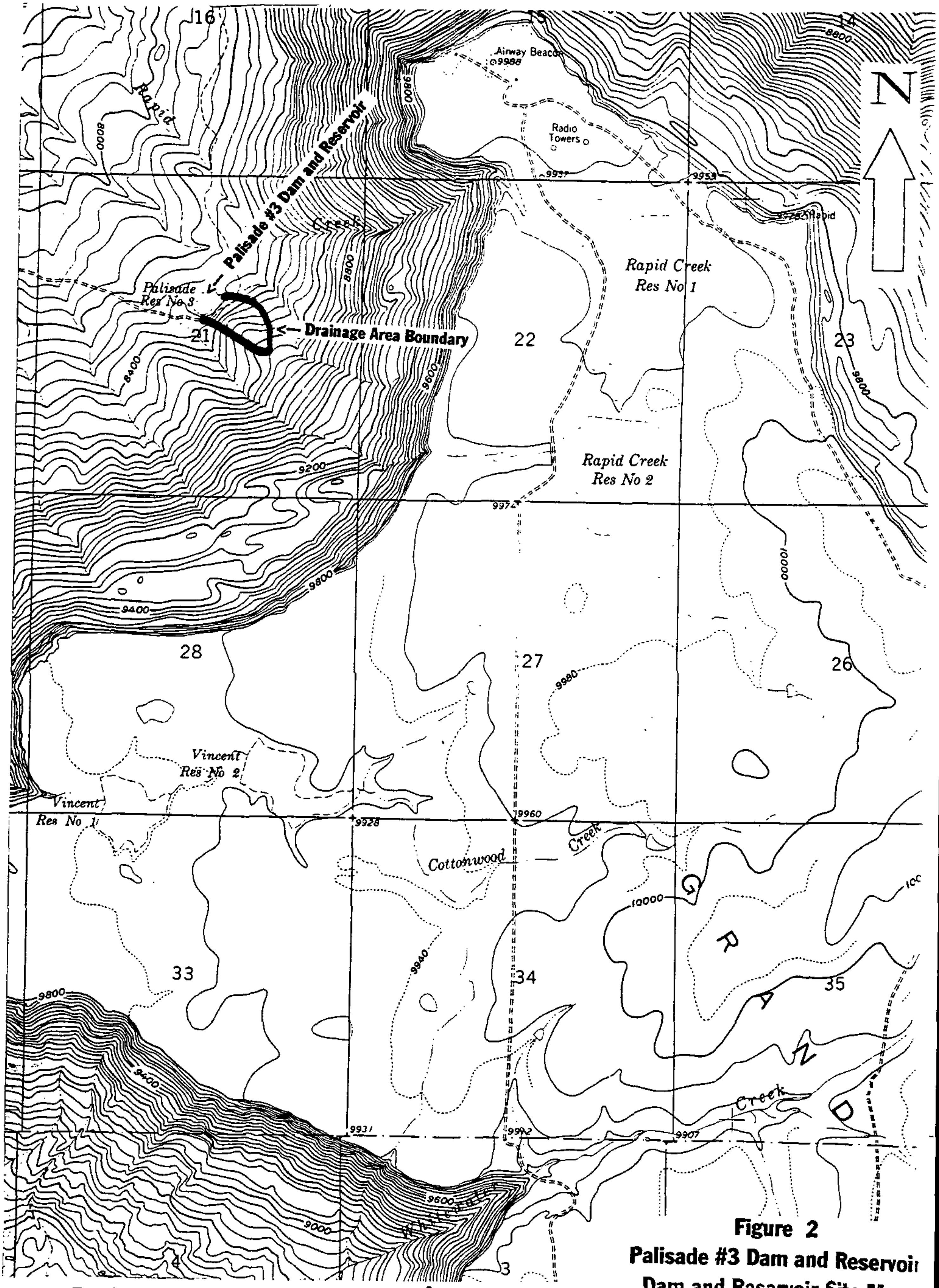


Figure 2
Palisade #3 Dam and Reservoi
Dam and Reservoir Site Map

WATER SUPPLY

The Town of Palisade owns a 3,000 acre watershed southeast of the Town from which the water supply is derived. The watershed is on the north side of the Grand Mesa.

A report prepared by Henningson, Durham, & Richardson (HDR) in 1979 entitled "Updated Engineering Report, Palisade Water System" included a water supply appendix (a copy of the report is included in the CWCB files). The appendix was prepared by Leonard Rice Engineers and evaluated the average and dry year runoff. The result was an estimated water supply of 1690 acre-feet in average years and 1150 acre-feet in dry years; including both surface runoff and springs.

The report recommended that Palisade enlarge Cabin Reservoir, which was accomplished a few years ago, and repair and enlarge the other reservoirs in the watershed, which has not been done. As is typical in Colorado, the main water supply problem is storing the spring runoff for use in the late summer and fall.

Reservoir #3 was an assumed to provide storage in the HDR report. The Town would like to have this reservoir available in the next few years. Historical operation of the reservoir showed that there is sufficient runoff and springs above the reservoir to fill the reservoir each year.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir. The present water level is restricted to about 7989 feet, which is below the outlet pipe; though there is about 17.75 acre-feet in the reservoir it is not accessible because the water level is below the outlet pipe. Of the about 42 acre-feet of capacity only about 24 acre-feet (42 - 17.75) is available for use.

The dam would be reconstructed in the same location as the present dam but the outlet pipe would be lowered so that the inlet is at elevation 8300 feet which would increase the useable storage by about 16 acre-feet. The total storage would be about 42 acre-feet, of which 1.7 acre-feet is below the outlet pipe, resulting in about 40 acre-feet of useable storage.

TABLE 1
PALISADE #3 DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8322	5.11	65.45	Top of Dam
8321	4.97	60.41	
8320	4.82	55.51	
8319	4.61	50.79	
8318	4.4	46.28	
8317	4.19	41.98	Spillway Crest
8316	3.98	37.89	
8315	3.77	34.01	
8314	3.56	30.34	
8313	3.35	26.88	
8312	3.14	23.63	
8311	2.93	20.59	
8310	2.75	17.75	
8309	2.52	15.11	
8308	2.29	12.7	
8307	2.06	10.52	
8306	1.83	8.57	
8305	1.6	6.85	
8304	1.37	5.36	
8303	1.14	4.1	
8302	0.91	3.07	
8301	0.68	2.27	
8300	0.45	1.7	Intake to Outlet Pipe
8299	0.39	1.28	
8298	0.33	0.92	
8297	0.27	0.62	
8296	0.21	0.38	
8295	0.15	0.2	
8294	0.09	0.08	
8293	0.03	0.02	
8292	0		

DAM EMBANKMENT

The dam, is jurisdictional and would be minor, Class III. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days, recommended but not required,
* a crest width equal to the vertical height divided by 5 plus 10 feet,
* a spillway capable of passing a 100 year flood,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications. The reconnaissance designs described herein are based upon a site inspection and review of available data; more detailed engineering work may result in a different design.

EMBANKMENT: The existing Palisade Reservoir #3 dam is 30 feet high with steep slopes (2.2:1 upstream and 1.6:1 downstream), a 4 foot crest width, and an outlet pipe that is in poor condition. The dam is restricted because of excessive seepage through the embankment. Major modifications would be necessary to correct the problems so reconstruction appears to be the best long term solution.

The existing embankment material would be removed and stockpiled for use in the new embankment, Table 2 shows the estimated volume of existing material to be excavated.

The reconstructed dam is expected to be an earth embankment with following the dimensions:

* 30 feet high,
* crest length of about 520 feet,
* crest width of 16 feet,
* 3.25H:1.0V upstream and 2.5H:1.0V downstream slopes
* 18 inch diameter outlet pipe,
* minimum 15 foot wide spillway (easily widened).

Figure 4 shows the cross section of the dam at the outlet pipe. Figure 5 shows the front view of the embankment looking upstream from below the dam.

A homogenous embankment is assumed subject to material tests for adequate pervious and impervious material for a zoned structure.

An estimated 15 foot deep, 20 foot wide core trench would be excavated most of the length of the embankment and upstream of the centerline of the embankment. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir.

Embankment material would be obtained from the stockpiled existing material and from a borrow area just south of the dam. The material would be placed in lifts and compacted to 95% Standard Proctor. Adequate testing will be required to monitor the compaction. Table 3 shows the estimated volume of material to be placed and compacted; 30% additional material is included for compaction.

There is volcanic rock in and around the reservoir basin which is expected to usable for rip rap. The rock is very hard but will not be the best sizes for rip rap which may require a thicker layer than the estimated 2 feet.

A toe drain is included to control seepage through the embankment. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 300 feet long.

OUTLET PIPE: The outlet pipe size is suggested to be 18 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance. Also, if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be reinforced concrete pipe or another material which will not deteriorate easily; CMP is not recommended.

SPILLWAY: The spillway will be sized to pass the 100 year flood from the approximate 40 acre drainage area. The flood from the small drainage area is expected to be passed by the 15 foot wide existing spillway. The spillway can be easily widened if the assumption is not correct. A concrete cutoff wall perpendicular to the flow of water is included to stabilize the spillway section. The wall would be about 2 feet thick, at least 2 feet below the ground surface at any point along the wall, and be the desired shape of the spillway cross section (roughly 15 wide at the base and sloping up a 1:1 on either side).

TABLE 2
PALISADE #3 DAM AND RESERVOIR
(Excavation of the Existing Embankment)

0 feet Stripping Depth
2.2 :1 Upstream
1.6 :1 Downstream
4 foot Crest Width
8322 foot Crest Elevation

20 foot Key Trench Width
15 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
100	8322	0	0				
				23	43	0	43
150	8318	4	46				
				100	185	0	185
200	8314	8	154				
				264	489	556	1045
250	8309	13	373				
				401	743	556	1299
300	8308	14	428				
				634	1174	556	1730
350	8302	20	840				
				969	1794	556	2350
400	8299	23	1097				
				1295	2398	556	2954
450	8295	27	1493				
				1493	2765	556	3321
500	8295	27	1493				
				1055	1641	467	2108
542	8305	17	617				
				309	664	0	664
600	8322	0	0				

Total Excavation Volume (cubic yards) 15700

TABLE 3
PALISADE #3 DAM AND RESERVOIR
(Placement of New Embankment)

0 feet Stripping Depth
3.25 :1 Upstream
2.5 :1 Downstream
16 foot Crest Width
8322 foot Crest Elevation

20 foot Key Trench Width
15 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Embankment (cy)
=====	=====	======	====	=====	======	======	=======
100	8322	0	0				
				55	102	22	124
150	8318	4	110				
				211	391	556	947
200	8314	8	312				
				503	931	556	1487
250	8309	13	694				
				741	1372	556	1928
300	8308	14	788				
				1129	2091	556	2647
350	8302	20	1470				
				1680	3111	556	3667
400	8299	23	1889				
				2209	4091	556	4647
450	8295	27	2528				
				2528	4681	556	5237
500	8295	27	2528				
				1816	2825	467	3292
542	8305	17	1103				
				765	227	89	316
550	8310	12	426				
				235	435	278	713
600	8320	2	44				
				44	33	56	89
620	8320	2	44				
625	8317	Edge of Spillway					
650	8317	Edge of Spillway					
670	8320	2	44				
				22	65	22	87
750	8322	0	0				
				Total Embankment Volume (cubic yards)			25200

Figure 3

Palisade #3 Dam and Reservoi

Cross Section at Outlet Pipe

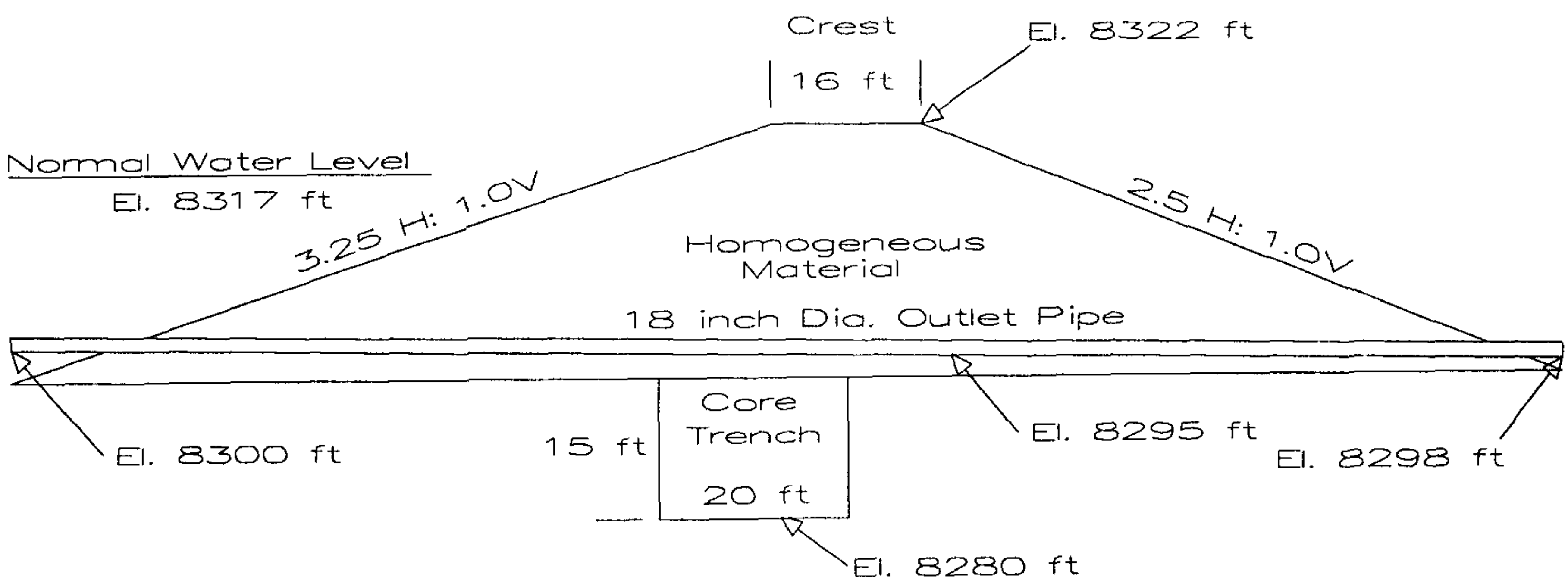
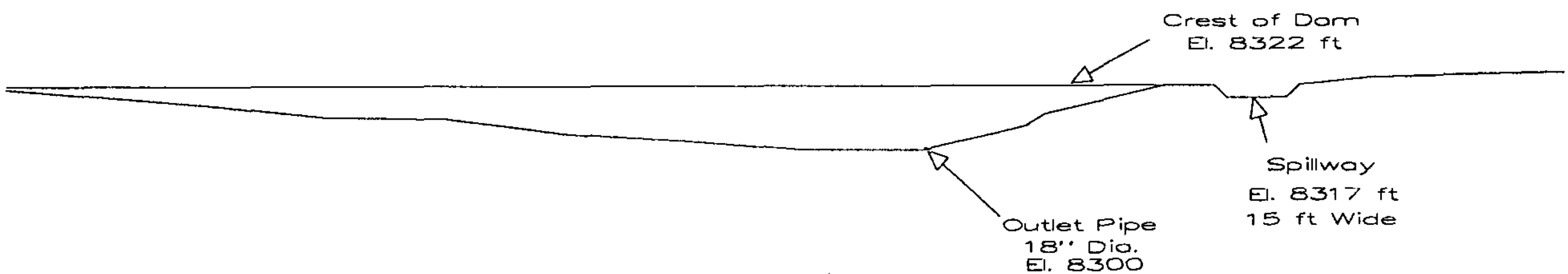


Figure 4
Palisade #3 Dam and Reservoir
Cross Section at Dam Center Line



COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 4. The unit costs are rough estimates of costs found in non-urban areas of the state.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

FINANCING

The cost for this work will require financing. It is suggested that the Town of Palisade fund the plans and specifications (about $25,000) and obtain a CWCB loan for the construction costs. Table 5 shows three financing options, Options 1 and 2 are standard CWCB financing terms as of December, 1993. Option 3 is a small change in the financing terms to decrease the annual payment.

Option 1 is recommended because the dam is fully repaid in 20 years rather than 30 years and the increased annual cost is only a few thousand dollars. The Town would save $60,000 or more by repaying the costs in 20 years.

TABLE 4
PALISADE #3 DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$5,000
Embankment				
Remove Embankment	cy	15700	$1.00	$15,700
Compacted Fill	cy	32800	$4.00	$131,200
Rip Rap	cy	1160	$20.00	$23,200
Toe Drain	lf	300	$20.00	$6,000
	Embankment Subtotal			$176,100
Outlet Works				
Pipe, 18" Diameter	lf	155	$50.00	$7,750
Gate	ls			$5,000
	Outlet Works Subtotal			$12,750
Spillway				
Excavation	cy	100	$2.00	$200
Concrete Cutoff Wall	cy	15	$300.00	$4,500
	Spillway Subtotal			$4,700
	Total of Above Items			$193,550
	Contingency (30%)			$58,100
	Land Cost			$0
	Field Cost Subtotal			$251,650
	Engineering & Admin (15%)			$37,700
TOTAL ESTIMATED CONSTRUCTION COST				$289,000
Construction Cost per Acre–Foot of Yield				$7,225
Estimated Annual Reservoir Yield in Acre–Feet				40

TABLE 5
PALISADE #3 DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$289,000	3.0%	20	$19,425	$486
2	$289,000	4.0%	30	$16,713	$418
3	$289,000	3.0%	30	$14,745	$369

Estimated Annual Reservoir Yield in Acre-Feet 40

RECOMMENDATIONS

The followings steps are recommended to increase the water storage of Palisade Reservoir #3:

1. Pursue modifications to Reservoir #1 until completed or an insurmountable problem arises, because the #1 storage is less costly per acre-foot. Once that is completed begin the process to reconstruct Reservoir #3. Soonest fall of 1995.

2. Retain an engineer to prepare plans and specifications for submission to State Engineer and prepare the loan application to the CWCB. If the Town cannot afford the cost of this engineering work, request a feasibility study loan from the CWCB when needed. Soonest submission is summer of 1996.

3. Obtain design approval from the State Engineer and funding from the CWCB. Soonest early summer of 1997.

4. Construct the modifications. Soonest summer of 1997.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

PROSPECT DAM AND RESERVOIR
Owned By The Henrylyn Irrigation District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

PROSPECT DAM AND RESERVOIR

PLAN DESCRIPTION

Prospect Dam and Reservoir is an existing structure located on a small creek in the South Platte River drainage about 6 miles southeast of the Town of Hudson. Figure 1 shows the reservoir relative to Denver and the Town of Hudson. Figure 2 is a copy of a USGS Quad map showing the reservoir site.

The Dam owner and contact is:

Henrylyn Irrigation District
Lawrence (Butch) Gerkin, Manager 536-4702
P.O. Box 85
Hudson, Colorado 80642

The dam was constructed in the early part of the century and is currently under a small restriction (1.5 feet) by the Colorado State Engineer.

The plan is to enlarge the dam from a present capacity of about 6,000 acre-feet to about 9,700 acre-feet. The Henrylyn Ditch which fills the reservoir has a drop into the reservoir of about 8 feet, the enlargement would make use of the reservoir capacity presently unused by that 8 feet of drop.

This reconnaissance report describes the engineering issues, construction, and costs of enlargement of the dam. The designs described herein are preliminary based upon available information and will likely change as detailed data and analysis are developed.

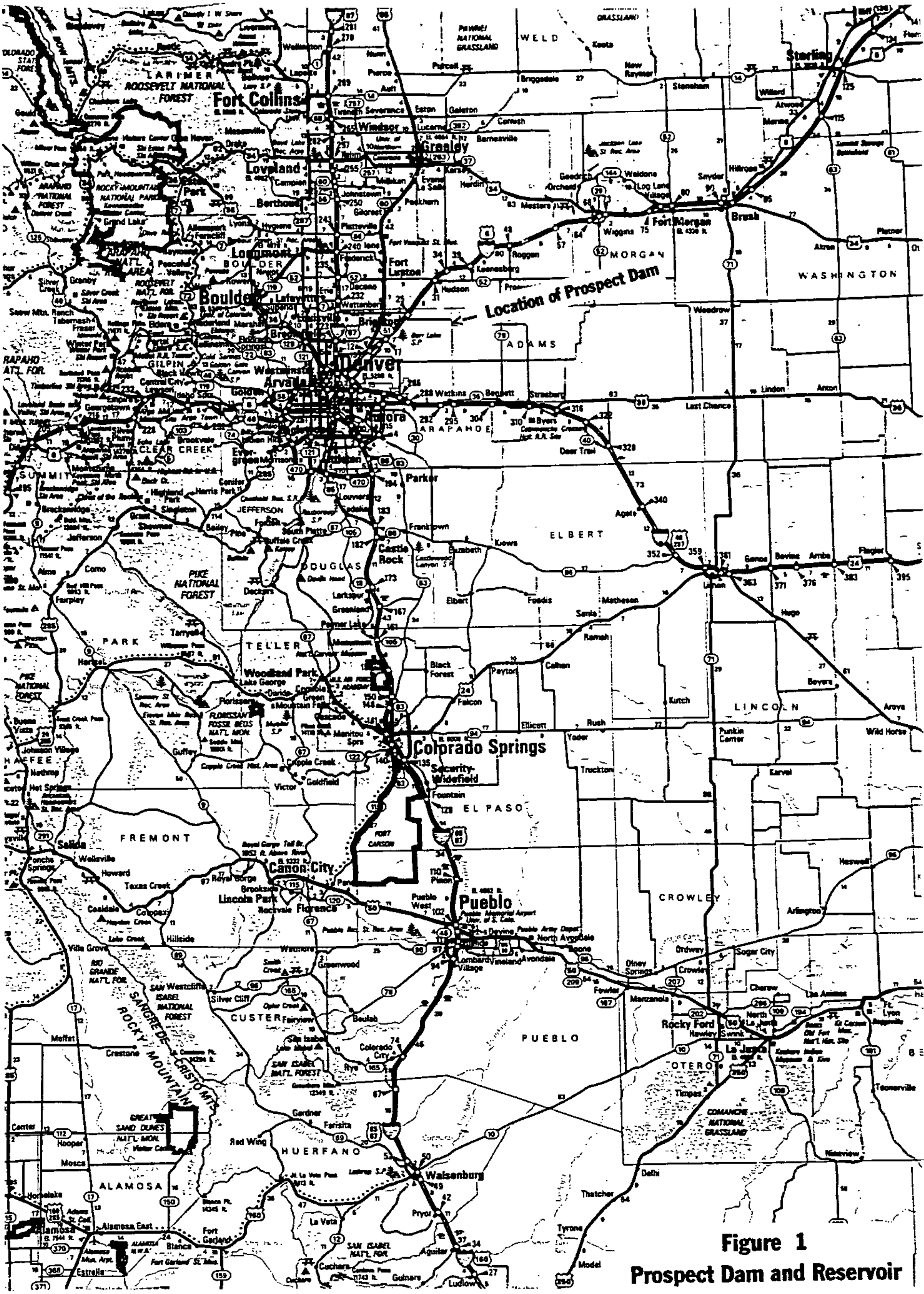


Figure 1
Prospect Dam and Reservoir
Location Map

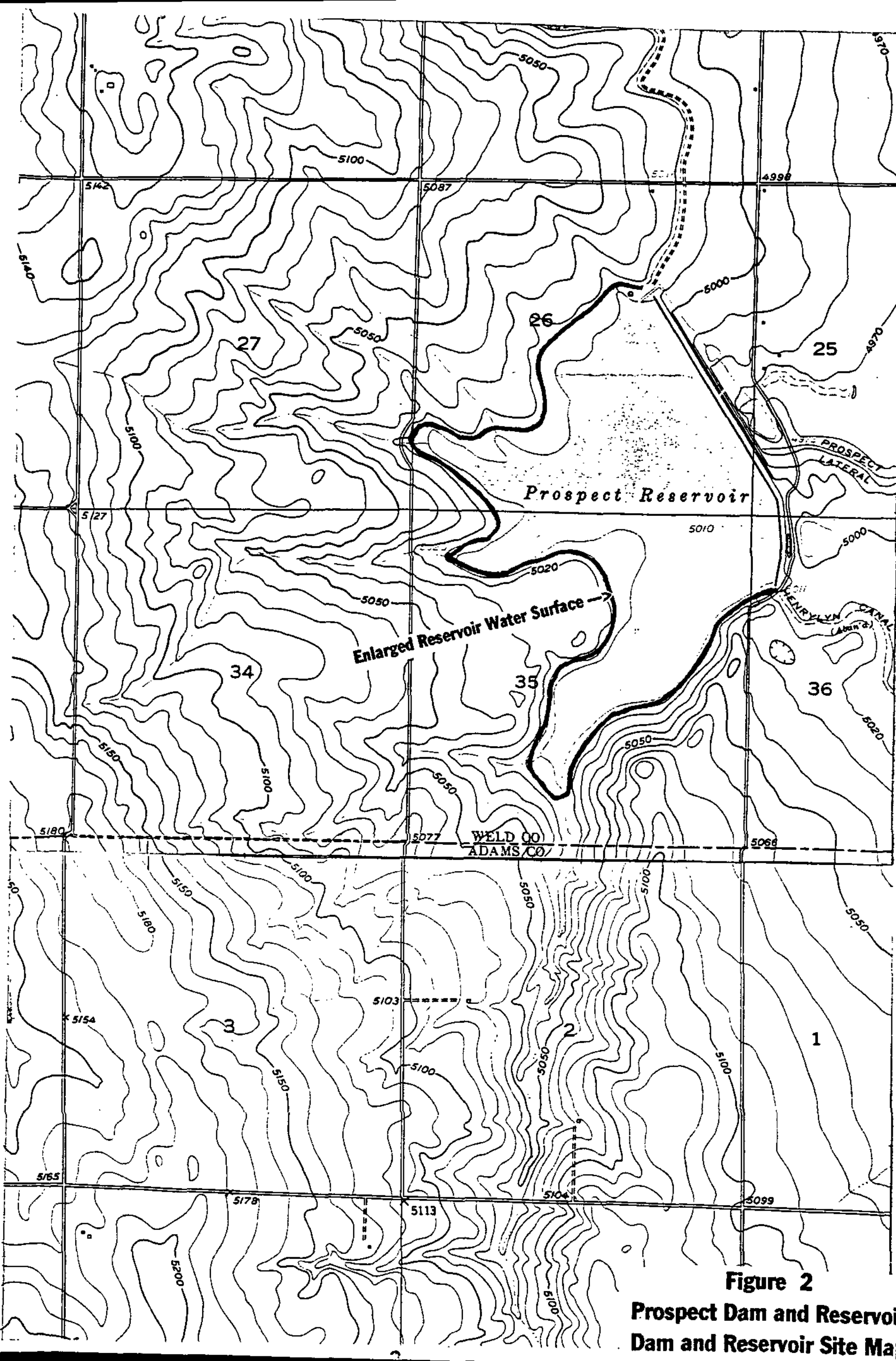


Figure 2
Prospect Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The District has direct flow and storage water rights from the South Platte River. The water is diverted during high spring flows to fill the three reservoirs owned by the District and to irrigate. When the water rights are out of priority and no further water can be diverted from the South Platte River, the District then uses water from the reservoirs. Prospect Reservoir is the lowest elevation reservoir in the system which has the least flexibility for providing water to all of the water users but the enlarged volume would be beneficial. In an average year the District provides about 30,000 acre-feet of storage water to 32,800 acres, this is in addition to the direct flow water when available.

The reservoir would be filled with irrigation water from the Hudson Canal followed by the Henrylyn Canal which diverts water from the South Platte River. There is essentially no flow in the small tributary in which the reservoir is located.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir based upon the Division Engineers records for the existing reservoir and Quad map areas for the enlargement. The elevations and corresponding gage heights are shown on Table 1. The enlargement would involve an increase of about 2958 acre-feet of additional storage which will inundate about 130 acres of land, which must be purchased.

TABLE 1
PROSPECT DAM & RESERVOIR
Elevation – Area – Capacity

Gage Height	Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
56	5030	719	16977.4	
55	5029	699.6	16268.1	
54	5028	680.2	15578.2	
53	5027	660.8	14907.7	
52	5026	641.4	14256.6	
51	5025	622	13624.9	
50	5024	602.6	13012.6	Enlarged Top of Dam
49	5023	583.2	12419.7	
48	5022	563.8	11846.2	
47	5021	544.4	11292.1	
46	5020	525.3	10757.3	
45	5019	506.6	10241.3	
44	5018	487.9	9744.1	Enlarged Spillway Crest
43	5017	469.2	9265.5	
42	5016	450.5	8805.7	Existing Top of Dam
41	5015	431.8	8364.5	
40	5014	413.1	7942.1	
39	5013	394.4	7538.3	
38	5012	375.7	7153.3	
37	5011	357.2	6786.8	Existing Spillway Crest
36	5010	338.4	6091.2	
34	5008	319.6	5433.2	
32	5006	300.8	4812.8	
30	5004	282	4230.0	
28	5002	263.2	3684.8	
26	5000	244.4	3177.2	
24	4998	225.6	2707.2	
22	4996	206.8	2274.8	
20	4994	188	1880.0	
18	4992	169.2	1522.8	
16	4990	150.4	1203.2	
14	4988	131.6	921.2	
12	4986	112.8	676.8	
10	4984	94	470.0	
8	4982	75.2	300.8	
6	4980	56.4	169.2	
4	4978	37.6	75.2	
2	4976	18.8	18.8	
0	4974	0	0.0	

DAM EMBANKMENT

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications. The reconnaissance designs described herein are based upon a site inspection and review of available data; more detailed engineering work may result in a different design.

The dam, is an intermediate Class II structure. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, 25 feet maximum,
* a spillway capable of passing a 50% PMP,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

EMBANKMENT: The existing dam is an earth embankment with the following dimensions:

* 42 feet high,
* crest length of about 4,410 feet,
* crest width of 17 feet,
* 2.0H:1.0V upstream and 2.0H:1.0V downstream slopes
* 34 inch diameter outlet pipe,
* concrete upstream face.

The enlarged dam will be an earth embankment with following the dimensions:

* 50 feet high,
* crest length of about 5,140 feet,
* crest width of 21 feet,
* 3.5H:1.0V upstream and 2.0H:1.0V downstream slopes
* 34 inch diameter outlet pipe,
* spillway width approximately 150 feet, 7000 cfs capacity,
* Rip rap upstream face.

Figure 4 shows the cross section of the dam at the outlet pipe superimposed over the existing embankment.

The upstream concrete face of the existing embankment would be removed and if possible stockpiled for use as rip rap on the enlarged dam. Also the pipeline on the north side of the embankment would be removed and replaced if needed.

The dam would be raised by placing material on the upstream face. The downstream slope includes a toe drain that was installed about 15 years ago and a pond, both of which must be removed if the enlargement fill is placed on the downstream face. Also, the concrete face is a structural concern which should be removed.

The downstream slope of 2.0H:1.0V would be extended upward at the same slope, an additional height of 8 feet. The crest would be 21 feet wide then the upstream slope would be placed at a 3.5H:1.0V slope, extending about 100 feet further into the reservoir. The material between the toe of the existing and new embankments must be excavated down to suitable material. A core trench 20 feet deep, 20 feet wide would be excavated most of the length of the embankment and upstream of the centerline of the embankment. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir.

The volume of fill to enlarge the dam is estimated by determining the volume of the existing embankment, Table 2, which is subtracted from the volume of the enlarged embankment, Table 3. The volume difference is increased by 30% to account for compaction.

Embankment material would be obtained from a 40 acre parcel of land east of the dam, owned by the District. The borrow area is expected to be impervious material so that the entire enlarged embankment will be the same impervious material.

The material would be placed in lifts and compacted to 95% Standard Proctor. Adequate testing will be required to monitor the compaction.

The concrete facing on the dam is assumed to be suitable for rip rap on the face of the enlarged dam.

The existing toe drain will be used to control seepage through the embankment.

OUTLET PIPE: The existing 34 inch diameter steel outlet pipe will be extended about 100 feet to the upstream toe of the enlarged embankment. The operator chamber will also be extended about 10 feet to the crest of the enlarged embankment in order to operate the existing gate.

SPILLWAY: The spillway will be sized to pass the 50% PMP. The spillway on the northwest abutment is expected to be moved to the north to accommodate the enlargement. The existing spillway width is expected to be adequate but can be easily widened if necessary.

A concrete cutoff wall perpendicular to the flow of water is included to stabilize the spillway section. The wall would be about 2 feet thick, at least 2 feet below the ground surface at any point along the wall, and be the desired shape of the spillway cross section.

TABLE 2
PROSPECT DAM EMBANKMENT
VOLUME OF EXISTING EMBANKMENT

0 foot Stripping Depth
2 :1 Upstream
2 :1 Downstream
17 foot Crest Width
5017 feet Crest Elevation

0 foot Key Trench Width
0 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
1300	5017	0	0				
				132	978	0	978
1500	5009	8	264				
				412	3662	0	3662
1740	5004	13	559				
				757	5888	0	5888
1950	4999	18	954				
				1202	19143	0	19143
2380	4994	23	1449				
				1747	32999	0	32999
2890	4989	28	2044				
				2392	9745	0	9745
3000	4984	33	2739				
				3137	9295	0	9295
3080	4979	38	3534				
				3982	11799	0	11799
3160	4974	43	4429				
				4429	6561	0	6561
3200	4974	43	4429				
				3982	7374	0	7374
3250	4979	38	3534				
				3137	10457	0	10457
3340	4984	33	2739				
				2392	4430	0	4430
3390	4989	28	2044				
				1747	4529	0	4529
3460	4994	23	1449				
				1202	65442	0	65442
4930	4999	18	954				
				477	13780	0	13780
5710	5017	0	0				

Total Volume of Existing Embankment (cubic yards) 206100

TABLE 3
PROSPECT DAM EMBANKMENT
VOLUME OF ENLARGED EMBANKMENT

2 foot Stripping Depth
3.5 :1 Upstream
2 :1 Downstream
21 foot Crest Width
5024 foot Crest Elevation

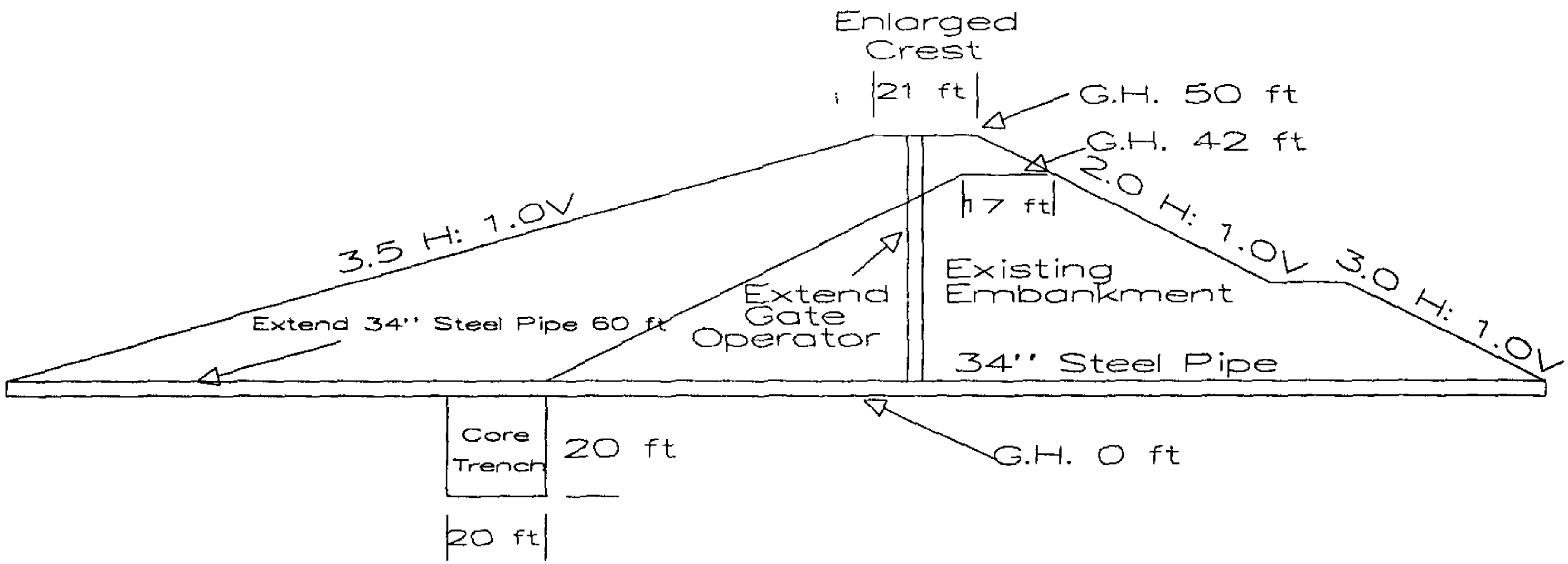
20 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
680	5030	0	0				
				113	536	30	566
1000	5020	6	225				
				319	3544	2222	5766
1300	5017	9	412				
				782	5793	2222	8015
1500	5009	17	1152				
				1473	13093	3556	16649
1740	5004	22	1793				
				2183	16979	3111	20090
1950	4999	27	2572				
				3030	48256	6370	54626
2380	4994	32	3488				
				4015	75839	7556	83395
2890	4989	37	4542				
				5138	20933	1630	22563
3000	4984	42	5733				
				6398	18957	1185	20142
3080	4979	47	7062				
				7795	23096	1185	24281
3160	4974	52	8528				
				8528	12634	593	13227
3200	4974	52	8528				
				7795	14435	741	15176
3250	4979	47	7062				
				6398	21327	1333	22660
3340	4984	42	5733				
				5138	9515	741	10256
3390	4989	37	4542				
				4015	10409	1037	11446
3460	4994	32	3488				
				3030	164967	21778	186745
4930	4999	27	2572				
				1492	43102	8667	51769
5710	5017	9	412				
				319	2363	1481	3844
5910	5020	6	225				
				113	167	30	197
6010	5030	0	0				

Total Volume of Enlarged Embankment (cubic yards) 571400

Figure 3

Prospect Dam and Reservoir
Cross Section at Outlet Pipe



COST ESTIMATE

The estimated cost to enlarge the dam is shown in Table 3. The unit cost for placement of compacted embankment was based on a contractor estimate received by the Manager of District of $1 per cubic yard. The amount in the estimated herein is $2 per cubic yard which was increased to account for the potential problems with placing the fill on an existing embankment and removing sediment from the reservoir basin.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

The cost to purchase 150 acres of land for the enlarged reservoir basin is based on $500 per acre.

FINANCING

The Henrylyn Irrigation District cannot fund the entire cost of the project.

The District presently has two loans with the CWCB; for original amounts of $653,000 and $260,000 which have been paid down to $440,000 and $189,000 respectively. The annual payments are $28,248 and $15,152, for a total of $43,400. If advantageous these loans might be refinanced with the enlargement of the Prospect.

The District presently assess $13 per acre for 32,800 acres. The total annual budget is about $500,000.

The District will not, in the near future, reconstruct both Bootleg and enlarge Prospect. The financial analysis herein assumes that Prospect will be reconstructed because it is more cost effective. The enlargement would yield addition storage of about 2958 acre-feet to the District. Repayment options are shown in Table 5, assuming a 100% loan; if the District can include some cash the amounts would be reduced.

Option 5, 3% for 40 years, is recommended because it results in a per acre-foot repayment of about $26 which is realistic for irrigation water. The annual repayment would be about $77,000 which would increase the annual assessment about $2.50 per acre, which would appear to be affordable to the irrigators.

TABLE 4
PROSPECT DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$10,000
Embankment				
Compacted Fill	cy	474900	$2.00	$949,800
Rip Rap	cy	3110	$20.00	$62,200
Remove Concrete Face	sq yd	40000	$1.00	$40,000
	Embankment Subtotal			$1,052,000
Outlet Works				
Outlet Pipe Extension	lf	60	$200.00	$12,000
Gate	ls			$15,000
	Outlet Works Subtotal			$27,000
Spillway				
Fill & Rip Rap	cy	5190	$5.00	$26,000
Concrete Control Section	cy	90	$300.00	$27,000
	Spillway Subtotal			$53,000
	Total of Above Items			$1,132,000
	Contingency (30%)			$339,600
	Land Cost (150 acres)			$75,000
	Field Cost Subtotal			$1,546,600
	Engineering & Admin (15%)			$232,000
TOTAL ESTIMATED CONSTRUCTION COST				$1,780,000
Construction Cost per Acre–Foot of Additional Storage				$600
Additional Reservoir Storage in Acre–Feet				2958

TABLE 5
PROSPECT DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$1,780,000	4.0%	30	$102,938	$35
2	$1,780,000	4.0%	40	$89,932	$30
3	$1,780,000	3.5%	30	$96,781	$33
4	$1,780,000	3.0%	30	$90,814	$31
5	$1,780,000	3.0%	40	$77,007	$26
6	$1,780,000	2.0%	30	$79,477	$27

Volume of Reservoir Enlargement in Acre–Feet: 2958

RECOMMENDATIONS

The District decided, based on a review of the draft of this report during January of 1994, that they are not presently in the financial position to afford the enlargement. The followings steps are recommended if the District decides to pursue the enlargement of Prospect Reservoir sometime in the future.

1. The cost per cubic yard to place and compact fill used herein is based upon a contractor estimate of $1 per cubic yard which is very low. In short, if there is a contractor that can place and compact fill for about $1 per cubic yard, the District should immediately prepare plans and specifications so that construction can begin as soon as possible (before the contractor can change his mind). The first step should be to reconfirm the contractor estimate of $1 per cubic yard. In winter of 1994.

2. If the contractor can place material for between $1 and $2 per cubic yard. The District would then decide if enlargement of the dam for about $2.50 per acre is affordable. If not discontinue the study; if yes proceed. In winter of 1994.

3. Obtain feasibility study funds, to prepare the plans and specifications for the State Engineer, and to obtain the necessary permits. Submit the plans and specifications to the State Engineer in August of 1994. Request the feasibility study funds as soon as possible. Request a construction loan from CWCB, also in August of 1994. Submit any necessary permit applications in August of 1994.

4. Obtain approval from State Engineer, funding from CWCB, and permits. Soonest early summer of 1995.

5. Construct the modifications. Soonest summer of 1995.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

RED MESA DAM AND RESERVOIR
Owned By The Red Mesa Ward Reservoir and Ditch Company

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

RED MESA RESERVOIR

PLAN DESCRIPTION

Red Mesa Reservoir is an existing reservoir located in the LaPlata River drainage in southwest Colorado, about 20 miles southwest of the City of Durango. The reservoir is located on Hay Gulch, a tributary to the LaPlata River. Figure 1 shows the general reservoir location, Figure 2 is a copy of a USGS Quad map showing the reservoir site and the lower portion of the drainage basin.

The dam is owned by the Red Mesa Ward Reservoir and Ditch Company (Company). The address and contact person are:

Red Mesa Ward Reservoir and Ditch Company
J. Pat Greer, Board Chairman 588-3325
8097 County Road 100
Hesperus, Colorado 81326

Trent Taylor, Board Vice-Chairman 588-3495
1290 County Road 102
Hesperus, Colorado 81326

The structure does not have any serious problems that has caused the dam to be restricted by the Colorado State Engineer. The major concerns are: (1) the crest sags in the middle and is about 3 feet lower than the outside edges of the crest, (2) the outlet tower should be removed and a standard gate installed with hydraulic operation from the crest, and (3) the spillway needs to be enlarged to pass the flood from the 50% probable maximum precipitation (PMP).

The LaPlata River drainage is a water critical basin primarily because of the LaPlata River Compact with the State of New Mexico. The owners of the reservoir would like to enlarge the reservoir for additional irrigation water and to sell water for plans of augmentation required for domestic water usage in the basin.

The drainage basin above the reservoir is a large basin that drains a gently sloping area, covered with pinion, pine, natural grass, and some irrigation.

Enlargement of the dam would provide about 2900 acre-feet of additional storage.

This reconnaissance report describes the engineering issues, preliminary embankment design, and estimated construction costs of enlarging the Red Mesa Dam.

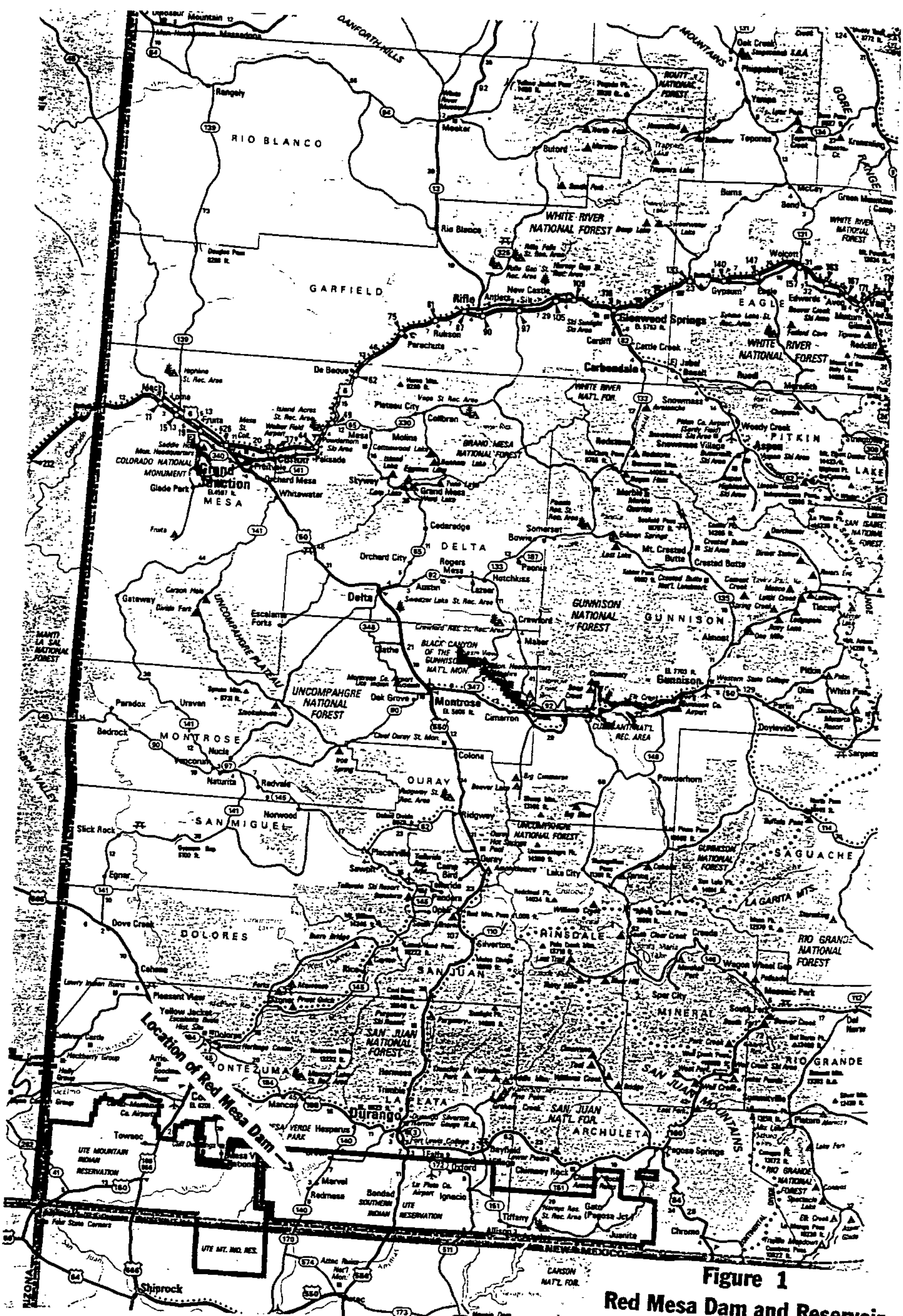


Figure 1
Red Mesa Dam and Reservoir
Location Map

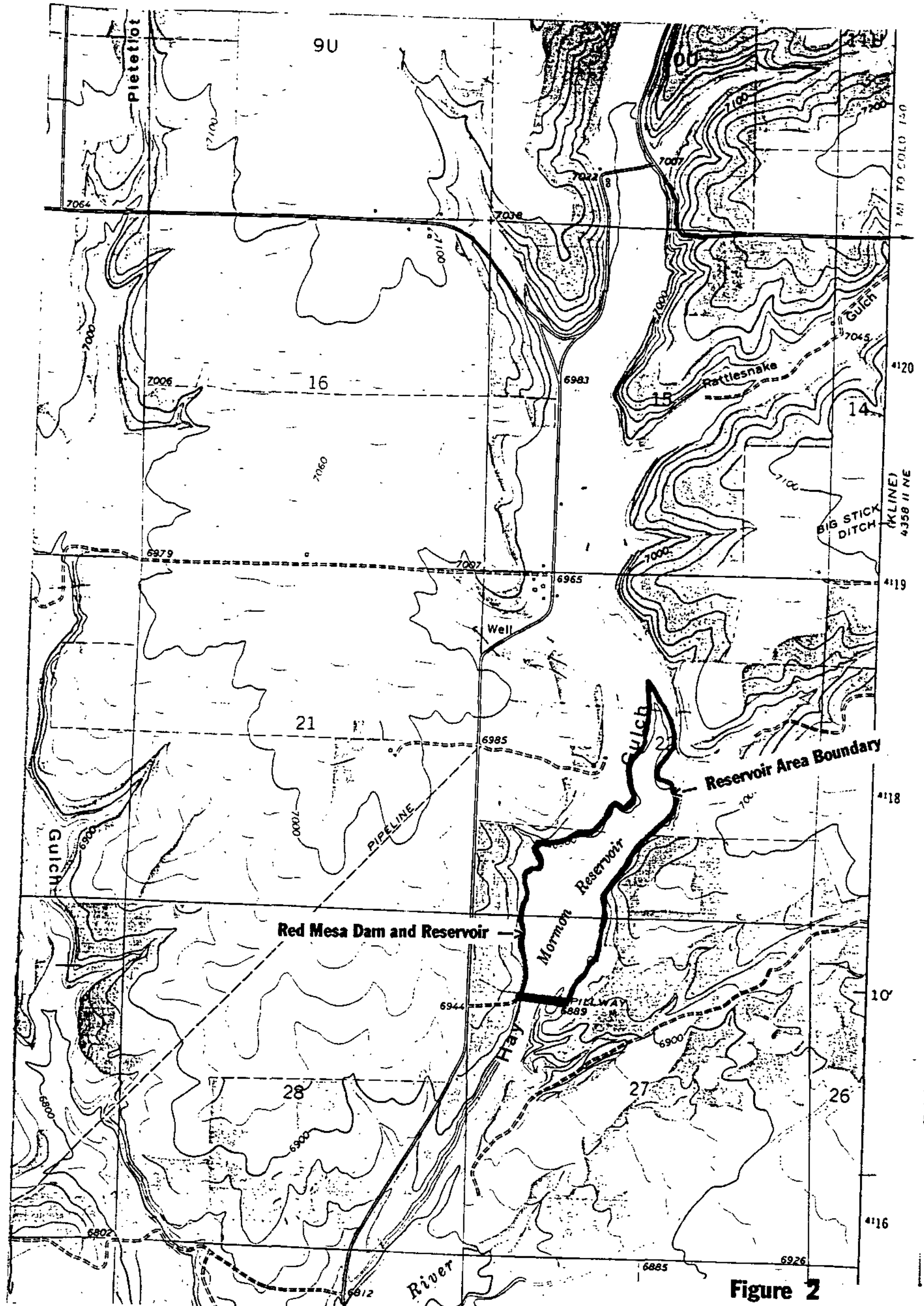


Figure 2
Red Mesa Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The Company has water storage rights totally 4074 acre-feet, of which about 1176 are absolute and remainder are conditional, with an adjudication date of 1915 and a priority date of 1905, which is a fairly junior priority in the LaPlata River basin. The reservoir is primarily filled from a 120 cfs diversion decree from the LaPlata River, plus whatever flows occur in Hay Gulch. The reservoir is not able to fill in the driest years such as 1977 and the reservoir fills on the average about 7 or 8 times out of 10 years.

If enlarged and used for plans of augmentation, adequate augmentation water for the following year should be left in the reservoir in the event that the reservoir cannot fill the next year. A plan for distribution of water in shortage years would be necessary. An evaluation of the water supply with the enlarged reservoir would be one of the first tasks.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir; the table was developed from area data contained in the original construction plans. The present water level is 6896 feet, which is a capacity of 1176 acre-feet. A 29 foot enlargement, to elevation 6925 feet, is proposed which would increase the storage to 4072 acre-feet and is the amount of the storage water right.

TABLE 1
RED MESA DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
6932	168.5	5190.5	Top of Enlraged Dam
6931	166	5023.2	
6930	163.5	4858.5	
6929	161	4696.2	
6928	158.5	4536.5	
6927	156	4379.2	
6926	153.5	4224.5	
6925	151	4072.2	Enlarged Spillway Crest
6924	148.5	3922.5	
6923	145.9	3775.3	
6922	143.3	3630.7	
6921	138.5	3489.8	
6920	138.2	3351.4	
6919	133.6	3215.5	
6918	129.1	3084.2	
6917	124.5	2957.4	
6916	120	2835.1	
6915	115.4	2717.4	
6914	110.9	2604.3	
6913	106.4	2495.6	
6912	101.7	2391.6	
6911	97.5	2292.0	
6910	93	2196.7	
6909	90	2105.2	
6908	87	2016.7	
6907	84	1931.2	
6906	82	1848.2	
6905	78	1768.2	
6904	75.1	1691.7	
6903	72	1618.1	Top of Existing Dam
6902	69.4	1547.4	
6901	66	1479.7	
6900	63.1	1415.2	
6899	61.4	1352.9	
6898	59.7	1292.4	
6897	58.1	1233.5	
6896	56.4	1176.2	Existing Spillway Crest
6895	54.7	1120.7	
6894	53.1	1066.8	
6893	51.4	1014.5	
6892	49.7	964.0	
6891	48.1	915.1	

TABLE 1
RED MESA DAM & RESERVOIR
Elevation– Area–Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
6890	46.4	867.8	
6889	45.1	822.1	
6888	43.7	777.7	
6887	42.3	734.7	
6886	40.9	693.1	
6885	39.6	652.8	
6884	38.3	613.9	
6883	36.9	576.3	
6882	35.6	540.0	
6881	34.2	505.1	
6880	32.9	471.6	
6879	31.6	439.3	
6878	30.2	408.4	
6877	28.9	378.9	
6876	27.6	350.6	
6875	26.2	323.7	
6874	24.9	298.2	
6873	23.5	274.0	
6872	22.3	251.1	
6871	20.9	229.5	
6870	19.6	209.2	
6869	18.6	190.1	
6868	17.6	172.0	
6867	16.6	154.9	
6866	15.6	138.8	
6865	14.6	123.7	
6864	13.5	109.7	
6863	12.6	96.6	
6862	11.5	84.6	
6861	10.5	73.6	
6860	9.5	63.6	
6859	8.9	54.4	
6858	8.2	45.8	
6857	7.6	37.9	Intake to Outlet Pipe
6856	7	30.6	
6855	6.4	23.9	
6854	5.7	17.9	
6853	5.1	12.5	
6852	4.5	7.7	

DAM EMBANKMENT

The Red Mesa Dam, is jurisdictional and is an intermediate Class II. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, with a maximum of 25 feet,
* a spillway capable of passing 50% of the PMP,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

Plans and specifications must be prepared and approved by the State Engineer prior to beginning construction. Soils tests and material evaluations will be required to prepare the plans and specifications. The reconnaissance designs described herein are based upon a site inspection and review of available data; more detailed engineering work may result in a different design.

EMBANKMENT: The existing Red Mesa Dam is about 50 feet high with slopes of 3.2:1 upstream and 2.4:1 downstream (based on field survey of the maximum section for this report), a 10 foot crest width, and a 4 ft by 2 ft horseshoe outlet tunnel. The dam is in relatively good condition and is not restricted. The main embankment concern is the crest elevation that is not consistent, the center of the dam is about 3 feet lower than the outside crest elevations. There is also an embankment groin leak which should be addressed in designs for an enlargement.

Enlargement of the dam will involve raising the crest from elevation 6903 feet (lowest point on the crest) to 6932 feet elevation (MSL elevations are plus or minus 5 feet) an increase of 29 feet. The upstream slope of 3.2H:1.0V will be extended and the downstream slope will be 2.5H:1.0V.

The enlarged dam will be an earth embankment with following the dimensions:

* 82 feet high,
* 7 feet of freeboard,
* crest length of about 720 feet (including spillway),
* crest width of 25 feet,
* 3.2H:1.0V upstream and 2.5H:1.0V downstream slopes
* extension of existing 2 ft by 4 ft horseshoe tunnel,
* a spillway width of 200 feet.

Figure 4 shows the cross section of the dam at the outlet tunnel. Figure 5 shows the front elevation view of the embankment looking upstream from below the dam.

The surface of the existing embankment and the area below the toe of the existing embankment will be removed and wasted because it contains humus and rocks. The material to raise the embankment will be placed on the downstream slope. A core trench is assumed at the downstream toe of the existing embankment that is 20 foot deep and 20 feet wide. Though the core trench is downstream of the crest, it is included to impede foundation water seepage.

The volume of material to be placed in order to enlarge the dam was quantified by estimating the volume of the existing embankment, shown in Table 2. The volume of the enlarged embankment is shown in Table 3. The difference between the existing and enlarged embankment is estimated to be the amount of material to be placed to raise the dam, plus 30% for compaction loss.

Embankment material is assumed to be obtained from a borrow area in the reservoir basin. The material is expected to be impervious material so that the entire downstream slope is homogeneous core material; if pervious material is available the design may be changed to include a pervious shell on the downstream slope. The material would be placed in lifts and compacted to 95% Standard Proctor. Adequate testing will be required to monitor the compaction.

A toe drain is included to control seepage through the embankment and to address the groin seepage. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 200 feet long.

No other drainage system is included in this preliminary design because the existing dam is apparently in good condition without serious seepage. Also, the enlargement includes the placement of a large mass of material on the downstream slope with a thick 25 foot crest width. If drainage filter material is readily available a chimney filter at the contact between the existing downstream slope and the new material should be considered.

Rock for rip rap does not appear to be available immediately around the reservoir and must be hauled from a site assumed to be within 5 miles. The area to be rip rap'd would be about 60 feet wide and 600 feet long.

OUTLET TUNNEL: The outlet tunnel would be extended about 70 feet through the new embankment. The reservoir outlet works tower will be removed and replaced with a gate structure. A hydraulic gate mechanism that is operated from the dam crest will be included.

SPILLWAY: The present spillway size is not adequate to pass the required flood, so the spillway for the enlarged dam will be increased. The drainage area is about 32 square miles and based on approximate estimates of runoff from thunderstorms from USBR reconnaissance procedures, the PMP would result in a flood of about 15,000 cfs. Since the dam is presently an intermediate Class II dam it must pass 50% of the PMP, or about 7500 cfs. Enlarging the dam may change the classification to intermediate Class I which requires 100% of the PMP. This would be addressed during the design phase.

A concrete ogee crest is assumed for the spillway. Using the equation: flow is equal to the length times a flow factor (C) of 2.7 times the water depth (freeboard of 7 feet) to the 1.5 power, the spillway length must be 150 feet wide.

The spillway will be raised from the present elevation of 6896 feet to 6925 feet (29 feet) and widened to about 150 feet. The spillway will be constructed on the east abutment. A concrete ogee control section is assumed. The sides of the spillway channel would be vertical on both sides. About 100 feet of the existing spillway channel will be filled to support the ogee concrete structure and prevent erosion under the concrete. A layer of rip rap will be placed over the fill to reduce erosion.

TABLE 2
RED MESA DAM
EXISTING EMBANKMENT VOLUME

0 foot Stripping Depth
3.2 :1 Upstream
2.4 :1 Downstream
10 foot crest width
6903 feet Crest Elevation

0 foot Key Trench Width
0 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
270	6917	0	0				
				129.5	105	0	105
330	6895	8	259				
				985	1459	0	1459
370	6880	23	1711				
				5053	14972	0	14972
450	6850	53	8395				
				7804	14452	0	14452
500	6854	49	7213				
				6666.5	37036	0	37036
650	6858	45	6120				
				3362	6226	0	6226
700	6890	13	603				
				302	224	0	224
740	6916	0	0				

Total Volume of Existing Embankment (cubic yards) 74500

TABLE 3
RED MESA DAM
VOLUME OF ENLARGED EMBANKMENT

2 foot Stripping Depth
3.2 :1 Upstream
2.5 :1 Downstream
25 foot Crest Width
6932 foot Crest Elevation

20 foot Key Trench Width
20 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Total Excavation (cy)
27	6935	0	0				
				403.5	294	81	375
52	6921	13	807				
				2161	2401	222	2623
82	6903	31	3514				
				3514	4685	267	4952
118	6903	31	3514				
				2112	4068	385	4453
170	6922	12	710				
				758.5	843	222	1065
200	6921	13	807				
				858	1398	326	1724
244	6920	14	909				
				1079	1039	193	1232
270	6917	17	1249				
				3280	7289	444	7733
330	6895	39	5310				
				7486	11090	593	11683
370	6880	54	9661				
				15935.5	47216	1185	48401
450	6850	84	22210				
				21225	39306	741	40047
500	6854	80	20240				
				19301	107228	2222	109450
650	6858	76	18362				
				12490	23130	741	23871
700	6890	44	6618				
				3995.5	5919	296	6215
740	6916	18	1373				
				1090	404	74	478
750	6921	13	807				
				404	176	81.5	257.5
765	6935	0	0				

Total Volume of Enlarged Embankment (cubic yards) 264600

Figure 3
Red Mesa Dam and Reservoir
Cross Section at Dam Center Line

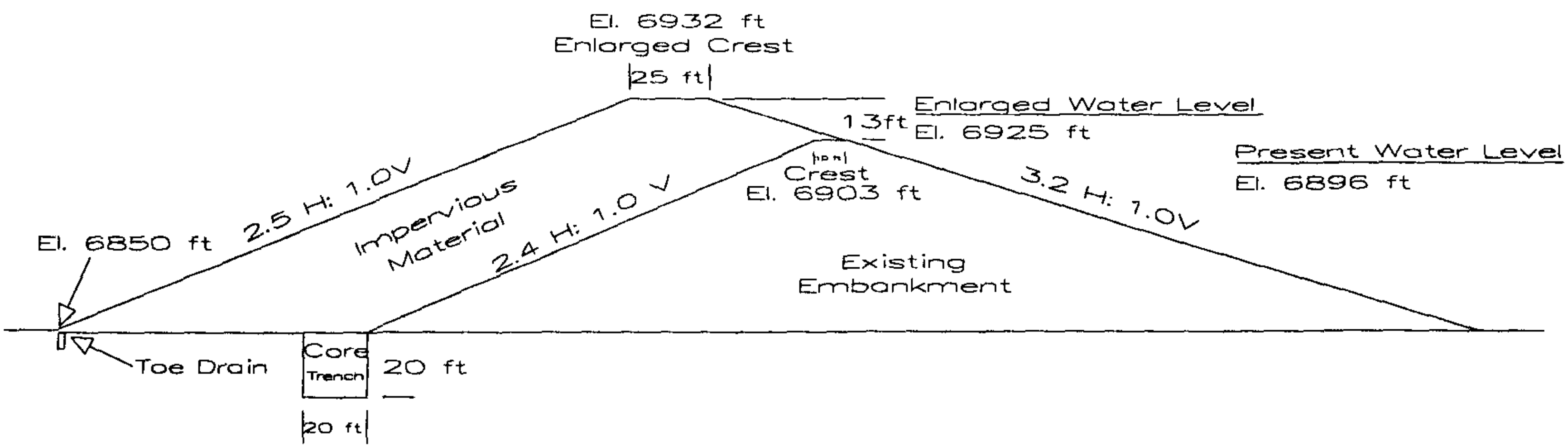
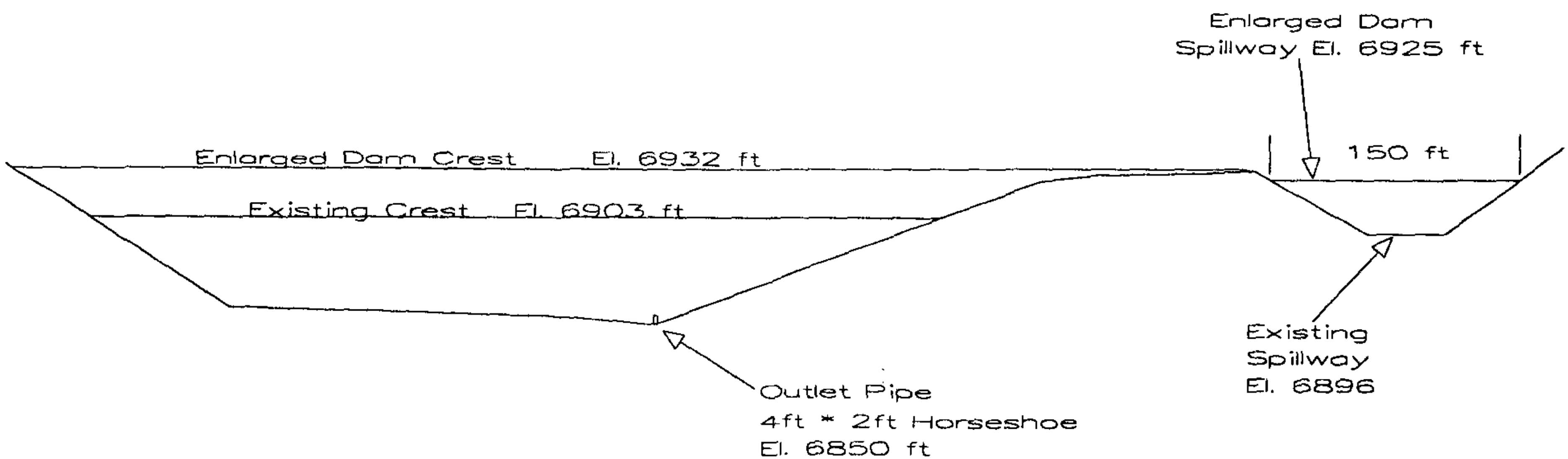


Figure 4
Red Mesa Dam and Reservoir
Embankment Looking Upstream



COST ESTIMATE

The estimated cost to reconstruct the dam is shown in Table 4. The unit costs are rough estimates of costs found in non-urban areas of the state.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes: testing for designs, preparation of plans and specifications, construction observation, CWCB financing costs, and any necessary permitting.

The land under and around the existing reservoir is owned by the Mormon Church. It is assumed that the 100 acres of land for the enlargement must be purchased for $1500 per acre. There are opportunities for land exchanges to reduce the acreage to be purchased but the more conservative assumption is used herein.

The cost estimate is at an appraisal level and will change when plans and specifications are prepared.

The enlargement will require a 404 permit which will trigger endangered fish species consultation with US Fish and Wildlife Service and wetlands impacts. This work should begin as soon as possible.

FINANCING

The cost for this work will require financing. The Reservoir Company would need to finance nearly the entire cost of the enlargement. Table 5 shows various financing terms. Option 1 is the standard rate as of December, 1993; the interest rate is based upon national interest rates.

Option 6 is recommended because the cost per acre-foot is reasonable, realizing that this is less than the standard CWCB terms. The irrigators who receive water from the reservoir must be willing to pay the same amount each year, regardless if the water is available.

If water for plans of augmentation, realizing the amount of water will be small, is sold for about $200 per acre-foot per year, the repayment ability is improved.

TABLE 4
RED MESA DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$10,000
Embankment				
Compacted Fill	cy	247000	$4.00	$988,000
Rip Rap	cy	3110	$20.00	$62,200
Toe Drain	lf	200	$20.00	$4,000
	Embankment Subtotal			$1,054,200
Outlet Works				
Outlet Pipe Extension	lf	40	$300.00	$12,000
Gate Repair & Control	ls			$40,000
	Outlet Works Subtotal			$52,000
Spillway				
Rip Rap	cy	1480	$20.00	$29,600
Concrete Control Section	cy	440	$300.00	$132,000
	Spillway Subtotal			$161,600
	Total of Above Items			$1,267,800
	Contingency (30%)			$380,300
	Land Cost (100 acres)			$150,000
	Field Cost Subtotal			$1,798,100
	Engineering & Admin (15%)			$269,700
TOTAL ESTIMATED CONSTRUCTION COST				$2,068,000
Construction Cost per Acre-Foot of Additional Storage				$710
Additional Reservoir Storage in Acre-Feet				2900

TABLE 5
RED MESA DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$2,068,000	4.0%	30	$119,593	$41
2	$2,068,000	4.0%	40	$104,483	$36
3	$2,068,000	3.0%	30	$105,508	$36
4	$2,068,000	3.0%	40	$89,467	$31
5	$2,068,000	2.0%	30	$92,336	$32
6	$2,068,000	2.0%	40	$75,597	$26

Volume of Reservoir Enlargement in Acre–Feet: 2900

RECOMMENDATIONS

The followings steps are recommended to enlarge the Red Mesa Dam:

1. The Red Mesa Reservoir and Ditch Company stock holders must decide if an annual payment of about $75,000 can be paid for the increased storage, the payment must be made regardless if water is available. To assist in making this decision the Company Board can evaluate the need for augmentation water and the potential income from selling the water. The possible State Engineer requirement to enlarge the spillway and replace the outlet gate should also be factored into the decision. If not, no further work is necessary; if yes continue. Soonest winter of 1994.

2. Apply for feasibility study funds from the CWCB to prepare detailed engineering evaluations of the enlargement. If the feasibility study funds are provided by the CWCB to evaluate the enlargement, it should be with the intent to provide a construction loan at reduced terms (e.g. 2% for 40 years). Soonest spring of 1994.

3. The feasibility study is suggested to evaluate the: water supply; demand for augmentation water; spillway sizing based on the PMP; various enlargement options based on supply, demand and spillway size; plans to obtain land for the enlargement; environmental compliance requirements; plans and cost to repair the existing dam with a new spillway and outlet gate; and if feasible develop an enlargement plan with costs. The water supply is a complicated evaluation because of the LaPlata River Compact and availability of winter flows. Even though the reservoir cost per acre-foot decreases as the reservoir size increases, a smaller reservoir may be advantageous because of the water supply. If an enlargement is found to be infeasible, it is recommended that the study costs be forgiven. Soonest is summer of 1994.

4. Assuming the enlargement is feasible, apply for CWCB construction funding. Once construction funding is available, prepare plans and specifications for the enlarged dam and simultaneously prepare the environmental compliance documents (e.g. 404 permit). Soonest summer fall of 1995.

5. Assuming the plans and specifications are approved, and environmental permits are approved; construct the enlargement. Soonest summer of 1996.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

SAMS KNOB DAM AND RESERVOIR
Sponsored By The Snowmass Water and Sanitation District

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

SAMS KNOB DAM AND RESERVOIR

PLAN DESCRIPTION

Sams Knob Dam and Reservoir would be a new structure located on Snowmass Creek a tributary of the Roaring Fork River. Figure 1 shows the general reservoir location.

The sponsoring entity for the dam and the contact person are:

Snowmass Water and Sanitation District
Richard Wall, Manager 923-2056
P.O. Box 5700
Snowmass Village, Colorado 81615

The water would be used for domestic, municipal, irrigation, recreational, industrial and other beneficial purposes in the Snowmass District service area and for snow making at the Snowmass Ski Area. There is also some potential for providing instream flow releases. This reservoir is the only proposed source of significant raw water storage capacity in the snowmass Creek basin for District operations. The water from the reservoir would be diverted into an adjacent drainage where the District's water treatment plant is located. Diversion of the water to another stream is not popular with the residents in the Snowmass Creek drainage, however the construction of Sam's Knob Reservoir was contemplated in the 1978 Intergovernmental Agreement which was ratified by the Pitkin County Commissioners, the Snowmass Water and Sanitation District Board and the Snowmass Land Company.

The District has had initial engineering plans prepared. The information obtained for the evaluation herein was a 1 inch equals 50 foot topographic map with the embankment superimposed, and elevation-area-capacity curve. The District has cursory information on the dam and reservoir, this report is mainly an attempt to bring the project to the forefront so that issues can be resolved and the construction initiated.

This reconnaissance report describes the engineering issues, preliminary designs, and costs of constructing the dam.

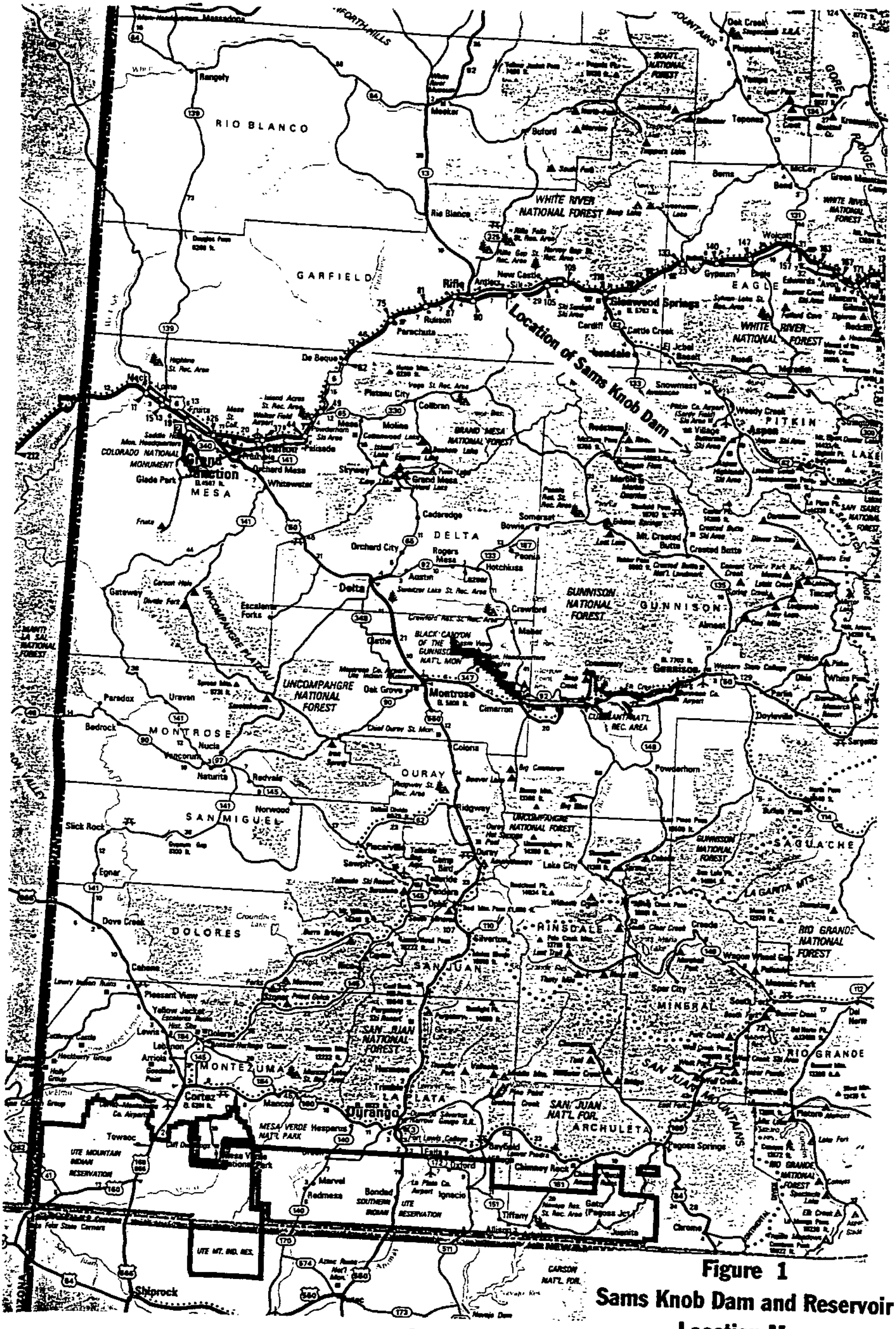


Figure 1

Sams Knob Dam and Reservoir Location Map

WATER SUPPLY

The District holds a 565 acre-feet of storage right at the Sams Knob reservoir site for domestic, municipal, irrigation, recreational, industrial and other beneficial uses. The original decree for the Reservoir was entered November 5, 1971, in Case No. 5884 of the Garfield County District Court with an appropriation date of March 22, 1967. The District has exercised reasonable diligence in the development of the conditional water rights, and the Water Court has most recently confirmed diligence in Case No. 90CW122. Although the 1967 appropriation date is relatively recent, estimates indicate there is adequate water available under this priority to fill the reservoir in most, if not all years. Detailed evaluation of the water yield is recommended during the feasibility study. For purposes of this report, the annual reservoir yield is assumed to be the reservoir capacity.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir. The area was taken from the elevation-area-capacity curves on the topographic drawing provided by the District. The capacity at the spillway crest elevation of 8252 feet is 537 acre-feet. The crest of the dam is planned to be at elevation 8267 feet. The stream channel is at elevation 8210 feet. The height of the dam is therefore 57 feet with a water depth of 42 feet to allow 15 feet of freeboard. The outlet pipe will be near the bottom of the reservoir so essentially all of the capacity will be useable.

Pursuant to an agreement entered into on August 13, 1978, the District has agreed with the Board of County Commissioners of Pitkin County, Colorado, that Sam's Knob Reservoir shall include in its design, construction and operation, provisions for maintenance of the minimum stream flow levels on Snowmass Creek immediately below the dam. the maintenance of minimum stream flow levels was determined by the Board of County Commissioners and the District to mean that at all times the District would release from the Reservoir the natural inflow or 12 cubic feet per second, whichever is less. When diverting through the Snowmass Creek Pipeline, the District would ensure that the outflow from the Reservoir is at least equal to the quantity of water diverted through the pipeline, except when an emergency water need of the District exists. Prior to the preparation of preliminary construction design drawings and specifications of the Reservoir, the District is obligated to consider all feasible alternatives to the construction of the Reservoir consistent with the Pitkin County Land Use Code. The Board of County Commissioners is to be given the opportunity to participate in the study, analysis and review of all such alternatives. The District further agreed to prepare an environmental impact appraisal in the nature of that required for major federal actions by 40 C.F.R. 1500.

TABLE 1
SAMS KNOB DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8267	36.2	702.0	Top of Proposed Dam
8266	35.5	691.0	
8265	34.8	680.0	
8264	34.1	669.0	
8263	33.4	658.0	
8262	32.7	647.0	
8261	32	636.0	
8260	31.3	625.0	
8259	30.6	614.0	
8258	29.9	603.0	
8257	29.2	592.0	
8256	28.5	581.0	
8255	27.8	570.0	
8254	27.1	559.0	
8253	26.4	548.0	
8252	25.7	537.0	Crest of Spillway
8251	25.1	516	
8250	24.4	495.0	
8249	23.8	473.9	
8248	23.2	452.8	
8247	22.6	431.7	
8246	22	410.6	
8245	21.4	389.5	
8244	20.8	368.4	
8243	20.2	347.3	
8242	19.6	326.2	
8241	19	305.1	
8240	18.5	284.0	
8239	17.8	266	
8238	17.1	248	
8237	16.4	230	
8236	15.7	212	
8235	15	194	
8234	14.3	176	
8233	13.6	158	
8232	12.9	140	
8231	12.2	122	
8230	11.3	104.0	

TABLE 1
SAMS KNOB DAM & RESERVOIR
Elevation – Area – Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
8229	10.45	104.0	
8228	9.6	95.1	
8227	8.8	86.2	
8226	8	77.3	
8225	7.2	68.4	
8224	6.4	59.5	
8223	5.6	50.6	
8222	4.8	41.7	
8221	4	32.8	
8220	2.8	15.0	
8219	2.5	13.5	
8218	2.2	12	
8217	1.9	10.5	
8216	1.6	9	
8215	1.3	7.5	
8214	1	6	
8213	0.7	4.5	
8212	0.4	3	
8211	0.1	1.5	
8210	0	0.0	

DAM EMBANKMENT

The dam would be a jurisdictional dam requiring preparation of plans and specifications for approval by the State Engineer prior to construction. The dam is expected to be an intermediate Class I structure; there would probably be loss of life if the dam failed.

The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days,
* a crest width equal to the vertical height divided by 5 plus 10 feet, 25 feet maximum,
* a spillway capable of passing a PMP flood,
* upstream rip rap to protect the embankment,
* and complete soils investigation and analysis.

EMBANKMENT: The dam is expected to be a homogeneous earth embankment constructed from impervious material in the reservoir basin. The dam would have the following the dimensions:

* 57 feet high,
* 15 feet of freeboard,
* crest length of about 1100 feet,
* crest width of 22 feet,
* 3.0H:1.0V upstream and 2.5H:1.0V downstream slopes
* 36 inch diameter outlet pipe,
* a 110 foot wide spillway which will pass the PMF.

A 15 foot deep, 27 foot wide core trench would be excavated most of the length of the embankment and upstream of the centerline of the embankment.

Figure 2 shows the cross section of the dam at the outlet pipe. Figure 3 shows the front elevation view of the embankment looking upstream from below the dam.

There is assumed to be adequate impermeable material for the embankment available in the reservoir basin. If there is any unsuitable material, e.g. excess rocks or humus, the material would be wasted near the reservoir. Table 2 shows the estimated volume of material required to construct the embankment; 30% is added to this amount to allow for compaction. The material would be placed in lifts and compacted to at least 95% Standard Proctor. Adequate testing will be required to monitor the compaction.

Rip rap is expected to be available near the reservoir.

A toe drain is included to control seepage through the embankment. The drain would probably be a sand filter (ASTM C-33 sand) with a slotted drain pipe to convey water out of the filter. The drain is estimated to be 5 feet deep, 2 feet wide and about 500 feet long.

OUTLET PIPE: The outlet pipe size is suggested to be 36 inch diameter which is significantly larger than the size required by the Rules and Regulations but provides easier operation and maintenance and if a liner is needed in 50 years or so, it can be installed without impacting the ability to drain the top 5 feet of the reservoir in 5 days. The pipe material should be thick walled steel, possibly lined with mortar or another material; CMP is not recommended.

SPILLWAY: The spillway will be sized to pass the PMP (probable maximum precipitation) from the approximately 35 square mile drainage area. Using Bureau of Reclamation criteria for estimating design floods for reconnaissance studies, the peak flow would be about 18,000 cfs with about 7000 acre-feet of volume.

A 110 foot wide channel and 15 feet of freeboard would pass about 18,000 cfs. The location of the spillway is on the east abutment and is planned to be a channel around the embankment then back to the stream. A concrete control section is included to maintain the channel shape. During the design process alternative spillway locations and configurations should be investigated to attempt to determine the best combination of spillway width and freeboard.

TABLE 2

SAMS KNOB DAM – EMBANKMENT VOLUME ESTIMATE

2 foot Stripping Depth
3 :1 Upstream
2.5 :1 Downstream
22 foot Crest Width
8267 feet Crest Elevation

27 foot Key Trench Width
15 foot Key Trench Depth

Station (feet)	Ground Elevation (feet)	Stripping + Height (feet)	End Area (sq ft)	Average Area (sq ft)	Embank. Volume (cy)	Trench Volume (cy)	Embank. Volume (cy)
75	8267	2	55				
				733	2796	773	3569
178	8250	19	1411				
				2005	5866	593	6459
257	8242	27	2599				
				2775	6064	885	6949
316	8240	29	2951				
				3138	9763	1260	11023
400	8238	31	3325				
				3138	11622	1500	13122
500	8240	29	2951				
				2951	4590	630	5220
542	8240	29	2951				
				3996	7104	720	7824
590	8230	39	5041				
				5041	26512	2130	28642
732	8230	39	5041				
				5800	7519	525	8044
767	8224	45	6559				
				8715	4519	210	4729
781	8210	59	10871				
				11045.5	17591	645	18236
824	8209	60	11220				
				11220	22024	795	22819
877	8209	60	11220				
				10055.5	25325	1020	26345
945	8216	53	8891				
				5921	10746	368	11114
994	8240	29	2951				
				1503	9797	1320	11117
1170	8267	2	55				

Total Embankment Volume (cubic yards) 185200

Total Cubic Yards of Excavation & Compacted Fill (30% compaction) 240800

Figure 3

Sams Knob Dam and Reservoir

Cross Section at Outlet Pipe

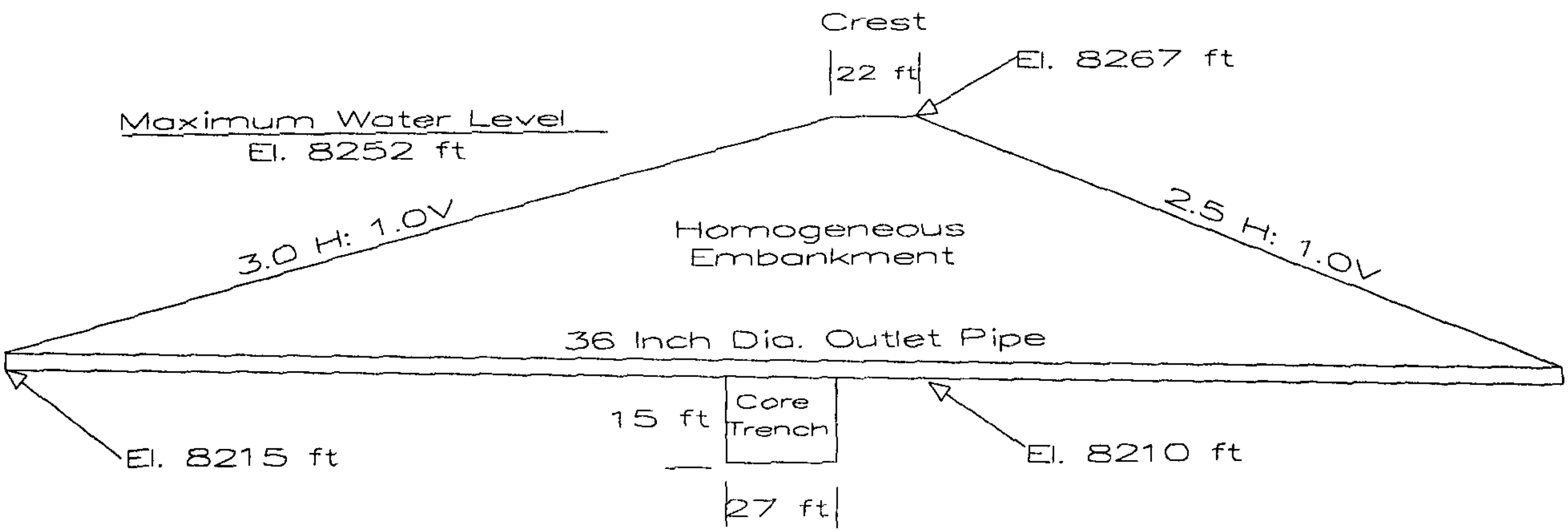
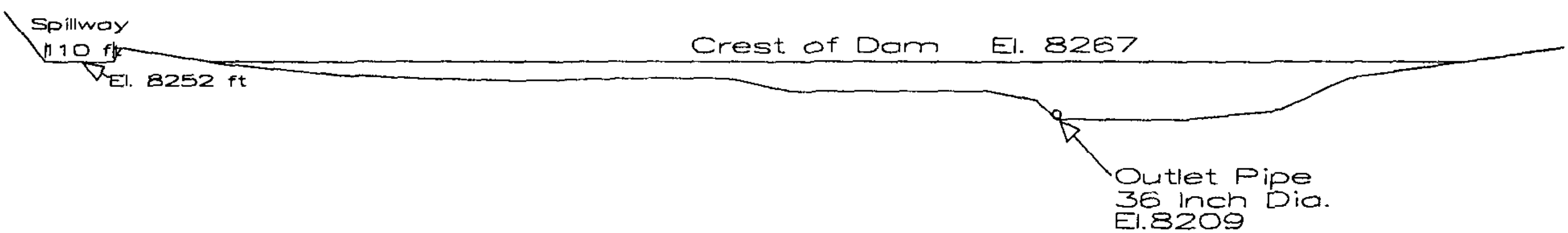


Figure 4
Sams Knob Dam and Reservoir
Cross Section at Dam Center Line

Looking Upstreem



COST ESTIMATE

The estimated cost to construct the dam is shown in Table 3. The unit costs are based upon average construction costs.

An amount of 30% is added for contingencies, which is slightly higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

The dam and reservoir would be on private land that is estimated to cost $10,000 per acre. Also, a line item for environmental permits is included for $250,000 because of the high visibility of the dam and reservoir.

The recent experience of the Colorado River Water Conservation District in obtaining permits and agreements to construct a reservoir near the Colorado River does not bode well for timely construction of dams such as Sams Knob. Since the reservoir is relatively small, it may have fewer problems.

FINANCING

The District will require financing to construct the dam. Table 4 shows two financing options assuming 100% funding by the CWCB, both options are standard CWCB loan terms as of December, 1993; the terms change with national interest rates. Either Option is recommended, the choice will be based upon the District's repayment ability.

The District's current capital debt is paid off in 1998 and would be in a financial position to repay the dam and reservoir.

TABLE 3
SAMS KNOB DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization	ls			$30,000
Embankment				
Exc. & Compacted Fill	cy	240800	$4.00	$963,200
Rip Rap	cy	3780	$20.00	$75,600
Toe Drain	lf	800	$20.00	$16,000
	Embankment Subtotal			$1,054,800
Outlet Works				
36" Outlet Pipe	lf	290	$150.00	$43,500
Gate	ls			$20,000
	Outlet Works Subtotal			$63,500
Spillway				
Excavation	cy	77780	$3.00	$233,300
Concrete Cutoff Wall	cy	90	$400.00	$36,000
	Spillway Subtotal			$269,300
	Total of Above Items			$1,387,600
	Contingency (30%)			$416,300
	Environmental Permits			$250,000
	Land Cost (35 acres)			$350,000
	Field Cost Subtotal			$2,403,900
	Engineering & Admin (15%)			$360,600
TOTAL ESTIMATED CONSTRUCTION COST				$2,765,000
Construction Cost per Acre–Foot of Yield				$5,150

TABLE 4
SAMS KNOB DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre–Foot
1	$2,765,000	3.5%	20	$194,548	$362
2	$2,765,000	4.0%	30	$159,900	$298

Volume of Reservoir Capacity/Annual Yield in Acre–Feet: 537

RECOMMENDATIONS

This report recommends that the District pursue development of additional water storage to meet District water needs when the District has the repayment ability. The general steps are listed below.

1. The District must decide if it is ready to begin the 4 to 8 year process to attempt to construct a new reservoir. If there are no problems, the soonest the dam could be constructed is 1998; more likely the dam could not be constructed until 1999 or 2000. Due to the preparation time to construct a reservoir, the District is encouraged to begin the development process soon if the reservoir is needed in about year 2000.

2. If the first step is affirmative, the next step is a feasibility study to develop more detailed engineering plans and costs, and begin the process to address the environmental issues. The study would include environmental compliance scoping and financing options. The CWCB is one source of feasibility study financing and the District is encouraged to discuss funding with John Van Sciver (866-3441) of the CWCB. Once the feasibility study is completed the issues concerning the project will be better defined. The feasibility study is expected to require about one year, completed in summer 1995.

3. If the feasibility study indicates that the project is ready to proceed to preconstruction activities, apply to the CWCB for a construction loan. The loan would include funds for plans and specifications, environmental permits, and any other preconstruction activities that are necessary; as well as the construction costs. The CWCB accepts construction funding requests in the fall of each year which must be approved by the State Legislature, so that funding is available the following summer. The preconstruction work is expected to require about 2 years, the soonest would be from summer 1996 to spring 1998.

4. Construction is estimated to require about one year. The soonest construction could begin is late spring of 1998 and be finished about one year later.

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

TODD DAM AND RESERVOIR
Owned By The Town of Paonia

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

TODD DAM AND RESERVOIR

PLAN DESCRIPTION

Todd Reservoir is an existing reservoir located in the North Fork of the Gunnison River drainage, about 5 miles south of the Town of Paonia. Figure 1 shows the reservoir location in Colorado, Figure 2 is a copy of a USGS Quad map showing the reservoir site and drainage basin.

The dam and reservoir are owned by the Town of Paonia. The contacts for the Town are:

Town of Paonia
Town Hall
Paonia, Colorado 81428

John Norris, Town Manager 303-527-4101
Joanne Fagan, Town Engineer (contract) 303-874-5342

The Town recently acquired the property primarily for the springs on the land, with Todd Reservoir being included in the purchase. The Town has installed collection pipelines to convey water from the springs around the reservoir to the Town's treatment plant about 3 miles north of the reservoir. The Town does not have any raw water storage; and is dependent upon the consistency of the flow from the springs and 2 million gallons of treated water storage.

The Town presently serves about 1300 taps but is committed to serving an additional 400 taps at various locations. There is not a meter at the water treatment plant, but the operator estimates that the Town presently uses about 2 acre-feet per day in the summer.

Todd Reservoir is not able to store water for controlled releases because the outlet gate does not function. Based on the size of the tree on the dam, the reservoir has not been fully operational in 20 to 30 years. The gate to outlet pipe is not operational and since water was coming through the pipe on the day of inspection, it is apparently stuck open, though not fully open.

The Town would like to improve Todd Reservoir so that it can provide raw water storage. This reconnaissance report describes the engineering issues, construction, and costs of improving the dam for controlled storage.

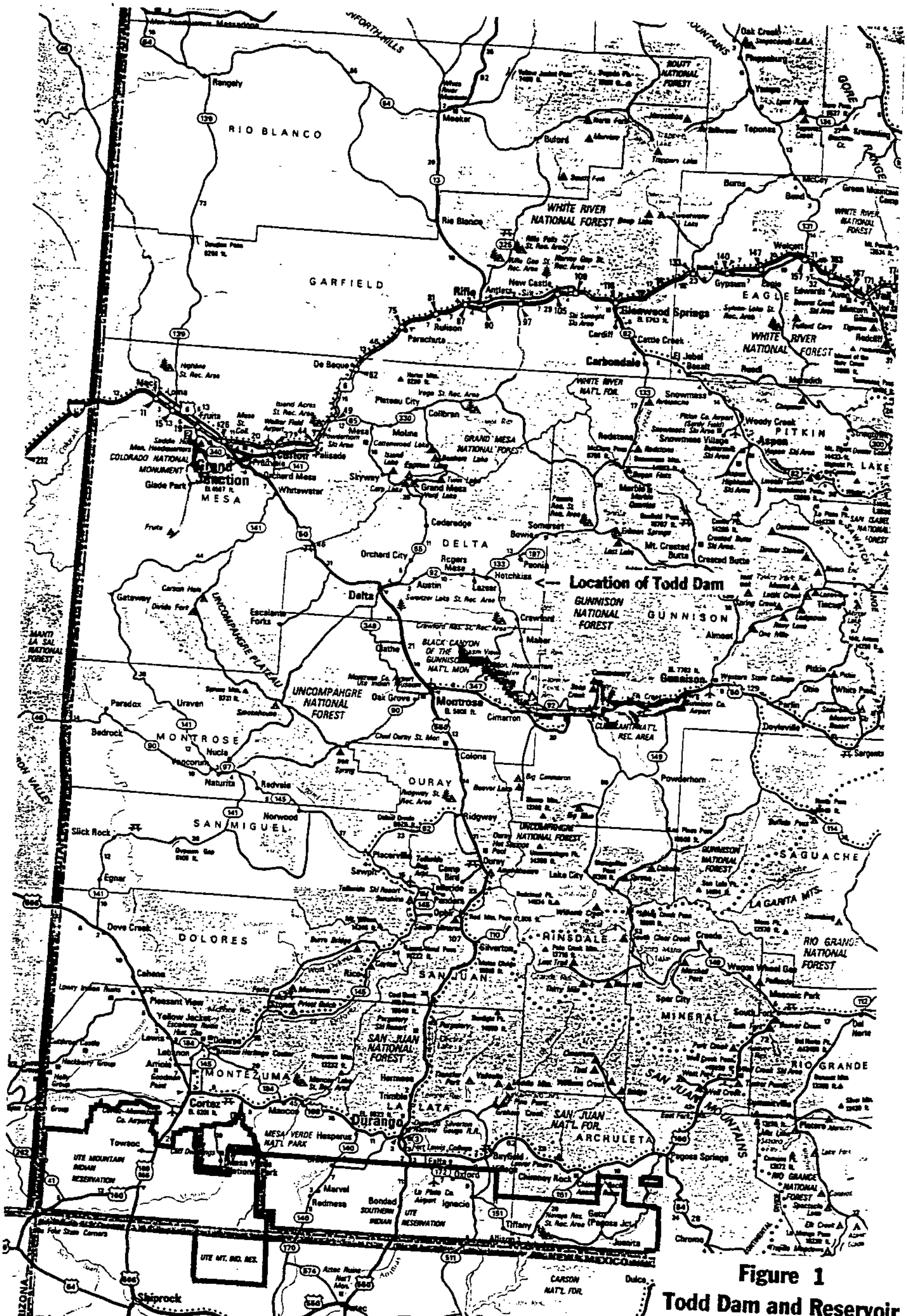


Figure 1

Todd Dam and Reservoir Location Map

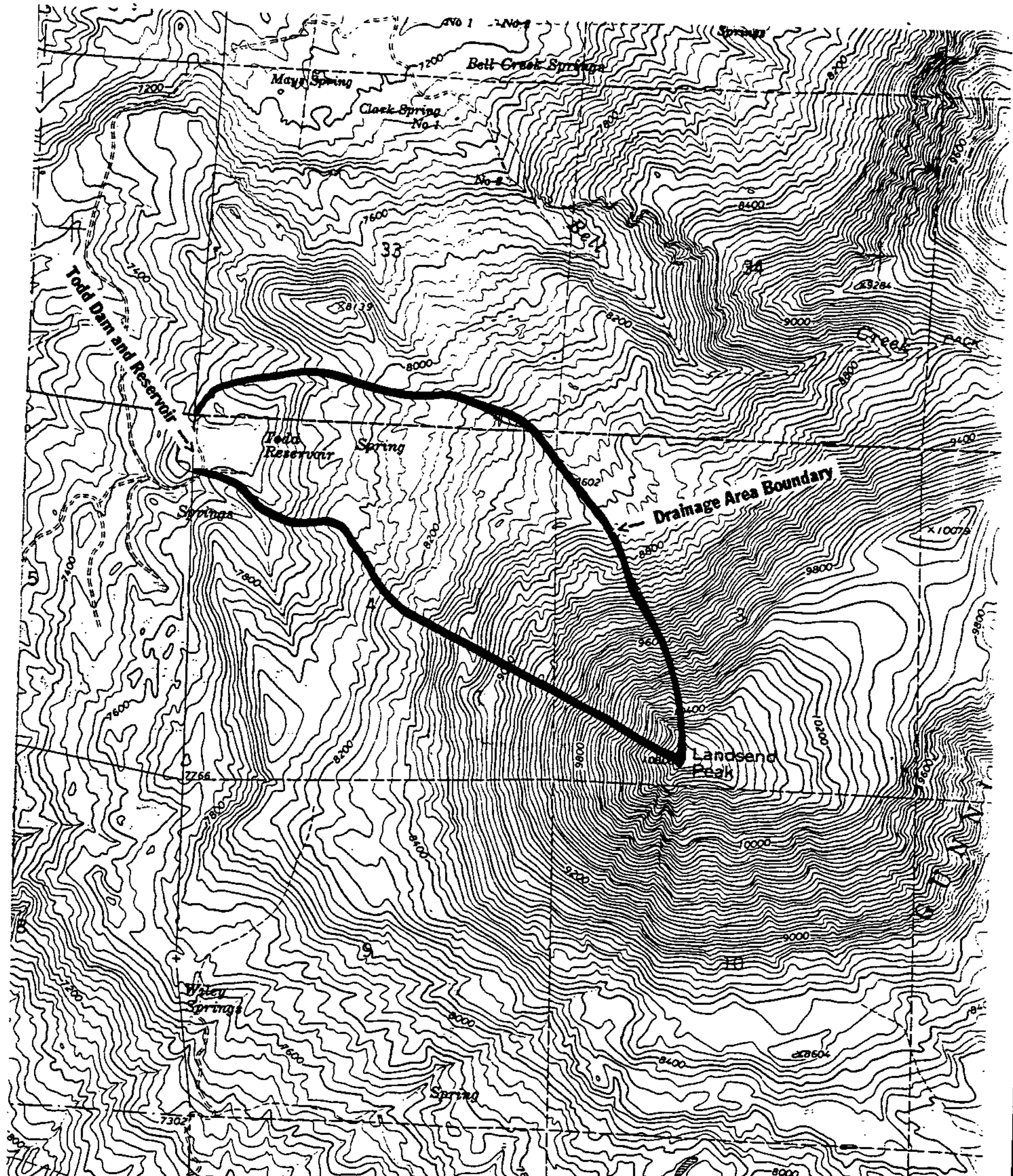


Figure 2
Todd Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The Town of Paonia purchased Todd Reservoir and the springs in 1991. The water storage right for the reservoir is 400 acre-feet, though this report suggests a storage capacity of about 110 acre-feet. The reservoir collects water from a 437 acre watershed on the north side of Landsend Peak (El. 10,800 feet). The reservoir is at elevation 7600 feet.

The combination of springs and spring runoff appear to be adequate in most years to fill the proposed 110 acre-foot reservoir. A visual inspection of the reservoir early this summer indicated that the reservoir was at the level of the trees around the reservoir which is about elevation 980 feet (100 acre-feet). This would suggest that there is adequate water to fill the reservoir in wet years, especially when accounting for the fact that the outlet pipe is apparently stuck open allowing water to be constantly bypassed. Based on this information, the proposed 110 acre-foot storage capacity can be filled in most years.

RESERVOIR

Table 1 shows the elevation-area-capacity values for the reservoir, which was developed from data from the original dam designs in 1905, see Figure 5. The dam is 45 feet high from the crest to the bottom of the intake to the outlet pipe (from original data), but about 64 feet high from the downstream toe to the crest. The original depth of the water in the reservoir is 40 feet, between relative elevations 952 and 992 feet.

The elevations shown are relative, there was no available survey monuments to obtain a precise elevation. Based on the Quad maps, the relative crest elevation of 997 feet is about 7600 feet MSL (plus or minus 10 feet).

The relative water elevation was 968 feet (28 acre-feet) on the day of inspection, 30 feet below the crest of the dam. The water level was at about elevation 980 feet this spring (photos by water system operator showing water near the base of the tree on the embankment).

With improvement of the dam, the reservoir is recommended to have a normal maximum water level of 980 feet (relative elevation) which results in about 110 acre-feet of storage. This would allow 17 feet of freeboard. This assumption may be changed based on more detailed evaluations of the dam.

TABLE 1
TODD RESERVOIR
Elevation – Area – Capacity

Relative Elevation	Area (acres)	Accumulative Capacity (Ac – Ft)	Note
997	15.87	318.6	Top of Dam
996	15.43	302.9	
995	14.99	287.7	
994	14.55	273.0	
993	14.11	258.6	
992	13.67	244.7	
991	13.23	231.3	
990	12.79	218.3	
989	12.36	205.7	
988	11.94	193.5	
987	11.53	181.8	
986	11.12	170.5	
985	10.72	159.6	
984	10.33	149.0	
983	9.95	138.9	
982	9.57	129.1	
981	9.21	119.7	
980	8.86	110.7	Proposed Spillway Crest
979	8.51	102.0	
978	8.17	93.7	
977	7.84	85.7	
976	7.51	78.0	
975	7.19	70.6	
974	6.88	63.6	
973	6.56	56.9	
972	6.26	50.5	
971	5.89	44.4	
970	5.51	38.7	
969	5.12	33.4	
968	4.72	28.4	
967	4.32	23.9	
966	3.91	19.8	
965	3.49	16.1	
964	3.07	12.8	
963	2.64	10.0	
962	2.2	7.5	
961	1.81	5.5	
960	1.47	3.9	
959	1.16	2.6	
958	0.89	1.5	
957	0.65	0.8	Intake to Outlet Pipe
956	0.25	0.3	
955	0.11	0.1	
954	0.05	0.1	
953	0.02	0.0	
952	0	0.0	

DAM EMBANKMENT

The dam is jurisdictional and is a small Class III. The "Rules and Regulations for Dam Safety and Dam Construction" prepared by the Colorado State Engineer, Division of Water Resources state the following criteria should be met:

* a minimum of 5 feet of freeboard,
* an outlet pipe capable of draining the top 5 feet of storage in 5 days, is recommended but not required,
* a crest width equal to the vertical height divided by 5 plus 10 feet, maximum of 25 feet,
* a spillway capable of passing the 100 year flood,
* upstream rip rap to protect the embankment,
* and soils investigation and analysis.

As a note if the reservoir capacity was below 100 acre-feet it would be a minor Class III dam which would lessen some of the safety requirements (e.g. pass 50 year flood, less soils analysis, etc.). This option should be considered during the evaluation phase, if appropriate.

The specific components of the plan to repair the dam are described below. The suggestions are subject to review by the State Dam Safety Engineer (who should be involved with the inspection of the outlet pipe) and subsequent preparation of plans and specifications by a registered professional engineer.

EMBANKMENT: The dam is an earth embankment with following the dimensions based upon a survey during the field inspection:

* 60 feet high (estimated at crest),
* crest length of about 230 feet,
* crest width of 13 feet,
* 3.6H:1.0V upstream and 2.5H:1.0V downstream slopes
* 6 inch diameter outlet pipe,
* 10 foot wide spillway, elevation 997.6 feet.

Figure 4 shows the cross section of the dam at the outlet pipe. Figure 5 shows the front view of the embankment looking upstream from below the dam.

The dam was inspected as part of this study on October 19, 1993. The dam is in a very narrow canyon, the downstream toe of the dam is only about 20 feet wide. The dam is about 64 feet high from crest to downstream toe and was about 30 feet from crest to water level on the day of inspection. The height directly under the crest is estimated to be about 60 feet. The original plans list the height as 45 feet which is from the crest to the outlet pipe.

The crest of the dam is lowest at the center, about 997 feet, and rises toward each abutment to about 1002 feet, see Figure 4. It is difficult to determine if the dam settled or was constructed in this manner. Once the outlet pipe is exposed, the vertical distance from the crest to the pipe can be measured and if about 45 feet, then the dam was constructed with an uneven crest.

The required freeboard must be at least 5 feet but 17 feet is suggested. The free board/reservoir content recommended herein is based on the estimated water supply and an attempt to provide a significant safety factor rather than conducting extensive geotechnical testing. The freeboard could be increased or decreased if the water supply and embankment evaluations indicate otherwise. The recommended reservoir water level and the associated spillway crest elevation should be reconsidered as part of the dam evaluations.

The crest width is 13 feet, the design criteria suggest 22 feet (60 feet divided by 5 plus 10). If necessary this can be achieved by lowering the crest elevation about 3 feet.

The embankment appears to require few repairs, there was no sign of seepage around the toe. The most significant repair appears to be removal of a tree and placement of rip rap on the upstream face. The large tree on the upstream face of the dam must be removed, along with the roots. Material excavated to remove the tree must be replaced in one foot lifts and compacted. If the roots are deep this could be a major effort.

Rip rap would be placed on the upstream face of the dam, from the elevation of the gate to the normal maximum water surface of elevation 980 feet. The rip rap should be at least 2 feet thick. Rock is assumed to be available from near the reservoir though not obvious on the surface during the inspection. The need for rip rap should be discussed with the Dam Safety Inspector during the evaluation process.

Due to the flat embankment slopes and the large freeboard, this report assumes that soils investigations (e.g. drill holes, test pits) will not be needed. Soils analysis to classify the material may be performed if needed.

The spillway is located about 400 feet to the south on a saddle into an adjacent drainage. The spillway elevation was 997.6 feet, which is the same elevation as the crest. This shows that the spillway has not been used and that all of the water into the reservoir passes through the outlet pipe, evaporates, or seeps into the ground water table. Incidentally the springs around the reservoir are uphill of the reservoir so seepage from the reservoir is not providing spring water.

OUTLET PIPE: The discharge end of the outlet pipe was below the water level on the date of inspection. There was water passing through the pipe (30 to 50 gpm). An attempt was made to place a valve on the downstream end of the pipe to control releases but it had frozen and broken. The upstream gate was not operational, nor visible.

The outlet pipe is a 6 inch diameter steel pipe. The condition of the existing pipe is critical to the economical repair of the dam; excavation to replace the pipe would require complete reconstruction of the dam. Inspection of the discharge end of the pipe indicates that it is a thick walled steel pipe, and appears to be useable.

The condition of the pipe must be checked prior to preparation of repair plans. If the pipe is useable, repair plans are affordable, if not the dam is probably too costly to repair. The recommended procedure to inspect the pipe is to excavate the upstream end of the pipe. This will probably require a coffer dam around the end of the pipe because the water level will be above the pipe.

Once the end of the pipe is uncovered, pass a small video camera as used to inspect well casings, through the pipe. The video camera used by the Division's Dam Safety Engineer is probably too small to pass through the 6 inch pipe. A registered engineer must oversee the inspection and review the video tape. The assumption herein is that the pipe is useable.

A new gate and gate control mechanism will be required. It is assumed that the entire gate structure, including the concrete base must be replaced. A trash rack will be necessary over the gate mechanism to screen out large objects from entering and possibly plugging the pipe.

The outlet pipe should be able to lower the top 5 feet of the reservoir in five days. The capacity between elevations 980 feet and 975 feet is about 40 acre-feet. Table 2 shows the estimated discharge capability of the pipe and shows the discharge averages 3.9 cfs between the two elevations which will release about 39 acre-feet in five days.

SPILLWAY: The spillway must be lowered to relative elevation 980 feet from the present elevation of 997.6 feet. The spillway is not located near the embankment but on a saddle to the south. The excavation should not be a problem and can easily be sized to pass the 50 year flood. For this study the spillway is estimated to have a 15 foot base width and slope upwards at 1 to 1 slopes. The length will be about 200 feet. The bottom and side of the spillway channel must be armored to inhibit erosion.

TABLE 2
TODD DAM & RESERVOIR
OUTLET PIPE DISCHARGE

Reservoir Water Level (feet)	Outlet Pipe Discharge (cfs)	Notes
997	4.8	Dam Crest Elevation
996	4.7	
995	4.7	
994	4.6	
993	4.6	
992	4.6	
991	4.5	
990	4.5	
989	4.4	
988	4.4	
987	4.4	
986	4.3	
985	4.3	
984	4.2	
983	4.2	
982	4.2	
981	4.1	
980	4.1	Proposed Normal Water Elevation
979	4	
978	4	
977	3.9	
976	3.9	
975	3.9	
974	3.8	
973	3.8	
972	3.7	
971	3.7	
970	3.6	
969	3.6	
968	3.5	
967	3.5	
966	3.4	
965	3.4	
964	3.3	
963	3.3	
962	3.2	
961	3.1	
960	3.1	
959	3	
958	3	
957	2.9	
956	2.9	
955	2.8	
954	2.7	
953	2.7	
952	2.6	Intake to Outlet Pipe

Outlet Discharge Equation: Q=A*(2G*H/sum of losses) ^ .5
Outlet Pipe Diameter: 0.5 feet
Outlet Pipe Area (A): 0.196 square feet
2G is: 64.4
H is depth of water above outlet pipe exit 933 ft
Sum of losses is: 7 Empirically Derived

Figure 3
Todd Dam and Reservoir
Cross Section at Outlet Pipe

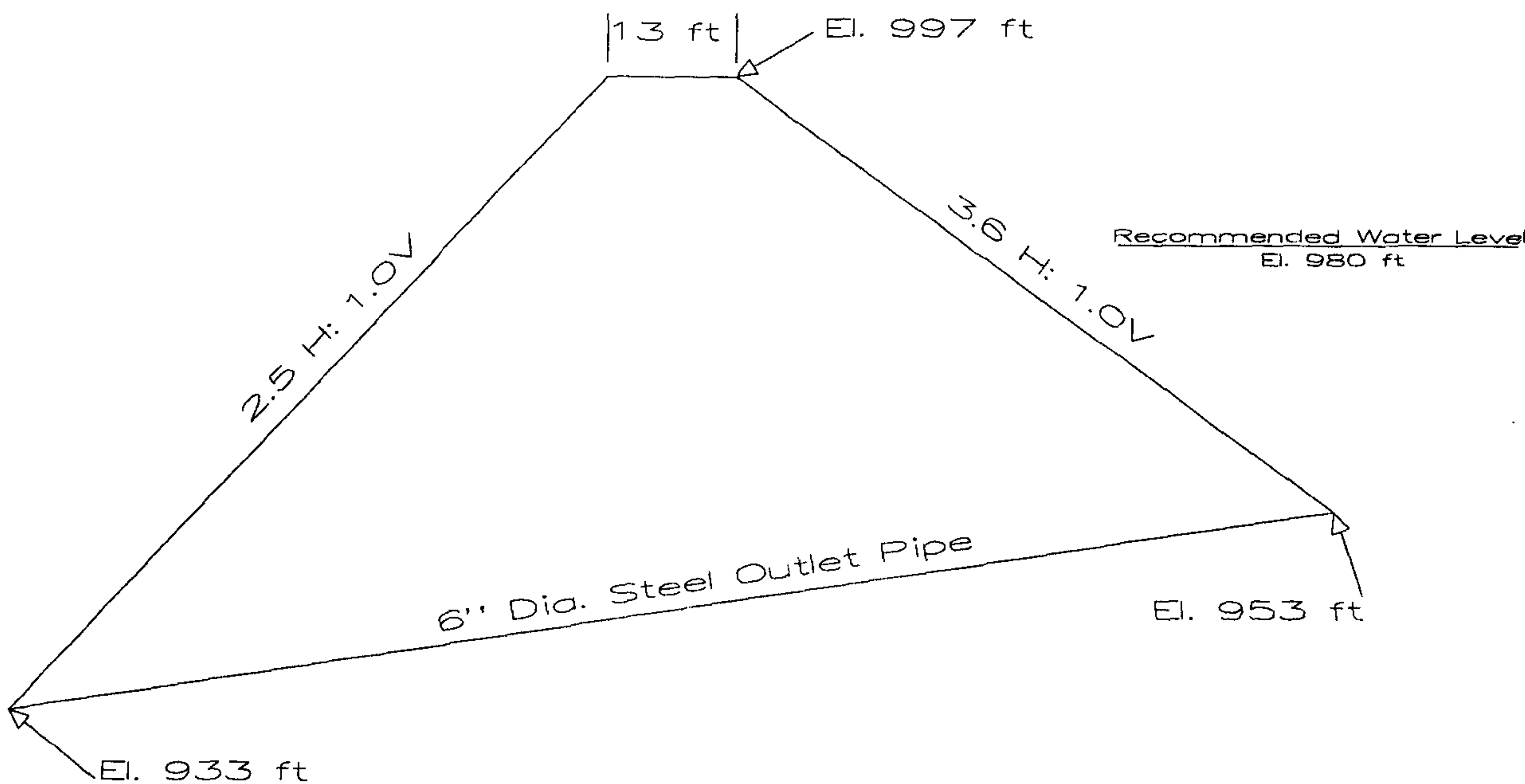
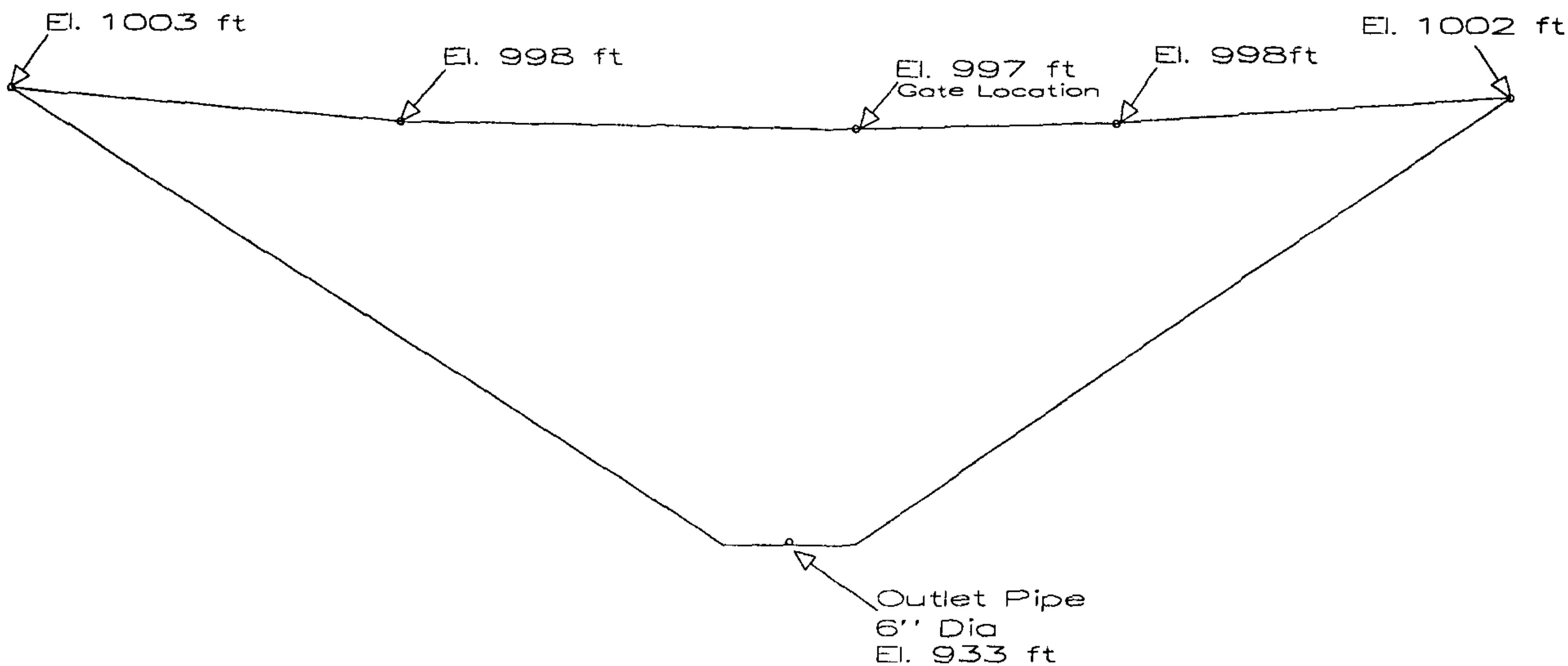


Figure 4
Todd Dam and Reservoir
Cross Section at Dam Center Line



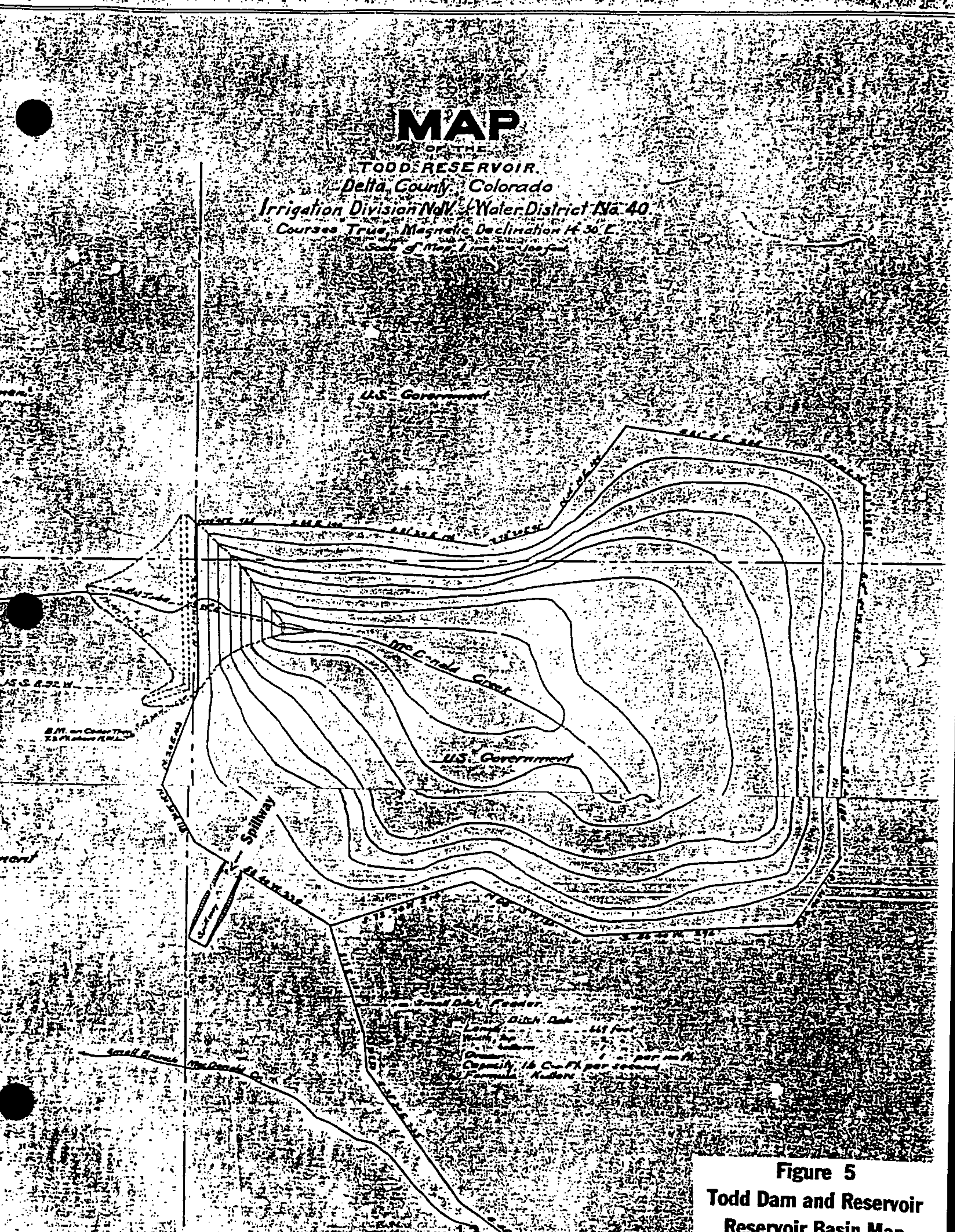


Figure 5
Todd Dam and Reservoir
Reservoir Basin Map

COST ESTIMATE

The estimated cost to raise the water level is shown in Table 2. The unit costs are rough estimates of costs found in rural areas of the state.

Access to the site is difficult due to the distance over steep and narrow roads. The large mobilization cost reflects the access difficulty and the need to widen the existing road to move equipment to the site. The equipment expected to be needed is a backhoe, loader, and truck to haul the rip rap.

The cost to excavate and inspect the outlet pipe is included in the cost even though the Town will probably perform the work prior to construction. The cost of the video camera is based upon information from a company that provides equipment to inspect well casings which costs about $1500 for 5 days. If the Division Dam Safety Engineer can pass his camera through the pipe, the cost would be reduced; however, this is unlikely.

An amount of 30% is added for contingencies, which is higher than the normal 20% because the unit costs are not firm. Engineering and administration is estimated at 15% which includes preparation of plans and specifications and construction observation.

The land is owned by the Town so there is no land cost.

Since the dam is constructed, there would not be any permits required, other than from the State Engineer for repairs. In short there are no environmental compliance requirements, except possible for the access.

TABLE 3
TODD DAM AND RESERVOIR
ESTIMATED CONSTRUCTION COST

Item	Units	Quantity	$/Unit	Cost
Mobilization (Access Road)	ls			$50,000
Embankment				
Remove Tree	ls			$5,000
Rip Rap	cy	1790	$20.00	$35,800
	Embankment Subtotal			$40,800
Outlet Works				
Excavate/Inspect Gate	ls			$5,000
Camera Inspection	ls			$2,000
New Gate and Stem	ls			$5,000
	Outlet Works Subtotal			$10,000
Spillway				
Excavation	cy	2220	$2.00	$4,400
Spillway Rip Rap	cy	370	$20.00	$7,400
	Spillway Subtotal			$11,800
	Total of Above Items			$112,600
	Contingency (30%)			$33,800
	Land Cost			$0
	Field Cost Subtotal			$146,400
	Engineering & Admin (15%)			$22,000
TOTAL ESTIMATED CONSTRUCTION COST				$168,000
Construction Cost per Acre–Foot of Storage				$1,530
Estimated Annual Reservoir Storage in Acre–Feet				110

FINANCING

The Town is assumed to fund the inspection of the outlet pipe which will require about 10 days of equipment and personnel time and about $2000 for the video camera. This cost is included in the construction cost to show the total project cost.

Even if the outlet pipe is useable, it is assumed herein that the Town would need funding to construct the improvements to the dam. Table 4 shows four financing options, all of which assume that the CWCB would finance the total project cost. Options 1 and 2 are standard CWCB financing terms as of December, 1993. Options 3 and 4 are included to show the additional cost to repay the loan in 15 or 10 years, rather than 20 or 30 years.

Option 3 is recommended because the annual repayment is only a few thousand dollars more than the longer periods and will save a considerable amount of interest costs.

RECOMMENDATIONS

Repair of Todd Dam and Reservoir, as described herein, appears to be a relatively inexpensive method to develop raw water storage. The Town is encouraged to pursue repair of the dam. The followings steps are recommended to investigate and if appropriate repair Todd Dam.

1. Drive a backhoe to the dam and excavate the upstream gate for visual and video camera inspection of the outlet pipe. This work is assumed to be performed by Town personnel with oversight by the Town Engineer and State Dam Safety Engineer. If the outlet pipe is useable proceed to the following steps; if not useable, the entire project must be reevaluated. Mark the high water level during 1994 which should be a low runoff year. Soonest summer of 1994 after the reservoir water level drops.

2. Assuming the pipe is useable, prepare plans and specifications for repairs to the embankment and submit to the Dam Safety Engineer. The reservoir storage capacity/water elevation assumed herein should be reevaluated. Soonest late summer of 1994.

3. Apply to the CWCB for financing based upon the costs determined in preparing the plans and specifications. Soonest late summer of 1994.

4. Construct the modifications. Soonest summer of 1995.

TABLE 4
TODD DAM AND RESERVOIR
FINANCING OPTIONS

Option	Construction Cost Estimate	Interest Rate	Years	Annual Cost	Annual Cost per Acre-Foot
1	$168,000	3.0%	20	$11,292	$103
2	$168,000	4.0%	30	$9,715	$88
3	$168,000	3.0%	15	$14,073	$128
4	$168,000	3.0%	10	$19,695	$179

Volume of Reservoir Storage in Acre-Feet: 110

COLORADO WATER CONSERVATION BOARD

SMALL DAM SITE RECONNAISSANCE STUDY

EVALUATION OF:

VICTOR #2 DAM AND RESERVOIR
Sponsored By The City of Victor

By:
HARRIS WATER ENGINEERING, INC.
954 SECOND AVENUE
DURANGO, COLORADO 81301
303-259-5322

February 15, 1994

VICTOR #2 DAM AND RESERVOIR

PLAN DESCRIPTION

Victor #2 Dam and Reservoir is an existing structure on East Fork Creek a tributary of Beaver Creek, about 5 miles northeast of the City of Victor. The reservoir is in the Arkansas River basin. Figure 1 shows the general reservoir location. Figure 2 shows Victor #2 Reservoir and Bison Reservoir. The reservoirs are owned by the City of Victor, the contact persons are:

City of Victor
Victor City Hall
500 Victor Ave., P.O. Box 86
Victor, Colorado 80860
Jim Robinson, Water Superintendent 719-689-2284
Sandy McDougall, Attorney 719-520-9288

#2 Reservoir presently has a capacity of about 180 acre-feet, with a current freeboard of 8 feet. The spillway was lowered 3 feet in 1984 due to safety problems, which decreased the storage by 23 acre-feet. The water in #2 Reservoir is used for municipal purposes in the City of Victor. Also, the City is presently selling about 100 acre-feet of raw water from the reservoir to a local mining company; however, the mining company needs to increase the water supply to about 500 acre-feet.

In order to evaluate the potential of the Victor water system to supply additional water, the mining company has retained Wright Water Engineers to prepare engineering evaluations. Those studies were ongoing as of the date of this report.

In 1986, the City and the CWCB, funded a feasibility study which addressed repairs to #2 Reservoir. The study was performed by Greenhorne and O'Mara, Inc. and was completed in March of 1987. A copy is in the CWCB files. This report summarizes the information in the 1987 report and recommends a plan to most cost efficiently provide municipal water using the City's existing facilities.

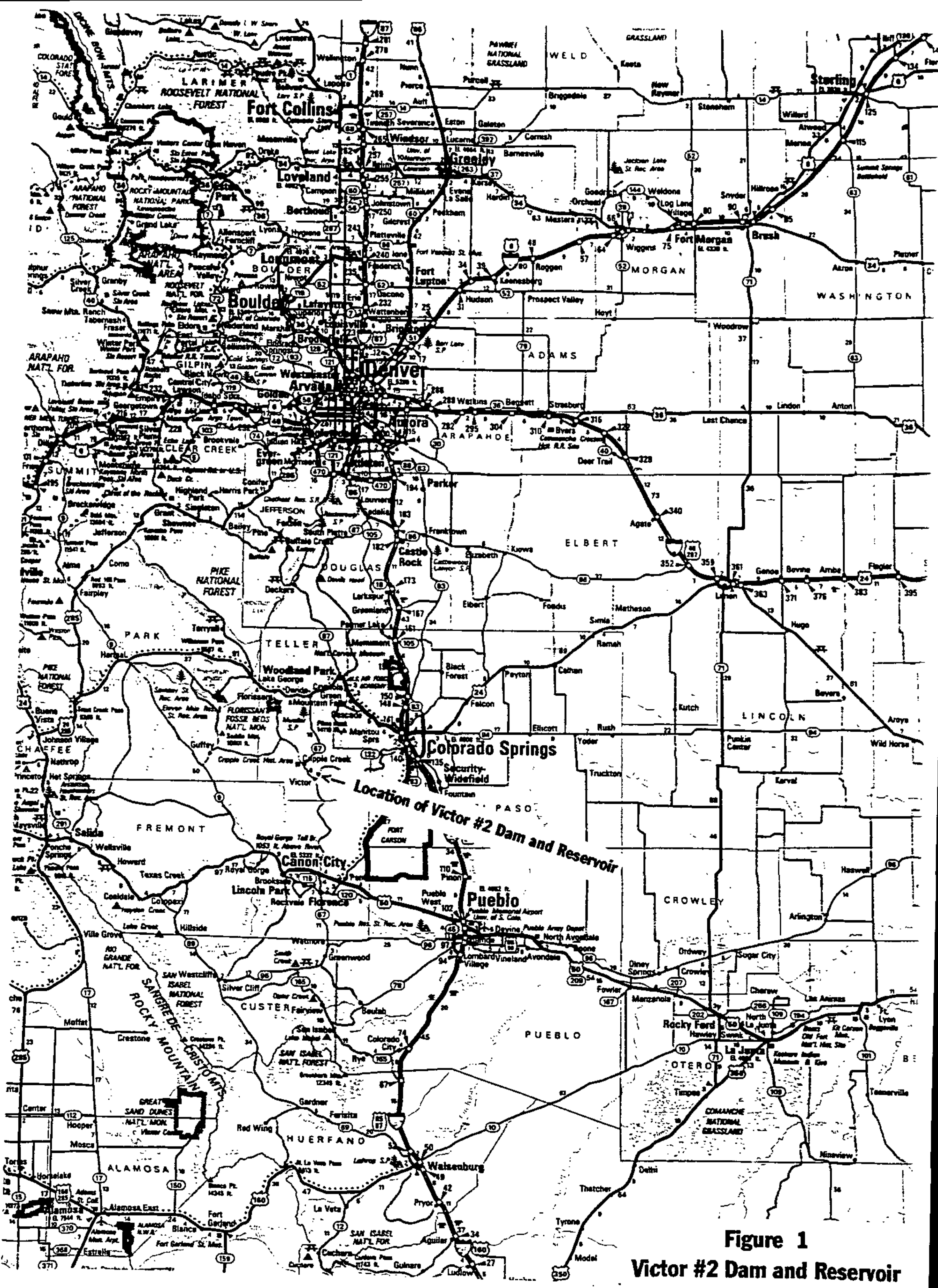


Figure 1
Victor #2 Dam and Reservoir
Location Map

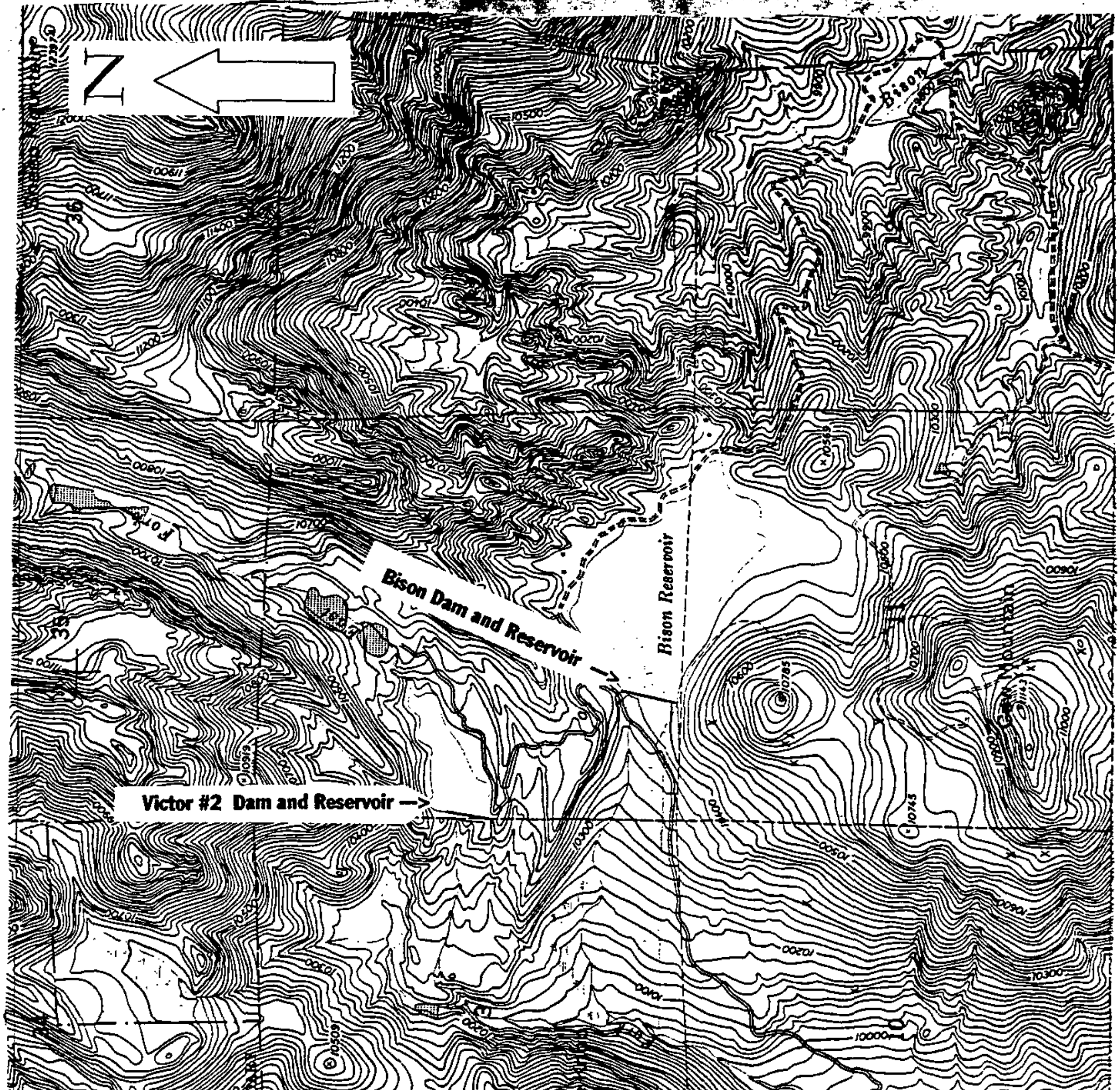


Figure 2
Victor #2 Dam and Reservoir
Dam and Reservoir Site Map

WATER SUPPLY

The water supply for the City of Victor is obtained from the East Fork of West Beaver Creek. The water supply from the drainage is shared with the City of Colorado Springs according to a court decree in 1909 which generally provides that Victor may have up to 0.75 cfs of flows from above the Strickler Tunnel in excess of 2.5 cfs whenever Victor's storage drops below 150 million gallons (460 acre-feet) and the streamflow at Victor's diversion point is below 2.47 cfs.

Greenhorne and O'Mara 1987 report included, as an appendix, a report prepared by Woodward Clyde Engineers in 1976, which estimated the available water supply in East Fork Creek at #2 Reservoir. The study concluded that: "Our correlation indicates average annual runoff from the 3.6 square mile watershed supplying Colorado Springs Reservoirs Nos. 7 and 8 and the Strickler Tunnel should approximate 1,200 acre-feet. Typically the City of Colorado Springs impounds most of this water. Average annual runoff from the 2.5 square mile watershed downstream from the Strickler Tunnel to Victor's reservoirs is estimated to approximate 900 acre-feet, or less than the estimated 1350 acre-feet capacity of Victor's reservoirs". The 1350 acre-feet of reservoir capacity includes #2 Reservoir and Bison Reservoir.

The Woodward-Clyde water supply estimate does not appear to consider the 0.75 cfs which Victor is entitled to, at times, from above the Strickler Tunnel. Assuming that the 0.75 cfs would be in priority for two months in an average year, the average Victor water supply would be increased by about 90 acre-feet, to approximately 990 acre-feet annually.

The Woodward-Clyde report concludes that the water supply in the East Fork Creek drainage is the water constraint for the City not the reservoir capacity. The City is pursuing water rights and storage on Beaver Creek to address this issue. This appears to be the situation, assuming that Bison Reservoir storage can be used which is presently not the case because of recreation use. The branch pipeline from Bison Reservoir to the water treatment has not been used in many years and may need improvements.

The 1987 report estimated the 2025 Victor water demand at 370 acre-feet an increase from today of about 260 acre-feet. The supply to the mining company is presently about 100 acre-feet which is in addition to the City requirement. The total water demand today is about 330 acre-feet. The mining company would like to increase its water usage to about 500 acre-feet in 1994, which would make the 1994 total water demand about 610 acre-feet; that would increase to about 870 acre-feet in 2025.

RESERVOIR

Tables 1 and 2 show the elevation-area-capacity values for #2 Reservoir and Bison Reservoir, respectively. The tables were developed from information from the Division Water Engineer's office in Pueblo.

There is a discrepancy in the Bison Reservoir capacity of exactly 100 acre-feet. The original elevation-capacity data is shown in Table 2 which shows a capacity of 1048 acre-feet. The dam safety engineer's reports and Woodward-Clyde used 1148 acre-feet. The smaller value of 1048 acre-feet is used herein because it is based on the original data submitted when the dam was built. The difference does not affect the conclusions herein.

The combined capacities of the reservoirs in their present condition is estimated to be 180 acre-feet in #2 Reservoir and 1048 acre-feet in Bison Reservoir; for a total of 1228 acre-feet.

The City uses #2 Reservoir for municipal water but currently does not use Bison Reservoir because it is used for fishing and recreation by City residents. The City would prefer to repair and/or enlarge #2 Reservoir so that Bison Reservoir can remain recreation and fishery.

TABLE 1
VICTOR #2 DAM & RESERVOIR
Elevation– Area–Capacity

Elevation	Area (acres)	Accumulative Capacity (Ac–Ft)	Description
10399			Top of Dam
10398			
10397			
10396			
10395			
10394			
10393			Previous Spillway El. 10392.2 ft
10392	16.7	206	
10391	16.36	190	Present Spillway El. 10390.5 ft
10390	15.74	174	
10389	15.22	158	
10388	14.46	143	
10387	13.92	129	
10386	13.37	116	
10385	12.83	102	
10384	12.33	90	
10383	11.75	78	
10382	11.05	66	
10381	10.31	56	
10380	9.55	46	
10379	8.55	37	
10378	7.7	29	
10377	6.58	21	
10376	5.74	15	
10375	4.63	10	
10374	3	6	
10373	2.25	4	
10372	1.49	2	
10371	0.88	1	
10370	0.35	0	

TABLE 2
BISON DAM & RESERVOIR
Elevation – Area – Capacity

Depth (feet)	Elevation (feet)	Accumulative Capacity (Ac–Ft)	Description
23	10386		Top of Dam
22	10385		
21	10384		
20	10383		
19	10382		
18	10381	1048	Spillway Crest
17	10380	960	
16	10379	869	
15	10378	785	
14	10377	701	
13	10376	624	
12	10375	541	
11	10374	465	
10	10373	395	
9	10372	326	
8	10371	258	
7	10370	197	
6	10369	142	
5	10368	96	
4	10367	72	
3	10366	54	
2	10365	38	
1	10364	19	
0	10363	0	

DAM EMBANKMENT

The #2 Reservoir is in poor condition, according to the Dam Safety Inspector, which may in the future result in a zero storage restriction by the State Engineer. Major rehabilitation will be required at some point in the future regardless if the dam is enlarged or not which would, as presently operated, would eliminate most of Victor's municipal water supply.

The 1987 report included a very thorough evaluation and description of construction work required to repair #2 Reservoir, refer to that report for details. Generally the dam would be raised 5.5 feet and the downstream slope flattened to 2.25H:1.0V. The construction cost was estimated to be $520,000.

The repairs were never constructed, probably because the cost was so large for 23 acre-feet. If there was a zero storage restriction the $520,000 cost for 210 acre-feet may be more feasible.

FINANCING

Based on the 1987 report the City tried to obtain grants from the Department of Local Affairs in combination with a CWCB loan, but was not successful.

In 1993, the City was required to construct a new wastewater treatment plant which is expected to increase the monthly water and sewer bill from about $30 to $60.

The bottom line is that the rate payers probably cannot afford to pay for an expensive repair to #2 Reservoir, because the monthly rates are very high. The best plan is to attempt to make best use of the existing facilities and delay major water supply costs as long as possible, while retiring some of the other debt. Concurrently, cooperate with the mining company to provide their water needs, though their 500 acre-foot need may be difficult in dry years.

RECOMMENDATIONS

The high City water/sewer rates due to repayment of the wastewater plant, are a prime factor in the following recommendations. Also, the water requirement of the mining company will apparently increase from about 100 acre-feet per year to about 500 acre-feet per year which is also a major factor.

The mining company is having Wright Water Engineers evaluate the Victor water system, in detail, to determine if the water rights and storage capacity can supply the City and mining needs. The findings and recommendations herein are general in nature based on cursory information and evaluations, the detailed studies may result in different recommendations.

The recommendations should be taken in the light of an outsider who does have to implement the suggestions (e.g. use of Bison Reservoir for water storage).

1. Increasing the storage capacity in East Fork Creek does not improve the City's water supply because there is adequate storage to utilize most of the annual runoff. The only advantage of increasing the storage at #2 Reservoir is so that Bison can remain solely for fishing and recreation. Additional storage would be useful on West Beaver Creek if there is unappropriated water available to store under the water rights held by the City.

2. Because of the high cost to rehabilitate #2 Dam, the recommended plan is to develop and rigorously implement a maintenance and monitoring program, in an attempt to delay further storage restrictions by the State Engineer. The Dam Safety Engineer is concerned about the condition of #2 dam and has indicated a zero restriction may be imposed. Reading the piezometer's is one method to monitor the internal condition of the embankment, which should be performed regularly while the dam is near full capacity; assuming the readings show the water levels are acceptable, further restrictions are less likely. At some point in the future, the State Engineer, may impose a severe restriction and the City should prepare for this occurrence; setting aside some of the income from the mining company is one possibility.

3. The City has adequate storage capacity in #2 and Bison Reservoirs for the present water demand with little impact; but if the mining demand increased to 500 acre-feet, the impact is significant. The City has pipelines from both reservoirs to the water treatment plant, though repairs and replacement of sections are needed to both pipelines. Using both reservoirs allows the City to have adequate storage at nearly no additional cost for the near term. In the long term, it is recommended that the City plan for major rehabilitation of the reservoirs.

4. The impact of using both reservoirs to provide water from June through October is small, unless the mining company wants 500 acre-feet annually. (1) Assuming the current water use, the peak 5 month period is estimated to be 200 acre-feet of the current 330 acre-foot annual demand. In the worst case there is no inflow to either reservoir. #2 Reservoir would be emptied first (assume 150 acre-feet useable), the remaining 50 acre-feet would be released from Bison Reservoir. The Bison Reservoir water level would be lowered about 0.5 feet. (2) A second option assumes a 1994 water use of 760 acre-feet (260 for Victor and 500 for mining), with 460 acre-feet used from June through October; the impact on Bison would be to lower the water level about 7 feet.

5. The current mining water use of 70 to 100 acre-feet has a small impact on the Victor water supply; however, increasing the demand to 500 acre-feet would have a major impact. Using the full storage of both Victor Reservoirs, would probably be adequate to supply the 500 acre-foot demand (except maybe in very dry years) but the impact on the Bison Reservoir water level would be significant. The work being performed for the mining company to quantify the Victor water system should evaluate as many alternative water sources as is realistic, particularly if the it is found that the Victor water system cannot provide the 500 acre-foot demand. If Victor is capable of and decides to provide the 500 acre-feet, the remuneration should be commensurate with the impact on the City and the general shortage of water in the basin.

SMALL DAM SITE RECONNAISSANCE STUDY

INVENTORY OF DAM SITES
39 SITES IDENTIFIED

This attachment includes one page descriptions of the 39 dam sites identified during the inventory task of the Small Dam Site Reconnaissance Study. The information was obtained through phone conversations.

The sites are in alphabetical order by sponsoring entity.

Entity: Battlement Mesa Water Conservancy District
Ed Currier, President 242-0905

Dam Name: Currier Reservoir

Location: T9s, R93w, Section 16, USGS Quad Map - South Mamm

County - Mesa, nearest town/city - Collbran

Source of Water: Stream - Carter Gulch

Water Rights - Transfer some of storage rights from Owens Reservoir

Stream Gage Records -

Dam Information: Options between 30 and 35 feet high, and 100 to 200 acre-feet. About 200 cy/acre-foot of storage. Located on land owned by Currier.

Existing Reports & Data: Little topography, rough hydrology. Ed is an engineer and could obtain much of the data.

Need for Water: Use - Irrigation

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Overcome inertia by making some cost estimates and financing options to see if there is any potential.

Entity: Big Stick Ditch Company

Glenn Dorell 247-4148

Dam Name: Big Stick Ditch Reservoir

Location: T34W, R11N, Section 4, 8 or 9, USGS Quad Map -
Stream Name - Soldier Creek, County - LaPlata,
nearest town/city - Durango

Source of Water: Stream - Diversions from Lightner Creek through the Big Stick Ditch, a transbasin diversion so not subject to LaPlata River compact
Water Rights - rights on Lightner Creek
Stream Gage Records - diversion records from Lightner Creek

Dam Information: SCS has performed some analysis

Existing Reports & Data: SCS data

Need for Water: Use - irrigation and possibly augmentation for domestic wells
When needed - immediately
Ability to Pay -
Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
The contact did not return my call.

Entity: Central Colorado Water Conservancy District
Tom Cech, manager 330-4540

Dam Name: Koenig Pit Reservoir

Location: T , R , Section , USGS Quad Map -

County - , nearest town/city -

Source of Water: Stream - filled by Lupton-Bottoms Ditch but don't have agreement yet.

Water Rights -

Stream Gage Records -

Dam Information: Line sides of gravel pit to store water. About 1500 acre-feet. $400 per acre-foot construction cost.

Existing Reports & Data: none

Need for Water: Use - augmentation water and exchanges with municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Probably have money to construct Koenig but would be interested in looking at CWCB financing. I suggested that he contact VanSciver.

Entity: City of Delta
Delta, Colorado

Ron Alexander 874-7566

Dam Name: Big Battlement

Location: T , R , Section , USGS Quad Map -

County - Delta, nearest town/city - Cedaredge

Source of Water: Stream - tributary

Water Rights -

Stream Gage Records -

Dam Information: Class II Dam, currently restricted to 4' above bottom, currently 20' plans to raise to 24'

Existing Reports & Data: City has tentative agreement with Cool Water Hydro to rehab and enlarge dam for hydropower production and lease to agriculture. No designs or cost estimates. Kuiper was the original engineer. Piping in the embankment.

Need for Water: The City presently receives its water from Project 7 which will be adequate for 10 to 20 years. The City has yearly agriculture leases for the small amount of water from Big Battlement. Long term supply plans are to use Big Battlement water for additional municipal supply. The hydro power production can occur and provide water for either municipal or irrigation use.

When needed - as soon as hydropower available

Ability to Pay - hydropower pay most of cost

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
If Delta were to repair and enlarge reservoir, need plan, cost estimates and financing.

Entity: Dolores Water Conservancy District
Cortez, Colorado
John Porter, manager 565-7562

Dam Name: Plateau Reservoir

Location: T , R , Section , USGS Quad Map -

County - Dolores, nearest town/city - Dolores

Source of Water: Stream - Plateau Creek

Water Rights - transferred storage rights from other locations, total of about 17,000 acre-feet

Stream Gage Records -

Dam Information: 245 foot high concrete arch, 17,000 acre-foot capacity, 22,000 cfs spillway. Site used as lower reservoir for pumped back storage.

Existing Reports & Data: Studies performed by Authority, Bureau of Reclamation, and Beck Engineers. Most data exists but needs current unit costs.

Need for Water: Use - peaking power, recreation, fish, irrigation, municipal

When needed - if Glen Canyon peaking power is reduced may be needed sooner than expected.

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Increased demand for peaking power.

Entity: Dolores Water Conservancy District
Cortez, Colorado
John Porter, manager 565-7562

Dam Name: Bear Creek Reservoir

Location: T , R , Section , USGS Quad Map -

County - Dolores, nearest town/city - Dolores

Source of Water: Stream - Bear Creek

Water Rights - MVIC will transfer to DWCD

Stream Gage Records -

Dam Information: Bear Creek is a tributary to Dolores River, dam would be in upper part of drainage.

Existing Reports & Data: SCS has performed some studies but not sure what has been done.

Need for Water: Use - municipal by exchange

When needed - Not immediate but Dolores Valley is growing and demand increases consistently.

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
New and/or updated engineering and costs, if feasible funds for further development and construction.

Entity: Dolores Water Conservancy District
Cortez, Colorado
John Porter, manager 565-7562

Dam Name: Monument Creek Reservoir

Location: T , R , Section , USGS Quad Map -

County - Dolores, nearest town/city - Dove Creek

Source of Water: Stream - Monument Creek

Water Rights - filled with Dolores Project water, DWCD has storage rights

Stream Gage Records -

Dam Information: Was part of the Dolores Project but was removed from the project and became a state facility. Project is authorized by CWCB but funding problems.

Existing Reports & Data: Thorough studies by Reclamation.

Need for Water: Use - municipal, recreation, fish, wildlife

When needed - need now

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Partners to help pay for costs.

Entity: City of Durango
949 East Second Avenue, Durango, Colorado 81301
Jack Rogers, Public Works Director 385-2860

Dam Name: Terminal Reservoir

Location: T , R , Section , USGS Quad Map -

County - LaPlata, nearest town/city - Durango

Source of Water: Stream - offstream site, water diverted to reservoir from Florida and Animas Rivers

Water Rights - Direct flow rights from both rivers that allow storage and use

Stream Gage Records - diversion records

Dam Information: Raise dam about 20 to 25 feet to increase capacity from about 230 acre-feet to no more than 1500 acre-feet.

Existing Reports & Data: Geotechnical report on dam and feasibility study report.

Need for Water: Use - municipal

When needed - within 6 years

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
City of Durango is taking steps to evaluate the reservoir sites and obtain the necessary permits. No outside assistance is needed at the present time, the City can bond for 3.5% for 20 years. May apply to CWCB in future when ready to construct enlarged reservoir.

Entity: City of Fort Morgan

Jack Odor, City Engineer (consulting) 867-5298
Kevin Crago, Public Works Director 867-3001

Dam Name: No dam site but need a raw water storage location.

Location: T , R , Section , USGS Quad Map -

County - , nearest town/city -

Source of Water: Stream - Pipeline from Carter Lake with NCWCD

Water Rights -

Stream Gage Records -

Dam Information: none

Existing Reports & Data: none

Need for Water: Use - municipal, possible industrial for PSCO

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Fort Morgan is a participant in the NCWCD pipeline to Broomfield and will be responsible for construction of a 90 mile pipeline to Fort Morgan. The reservoir would be used to provide peak demands to reduce the size of the pipeline. A site has not been identified. There are also several possible partners including PSCO and Morgan County Quality Water Association (sp?).

Work for my study would involve reviewing possible sites and making some costs estimates to evaluate the sites.

Entity: Fruitland Mesa Water Conservancy District
Don Meeks, Board member 921-5757
82551 Hiway 92, Maher, Colorado 81421

Dam Name: Backmeadow Reservoir

Location: T , R , Section , USGS Quad Map -

County - Montrose, nearest town/city -

Source of Water: Stream - Fill from decreed ditch, will need to convert divert diversion to storage.

Water Rights -

Stream Gage Records -

Dam Information: About 60 acre-feet, good dam site.

Existing Reports & Data: none

Need for Water: Use - irrigation, may be some domestic potential

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
On Meeks property. Needs initial engineering to determine economics.

Entity: Fruitland Mesa Water Conservancy District
Don Meeks, Board member 921-5757
82551 Hiway 92, Maher, Colorado 81421

Dam Name: Gould Reservoir

Location: T , R , Section , USGS Quad Map -

County - Montrose & Delta, nearest town/city -

Source of Water: Stream - Crystal Creek

Water Rights - conditional decrees for enlargement

Stream Gage Records -

Dam Information: The reservoir enlargement was part of the Fruitland Mesa Project proposed by USBR. Significant studies have been performed.

Existing Reports & Data: USBR studies.

Need for Water: Use - irrigation, may be some domestic potential

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Needs new economic evaluation as stand alone reservoir. Should be able to use USBR data and update to current unit costs. Meets local water needs the best but all irrigation, domestic use is in the future somewhere.

Entity: Fruitland Mesa Water Conservancy District
Don Meeks, Board member 921-5757
82551 Hiway 92, Maher, Colorado 81421

Dam Name: Soap Creek Reservoir

Location: T , R , Section , USGS Quad Map -

County - Montrose & Delta, nearest town/city -

Source of Water: Stream - Crystal Creek

Water Rights - conditional decrees, difficult to due diligence

Stream Gage Records -

Dam Information: The reservoir was part of the Fruitland Mesa Project proposed by USBR. Significant studies have been performed. Build as stand alone then use to supply downstream calls to Uncompahgre Water Users and Redlands. One proposal to move rights to Blue Mesa Reservoir but may lose half of storage.

Existing Reports & Data: USBR studies.

Need for Water: Use - exchange for irrigation and may be some domestic potential

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Needs new economic evaluation as stand alone reservoir. Should be able to use USBR data and update to current unit costs. Can best meet potential demands on the Gunnison River, need tunnel to meet local irrigation demands.

Entity: Granby Ditch and Reservoir Company

Ernie Buchhein 856-3932

Dam Name: Granby Reservoir #12

Location: T , R , Section , USGS Quad Map -

County - Delta, nearest town/city - Cedaredge

Source of Water: Stream - headwater of small tributary, Dirty George Creek

Water Rights - yes

Stream Gage Records -

Dam Information: Dam has been under a 5 foot restriction for 6 years or more. Needs a toe drain about 600 feet long. Access to dam is over an extremely rough road which is on Forest Service land who will not allow improvements. Adjacent to City of Delta's Big Battlement Reservoir which is also under consideration for improvement.

Existing Reports & Data: none, other than dam safety reports

Need for Water: Irrigation Use 700 shares

When needed - now

Ability to Pay - about $1 to $2 per share to fix

Local Support -

Environmental Issues: road access

What Does Project Need to be Constructed:
engineering plans, economic evaluation and financing

Entity: Grand Mesa Water Conservancy District
P.O. 129 Cedaredge, CO 81413
Bud Burgess 856-3347

Dam Name: Cactus Park

Location: T , R , Section , USGS Quad Map -
Stream Name - offstream, near LaRoux Creek
County - Delta, nearest town/city - Cedaredge

Source of Water: Stream - offstream, could collect water from several different streams including LaRoux, Surface, and Current Creeks. Could also reregulate releases from upstream reservoirs on Grand Mesa. Water available about 95% of time. Power production on mesa with smaller reservoirs then reregulated by Cactus Park. Also, senior rights downstream, junior upstream, try to
Water Rights - Conditional rights, 1961, for about 30,000 acre-feet. Jointly held with North Fork WCD due to connection with Overland Canal.
Stream Gage Records - Hydrology study performed

Dam Information: Maximum size is 30,000 acre-feet, looks like 15,000 acre-feet is better size for demands. Land is privately owned.

Existing Reports & Data: Reclamation performed detailed studies in 1970's and looked at alternatives. Drilled site, surveys. Western Engineers performed more studies. CWCB funded a hydrology study performed by PRC. Adequate data for appraisal evaluation.

Need for Water: Use - irrigation, no near term municipal water demand but could be some in 10 to 20 years, questionnaire showed need for about 15,000 acre-feet
When needed - irrigation water immediately
Ability to Pay - Cost this year is $20/cfs, survey showed willingness to be $20 to $50/cfs.
Local Support - Grand Mesa WCD would be sponsoring entity, Mr. Burgess appears to be committed to project.

Environmental Issues:

What Does Project Need to be Constructed:
Updated economics and paying demand.

Entity: City of Greeley

Nancy Koch 350-9816

Dam Name: Milton-Seaman Reservoir

Location: T , R , Section , USGS Quad Map -

County - Larimer, nearest town/city - Greeley

Source of Water: Stream - North Fork of Poudre

Water Rights - 10,000 acre-feet conditional, 1991; will need additional conditional

Stream Gage Records -

Dam Information: Initially looked at earth structure to enlarge existing dam. RCC downstream needs to be considered.

Existing Reports & Data: Feasibility level designs, costs, hydrology for firm yield. $2400/acre-foot of firm yield.

Need for Water: Use - municipal

When needed - not immediately, one of the future alternatives

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Water rights are junior to Fort Collins which may build dam upstream which will reduce the yield in half.

Looking for partners. Not much that CWCB could assist with.

Entity: Henrylyn Irrigation District
P.O. Box 85, Hudson, Colorado
Butch Gergen, manager 536-4702

Dam Name: Prospect Reservoir

Location: T , R , Section , USGS Quad Map -

County - Weld, nearest town/city - Hudson

Source of Water: Stream - Sand and Lost Creeks, fill with ditch water.

Water Rights - District has direct flow and storage decrees that are not tied to a particular facility, can be moved around. The decrees for the new facilities would be junior.

Stream Gage Records -

Dam Information: About 40 feet high with long dike, presently about 6300 acre-feet, could be enlarged to about 12,000 acre-feet. District owns land for enlargement.

Existing Reports & Data: none

Need for Water: Use - Irrigation primarily, may be some municipal.

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
The delivery ditch is presently about 15 feet above the reservoir water level, idea is to raise reservoir so there is minimal drop from ditch to reservoir.

Need appraisal engineering to determine if there is technical and economic potential.

Entity: Henrylyn Irrigation District
P.O. Box 85, Hudson, Colorado
Butch Gergen, manager 536-4702

Dam Name:

Location: T , R , Section , USGS Quad Map -

County - Weld, nearest town/city - Hudson

Source of Water: Stream -

Water Rights - District has direct flow and storage decrees that are not tied to a particular facility, can be moved around. The decrees for the new facilities would be junior.

Stream Gage Records -

Dam Information:

Existing Reports & Data:

Need for Water: Use - Irrigation primarily, may be some municipal.

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:

Entity: Henrylyn Irrigation District
P.O. Box 85, Hudson, Colorado
Butch Gergen, manager 536-4702

Dam Name: Bootleg Reservoir

Location: T , R , Section , USGS Quad Map -

County - Weld, nearest town/city - Hudson

Source of Water: Stream - Boxelder Creek

Water Rights - District has direct flow and storage decrees that are not tied to a particular facility, can be moved around. The decrees for the new facilities would be junior.

Stream Gage Records -

Dam Information: Historically dam has primarily been used for flood control. Looked at rehab. and found it would take about $100,000 to repair but not adequate benefits so breached rather than continue liability. Capacity would be about 1700 acre-feet.

Existing Reports & Data: Corp in Omaha, performed some studies in relation to flood control.

Need for Water: Use - Irrigation primarily, may be some municipal.

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Site is only about 5 miles from new airport, may be possibility of site providing water to airport in some manner. The District has not been able to get the attention of FAA or others to evaluate possibility.

Needs updated appraisal engineering and cost estimate also contacts with airport to determine if there is any potential use.

Entity: City of Idaho Springs
P.O Box 907 Idaho Springs, Colorado 80452
Dennis Jorgenson, water manager 567-2400
Bob Jones, Mayor

Dam Name: Idaho Springs

Location: T , R , Section , USGS Quad Map -

County - Clear Creek, nearest town/city -

Source of Water: Stream - Chicago Creek

Water Rights - 150 acre-feet, conditional for 1200 acre-feet

Stream Gage Records -

Dam Information: dam is 13 miles from town, restricted to 75 acre-feet of present 150 acre-foot capacity. Enlargements to 1200 acre-feet have been studied.

Existing Reports & Data: Have surveys and information on dam but he didn't have the data at hand, would have to find it. Surveys, costs estimates, hydrology. Approved exchange agreement with Coors.

Need for Water: Use - municipal and industrial. Has been talks with Coors in past to jointly build reservoir for Coors and Idaho Springs.

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Considering annexing 4000 acres between City and Blackhawk.

Construction would provide excess water in water short drainage but presently not other buyers.

Need affordable financing, not sure what would be required.

Entity: City of Idaho Springs
P.O Box 907 Idaho Springs, Colorado 80452
Dennis Jorgenson, water manager 567-2400
Bob Jones, Mayor

Dam Name: Mattie Reservoir

Location: T , R , Section , USGS Quad Map -

County - Clear Creek, nearest town/city -

Source of Water: Stream - Chicago Creek

Water Rights - 10-20 acre-feet, have water rights

Stream Gage Records -

Dam Information: Old mining reservoir that the City owns, 3 miles from treatment plant.

Existing Reports & Data: apparently none

Need for Water: Use - municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Serious planning for the City to provide water to Central Blackhawk and land in between. If so the city will need additional water. Existing treatment plant is about 1.2 mgd.

Entity: Town of Kremmling
William Koelm 724-3249

Dam Name: Jones #2

Location: T , R , Section , USGS Quad Map -

County - , nearest town/city -

Source of Water: Stream -

Water Rights -

Stream Gage Records -

Dam Information: Add 12 feet, cost about $200,000

Existing Reports & Data: Report from Wheeler & Associates due 9/25/93.

Need for Water: Use - municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Engineering is not needed, I offered to look at financing. He is not sure CWCB funds are needed but will call me if he would like to have his project included in list as "notification".

Entity: LeRoux Creek Water Users Association
P.O Box 130 Hotchkiss, Colorado 81419
Thomas Avery - President 872-3911
Joanne Fatan - Engineer 874-5342

Dam Name: Sheepsdrive Reservoir

Location: T , R , Section , USGS Quad Map -

County - Delta, nearest town/city - Hotchkiss

Source of Water: Stream - offstream

Water Rights - Water rights for 30 reservoirs apparently not allocated to sites. Not sure how it works but Fatan was comfortable.

Stream Gage Records -

Dam Information: A breached dam that is about 20' high and stored about 200 acre-feet, includes a dike on one side of reservoir. Unrated classification.

Existing Reports & Data: No reports.

Need for Water: Use - irrigation for orchards, 5400 shares based upon 5400 acre-feet of storage but proportioned since there is not that much storage.

When needed - Have storage rights for 5400 acre-feet but only store about 4000 acre-feet. Always looking for ways to expand capacity. Needed especially in dry years.

Ability to Pay - Present O&M about $2.50/share. Could pay maybe $0.50 to $1 per share for construction.

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Can fund designs but need construction financing if feasible. Probably less than $100,000.

Entity: LeRoux Creek Water Users Association
P.O Box 130   Hotchkiss, Colorado   81419
Thomas Avery - President 872-3911
Joanne Fatan - Engineer   874-5342

Dam Name: Bailey Reservoir

Location: T , R , Section , USGS Quad Map -

County - Delta, nearest town/city - Hotchkiss

Source of Water: Stream - West Fork

Water Rights - Water rights for 30 reservoirs apparently not allocated to sites. Not sure how it works but Fatan was comfortable.

Stream Gage Records -

Dam Information: About 20' to 30' high. Could add 2' to 4' to height. Rehab'ed and enlarged in late 1970's. Class III

Existing Reports & Data: No reports.

Need for Water: Use - irrigation for orchards, 5400 shares based upon 5400 acre-feet of storage but proportioned since there is not that much storage.

When needed - Have storage rights for 5400 acre-feet but only store about 4000 acre-feet. Always looking for ways to expand capacity. Needed especially in dry years.

Ability to Pay - Present O&M about $2.50/share. Could pay maybe $0.50 to $1 per share for construction.

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Funds to perform initial studies to determine if there is any potential.

Entity: Lilylands Canal and Reservoir Company
P.O. Box 130
Norwood, Colorado 81423
Bill Bray 327-4427

Dam Name: Lilylands Dam and Reservoir (enlargement)

Location: T , R , Section , USGS Quad Map -
County - San Miguel, nearest town/city - Norwood

Source of Water: Stream - Spectacle Creek, Collection system for runoff from north side of Lone Cone.
Water Rights -
Stream Gage Records - minimal

Dam Information: Enlarge reservoir to about 3000 acre-feet

Existing Reports & Data: Reclamation performer aerial photographs and topography of dam and reservoir. Also, dug 10 test pits and performed soils analysis. Copy of materials test obtained.

Need for Water: Use - Irrigation
When needed - when available
Ability to Pay -
Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Cost and economic analysis to determine if feasible then funding for designs and construction.

Entity: City of Loveland

Larry Howard 962-3703

Dam Name: Greenridge-Glade Reservoir (Loveland Supply Reservoir)

Location: T , R , Section , USGS Quad Map -

County - , nearest town/city - Loveland

Source of Water: Stream -

Water Rights - 600 acre-feet enlarge to 6000 acre-feet

Stream Gage Records -

Dam Information:

Existing Reports & Data: 1986 study funded 50% by CWCB. 12 alternatives considered. concluded City would have 2400 acre-foot deficit in 30 years. Built 3500 acre-foot reservoir and purchased CBT water but 3 years of CBT increases have made City look for other sources.

Need for Water: Use

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
USBR will be lead on environmental studies. Doesn't appear to be much involvement for this study, the City has things well under control.

Entity: Mt. Crested Butte Water and Sanitation District
Frank Glick, manager 349-7575

Dam Name: The Reservoir

Location: T13s, R86w, Section 23, USGS Quad Map -

County - Gunnison, nearest town/city - Mt. Crested Butte

Source of Water: Stream - unnamed tributary of Washington Gulch

Water Rights - have storage rights

Stream Gage Records -

Dam Information:

Existing Reports & Data: Appraisal study currently underway.

Need for Water: Use - municipal, snow making, augmentation, recreation

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
If study shows the project is feasible, funds for further plans and construction.

Entity: Town of Oak Creek
Nancy Crawford, Town Manager 736-2422

Dam Name: Sheriff Dam

Location: T , R , Section , USGS Quad Map -

County - Routt, nearest town/city -

Source of Water: Stream - Trout Creek

Water Rights - have 980 acre-feet decrees

Stream Gage Records -

Dam Information: Spillway inadequate for 75% of PMP but no restriction.

Existing Reports & Data: 1988 Feasibility Study, CWCB helped finance, no designs, cost about $600,000.

Need for Water: Use - municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
There is presently not a loss of reservoir storage, may be potential for enlargement.

I suggested that Ms.Crawford contact the CWCB for funds and financing options for rehab..

Entity: Town of Palisade

Rick McKay, water foreman 464-5602
Larry Cleaver, Town Manager

Dam Name: Palisade #1

Location: T , R , Section , USGS Quad Map -

County - Mesa, nearest town/city - Palisade

Source of Water: Stream - Walker Creek in Rapid Creek drainage

Water Rights - 87 acre-feet, less than 30 acre-feet now

Stream Gage Records -

Dam Information: The dam was reconstructed in 1990 but was left as a non-jurisdictional dam, 10 feet high. The dam is probably capable of storing full decree but needs testing to assure safety or to address additional needs. Estimate for testing is about $30,000. Would also need hydrology.

Existing Reports & Data:

Need for Water: Use - municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Need funds for testing and hydrology to show it is safe for additional storage and become a jurisdictional dam. If additional construction work is needed following testing, funds for additional work if affordable.

Entity: Town of Palisade

Rick McKay, water foreman 464-5602
Larry Cleaver, Town Manager

Dam Name: Palisade #3

Location: T , R , Section , USGS Quad Map -

County - Mesa, nearest town/city - Palisade

Source of Water: Stream - Rapid Creek

Water Rights - 96 acre-feet, presently 45 acre-feet is full but restricted to about half

Stream Gage Records -

Dam Information: The dam has steep slopes and downstream face is in poor condition. Needs testing and hydrology studies. Could not be enlarged to store entire 96 acre-foot decree but more than 45 acre-feet.

Existing Reports & Data: None.

Need for Water: Use - municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Need funds for testing and hydrology to show to evaluate requirements for enlarging and becoming a jurisdictional dam. If additional construction work is needed following testing, funds for additional work if affordable.

Entity: Town of Paonia
Joanne Fatan, engineer 874-5342

Dam Name: Todd Reservoir

Location: T , R , Section , USGS Quad Map -

County - Delta, nearest town/city - Paonia

Source of Water: Stream - Bell Creek

Water Rights - have decrees

Stream Gage Records -

Dam Information: 37 feet high, about 200 acre-feet capacity, restricted to 10 feet below crest with about 100 acre-feet. Has an uncontrolled gate and outlet pipe needs cleaning. Easily raised because spillway needs to be added which might involve raising the crest to incorporate a spillway.

Existing Reports & Data: none

Need for Water: Use - municipal

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Town purchased a spring and got the reservoir.

Needs some preliminary cost estimates and yield.

Entity: Red Mesa Ward Reservoir and Ditch Company
Red Mesa, Colorado
Pat Greer

Dam Name: Red Mesa Ward Reservoir Enlargement

Location: T34N, R12W, Section 27 & 22,
USGS Quad - Mormon Reservoir
Stream Name - Hay Gulch, also filled from LaPlata River
LaPlata County
nearest town/city - Durango

Source of Water: Stream - Hay Gulch and diversion from LaPlata River

Water Rights - Original storage right of 1176 acre-feet, newer conditional of about 1300 acre-feet. There is not sufficient water in the LaPlata River to fill the newer right in dry years.

Stream Gage Records - None at site.

Dam Information: The outlet tower is damaged is broken below water line and needs repair. SCS has drilled the dam, conducted surveys, and performed some material analysis. (Information either with SCS or Water Commissioner.) The dam and reservoir is owned by the Company but the Mormon Church owns the land under and around the reservoir.

Existing Reports & Data: SCS data.

Need for Water: Use - Water will be primarily designated for irrigation but could also be used for plans of augmentation.

When needed - The water is needed all of the time. The LaPlata River is very water short and even in wet years there is not enough water.

Ability to Pay - There are 1176 shares of water, with 1 share per acre-foot. The present charge is $3.50 per acre-foot. The irrigators might be able to pay an additional amount of about $15 per acre-foot.

Local Support - Good support.

Environmental Issues: Endangered fish species, wetlands, normal stuff.

What Does Project Need to be Constructed: Needs to be affordable. A combination of irrigation water and augmentation water may make the project feasible.

Entity: Snowmass Water and Sanitation District

Dick Wall, manager 923-2056

Dam Name: Sams Knob Reservoir

Location: T , R , Section , USGS Quad Map -

County - Pitkin, nearest town/city -

Source of Water: Stream - Snowmass Creek, normally peaks at 300-400 cfs but this year 500 cfs, still running 17 cfs. Will not reduce flow in Snowmass Creek below 4 cfs.

Water Rights - 256 acre-feet conditional and 6 cfs direct diversion

Stream Gage Records -

Dam Information: Dam is in Snowmass drainage but treatment plant in adjacent drainage so it is a transbasin diversion.

Existing Reports & Data: Surveyed, drawings, hydrology (?), drilling this fall

Need for Water: Use - municipal primarily, also snow making and stream flow maintenance in Snowmass Creek. Apparently CWCB reduced instream flow from 12 to 7 cfs and is being sued. Reservoir could maintain 7 cfs in stream, might solve some of CWCB instream flow problem.

When needed -

Ability to Pay -

Local Support - Protest by persons in Snowmass drainage because of diversion, but County Commissioner support and need for water.

Environmental Issues:

What Does Project Need to be Constructed:
Needs financing for permitting, designs, and construction; not much, if any, initial engineering work.

Entity: Upper Arkansas WCD
P.O. box 1090 Salida, Colorado 81201
Ken Baker - manager 719-539-5308

Dam Name: North Fork Reservoir

Location: T , R , Section , USGS Quad Map -
County - Chaffee, nearest town/city - Poncha Springs

Source of Water: Stream -

Water Rights - Water rights currently for recreation, need municipal water right

Stream Gage Records -

Dam Information: about 50' high with 595 acre-feet, raise to 1095 acre-feet about 10' to 15'

Existing Reports & Data: Have engineering study that with surveys, hydrology, etc..

Need for Water: Use - for municipal water at Salida

When needed - unclear

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Need municipal decree along with recreation, funds for designs and economic evaluation, then construction funds.

Presently, they have other priorities that are taking the WCD's time, though this may be important the other issues are taking the energy.

Entity: Upper Eagle Valley Regional Water Authority
846 Forest Road   Vail, Colorado
Warren Garbe   476-7480

Dam Name: East Lake Creek Reservoir

Location: T , R , Section , USGS Quad Map -

County - Eagle, nearest town/city - Avon

Source of Water: Stream - East Lake Creek

Water Rights - 8000 acre-foot conditional decree currently owned by the property owner.

Stream Gage Records -

Dam Information: About $20 million cost.

Existing Reports & Data: Studied quite a lot, surveys, hydrology.

Need for Water: Use - municipal

When needed - if financing today, build tomorrow

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
The Authority includes 6 metro districts. The districts own water facilities but Authority operates them. The Authority needs to expand treatment plant at about $10 million, then difficult to also build $20 million reservoir.

Need financing, not engineering.

Entity: Ute Water Conservancy District
P.O. Box 640 Grand Junction, Colorado 81501
Charlie Stockton 242-7491

Dam Name: Owens Creek Reservoir

Location: T , R , Section , USGS Quad Map -

County - Mesa, nearest town/city - Colburn

Source of Water: Stream - Confluence of Owens and Buzzard Creeks

Water Rights - 32,000 acre-feet but best size is about 20,000 acre-feet that will fill 7 of 10 years, held jointly with Battlement Mesa WCD.

Stream Gage Records -

Dam Information: About 265 feet high and 1600 feet long

Existing Reports & Data: Initially part of USBR West Divide study. Reevaluated with just Owens Creek Reservoir by various entities including CWCB. Feasibility information available.

Need for Water: Use - primarily municipal, irrigation, fishery in and below reservoir, releases for endangered species in "15 mile reach".

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Reservoir on Forest Service land which has been withdrawn. Ute WCD will benefit the most from the project but has other options that it is investigating such as purchasing existing hydropower reservoirs converting to municipal primarily and producing power when possible. Probably no enlargements.

Entity: City of Victor
City Hall
500 Victor Ave, Box 86
Victor, Colorado 80860
Jim Robinson, Water Superintendent 719-689-2284
Sandy McDougall (attorney) 719-520-9288

Dam Name: #2 Reservoir. The city has several decrees, the primary reservoir is #2 with 202 acre-feet on the East Fork of West Beaver Creek, but is restricted, could enlarge maybe 2 feet. Bison Reservoir is largest at 1147 acre-feet and is offstream, but has poor quality water, was an old buffalo ground. Also have 3 small reservoirs in poor condition, largest is Altman Dam at 12.28 acre-feet, attorneys idea is to put a disposable dam in place rather than try to build spillway.

Location: T15S, R69W, USGS Quad Map - Pikes Peak
#2 is in Section 2, Bison in Section 2 & 11, Altman in Section 15

County - Teller, nearest town/city - Victor

Source of Water: Stream - East Fork of West Beaver Creek

Water Rights - #2 and Bison have adjudication dates of 1954, Altman is 1916. Even though junior rights, there are agreements with senior downstream rights not to call water and in some cases a call would be futile. The rights are better than the date would indicate.

Stream Gage Records -

Dam Information: No dam information.

Existing Reports & Data: none

Need for Water: Use - municipal for about 428 people

When needed - immediately

Ability to Pay - present rates $2.10 per/1000 gal. Have contract with mining company for raw water that is sold for $3.10/1000 gal.

Local Support - representatives appear very active and dedicated

Environmental Issues:

What Does Project Need to be Constructed:
Engineering, economic evaluation and financing.

Entity: Welton Ditch Company
John Singletary, spokesman for reservoir development
201 W8th Suite 410, Pueblo, Colorado 81003

Dam Name: Cuchares Reservoir

Location: T , R , Section , USGS Quad Map -
County - Huerfano, nearest town/city - Walsenberg/Pueblo

Source of Water: Stream - Cuchares Creeks

Water Rights - 66,000 acre-feet rights but practical size is 35,000 maximum or less

Stream Gage Records - some

Dam Information: Built in 1910, partially breached, filled with sediment so that about 3000 acre-feet is needed to use outlet, very good dam site

Existing Reports & Data: none, State Engineer reports

Need for Water: Use - irrigation primary with possibly fishery, recreation, DOW is interested

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Owned by Huerfano-Cuchares Ditch Co. who is considering selling, may have contract to sell.

Possible to combine Welton and Huerfano-Cuchares Ditch Companies, buy Cuchares and Orlando Reservoirs in cooperation with DOW, then improve.

Need engineering work on costs to improve and water supply.

Entity: Welton Ditch Company
John Singletary, spokesman for reservoir development
201 W8th Suite 410, Pueblo, Colorado 81003

Dam Name: Orlando Reservoir

Location: T , R , Section , USGS Quad Map -
County - Huerfano, nearest town/city - Walsenberg/Pueblo

Source of Water: Stream - Huerfano Creek

Water Rights - 3800 acre-feet, possible enlargement

Stream Gage Records - some

Dam Information: 10 miles from Cuchares

Existing Reports & Data: none, State Engineer reports

Need for Water: Use - irrigation primary with possibly fishery, recreation, DOW is interested

When needed -

Ability to Pay -

Local Support -

Environmental Issues:

What Does Project Need to be Constructed:
Owned by a developer who is selling 40 acre tracts. Would like to buy reservoir and use water.

Possible to combine Welton and Huerfano-Cuchares Ditch Companies, buy Cuchares and Orlando Reservoirs in cooperation with DOW, then improve.

Need engineering work on costs to improve and water supply.