NELSON TUNNEL

WATER MANAGEMENT FEASIBILITY STUDY

for the

WILLOW CREEK RECLAMATION COMMITTEE

CREEDE, COLORADO

McLaughlin Rincón
engineering design consulting

January 2006

January 24, 2006

The Willow Creek Reclamation Committee
c/o Kelley Thompson
PO Box 518
Creede, Colorado 81130

RE: Letter of Transmittal/Summary
Nelson Tunnel Feasibility Study

Committee Members:

Submitted attached is the Water Management Feasibility Study for overflow waters emanating from the Nelson Tunnel. The Nelson Tunnel flow is acid mine drainage – and is "responsible" for about 75% of the heavy metals contaminants in Willow Creek.

The study develops an optimum treatment system for this water, with estimates of capital and operating costs. A chemical precipitation process plant, located either near the Creede City Hall or the municipal wastewater treatment plant is recommended.

To partially offset the costs of treatment, the feasibility of using the water to generate hydropower and of using the inherent water inherent water temperature to recover heat was also evaluated. Although not necessary to finance/construct at the same time, both electrical generation and heat recovery are recommended. Present, and rising, energy costs will make these additions economically justifiable.

The recommended budget for the treatment facility, intake, and connecting pipeline is $2,009,750.

The alternate of using the heat and energy to activate the fish hatching was found to be too expensive, primarily because of the capital requirements for the long transmission pipeline. We were impressed with the physical condition of the fish hatchery facilities, and believe that a local (deep) alluvial well probably would result in a less costly water supply.

We will be available to review the study with you.

Respectfully submitted,
McLaughlin Rincón, Ltd.

Ronald C. McLaughlin, P.E. & L.S.

Ronald J. McLaughlin, P.E.

NELSON TUNNEL
WATER MANAGEMENT FEASIBILITY STUDY FOR THE WILLOW CREEK RECLAMATION COMMITTEE
CREEDE, COLORADO

TABLE OF CONTENTS

LETTER OF TRANSMITTAL

I. INTRODUCTION

Background I-1
Scope of Study I-1

II. WATER TREATMENT

Design Criteria II-1
Treatment Options II-2
    Biological II-2
    Chemical/Physical II-3
    Electrical/Physical II-6

III. RECOVERY OF ENERGY, HYDROELECTRIC – PIPELINES

General III-1
Power Available III-1
Location III-1
Cost Estimates III-3
Pipelines III-4

IV. RECOVERY OF HEAT ENERGY

General IV-1
Fish Hatchery IV-1
Building Heat IV-2

V. CONCLUSIONS AND RECOMMENDATIONS

DRAWING. Location Map (at back of report)

APPENDIX A. Nelson Tunnel Quality Data

I. INTRODUCTION

BACKGROUND

The Nelson Tunnel collects water from a vast network of abandoned mine works north of the City of Creede, Colorado. The tunnel entrance is located on West Willow Creek, about 1.5 miles north of town. The collected water, approximately 200 gallons per minute, contains significant heavy metal contamination. Due to this contamination, Willow Creek cannot support a fishery and is detrimental to the valuable fishery in the Rio Grande River.

It has been estimated that the Nelson Tunnel discharge alone is responsible for 75% of the total inorganics (heavy metals) contamination in Willow Creek below the tunnel discharge. Since this single point source is responsible for such a large fraction of the contamination, the Willow Creek Reclamation Committee wishes to investigate the feasibility of capturing and treating this water – as well as the potential benefits and uses for the treated water.

SCOPE OF STUDY

The report will evaluate 3 proposals/goals and recommend a plan for implementation. These are:

1. **Treatment of Nelson Tunnel Discharge.** While there a number of possible processes which could be used to treat the discharge from the Nelson Tunnel; e.g. Chemical, Electrical or Biological precipitation followed by separation has been identified as most likely feasible. Three precipitation methods will be evaluated and comparative preliminary cost estimates prepared. Potential sites for the treatment plant are at the tunnel adit, north edge of town, the Waste Water Treatment Plant site or the Fish Hatchery located south of town.

2. **Recovery of Energy- Hydroelectric.** Once the discharge has been captured in a pipe and conveyed to a discharge point a potential to capture energy, as electricity, will exist. The available energy will depend on the elevation and location of the treatment site and discharge point. This energy could be used to offset power required for treatment, offset power required for municipal buildings

or sold to the electric utility. The value of this power will be used in the evaluation of possible plans.

3. **Recovery of Energy-Heat.** The temperature of the Nelson Tunnel discharge is fairly warm all year, approximately 57 to 63 degrees F during winter months. There are two potential uses for the heat contained in the discharge. The Town leases a fish hatchery from the State of Colorado. The hatchery is not presently in use due to inefficiency resulting from the lack of a warm water source, necessary for growth of fry. If the Nelson Tunnel discharge were sufficiently treated, the warm water could be used as the water supply for the hatchery. Alternatively, heat recovery, using water to air heat pumps, could be used to offset the cost of power used to heat municipal (or other) buildings.

4. **System Alternatives.** System design involves integrating the above proposals. Pipeline length and routing depends on selected facility location. Preliminary analyses indicated the practicality of evaluating alternate treatment plant sites:

    a. Nelson Tunnel. (Although this would involve minimal pipeline costs, it was determined that winter access problems preclude the use of this site.)

    b. Canyon. This site is north of Creede, near the canyon mouth.

    c. North end of Creede. This site would be convenient for operations (near present City shops). Also, the demand for heat and electrical energy exists in this area.

    d. Creede Wastewater Plant Site. The new facilities could be operated in conjunction with the municipal plant. There is a significant demand for electrical energy here.

    e. Fish Hatchery. Demand for water, heat energy, and some electrical power here.

II. WATER TREATMENT

DESIGN CRITERIA

The Nelson Tunnel discharge has been sampled for quality and quantity numerous times between September 1999 and November 2002 by the Willow Creek Reclamation Committee. The results of this study were published in 2004 by the Committee. Tables 12 and 13, relating to the Nelson Tunnel, are attached to this report as Appendices A. For purposes of this report, the flow rate to be treated is assumed to be a maximum of 250 gpm (360,000 gpd), and the facilities designed to accommodate a possible expansion to 500 gpm.

The flow rates and water quality of the Tunnel discharge vary significantly. For estimation purposes the water quality will be assumed to be as listed in the following table (Major constituents, dissolved):

TABLE II-A
DESIGN RAW WATER CONTAMINANTS
(See Appendix A)

Constituent	Concentration mg/l Dissolved	Load, lbs/day at 250 gpm	TVS ug/l, from 2004 Report, for Reference Only
Calcium	250	750	
Magnesium	30	90	1.84
Cadmium	.5	1.5	7.12
Copper	.2	.6	
Iron	.2	.6	
Manganese	15	45	
Lead	1	3	1.88
Zinc	80	240	93.9
Aluminum	1.5	4.5	87.0

*These values are assumed to be yearly averages for operating cost estimation; however, the treatment system will be designed to be capable of treatment the constituents at the maximum levels anticipated.

TREATMENT OPTIONS

Biological Reduction

Biological treatment relies on the ability of microorganisms and plants to reduce sulfate to sulfide. The resulting sulfide combines with dissolved metals to form insoluble precipitates which then settle or are removed. Removal by plant uptake of metals is minor and not considered a factor.

This treatment is accomplished using constructed wetlands, ponds or flow through an organic media. These facilities may be combined with limestone pretreatment using beds or channels, for pH adjustment.

The results reported for this type of treatment are not consistent and highly variable. Most reports are from pilot studies with no data from long term full scale projects available. Area requirements are not well established, but loading rates for wetland have been reported at ½ acre per 1 gallon per minute. Since the rate of biological reactions is significantly affected by temperature and climate, it would be expected that area requirements at Creede would be greater than most reported conditions.

The successful pilot studies generally are treating water with much lower concentrations (where 50 to 75% removal is all that is required) of metals than the Nelson Tunnel discharge. In water with higher concentrations of metal, biological treatment has been suggested for pretreatment prior to mechanical/chemical treatment.

Long term success for biological treatment is doubtful for the Nelson Tunnel discharge due to the area required, temperature and metals loading. The zinc alone would produce 130,000 pounds per year of Zinc Sulfide (dry) sludge that would be retained in the treatment system. Ultimately this material would have to be removed, dried, stabilized and disposed of. Since it would not be practical to enclose a wetlands treatment system in a building, it is likely freezing would be a possibility and that biological reaction rate would be nearly zero. The beneficial use of effluent using heat recovery would also be eliminated.

Chemical/Physical Treatment

This treatment method consists of the addition of chemicals to react with dissolved metals, in a reactor vessel, to form a solid precipitate. This is followed by a solid/liquid separation process that produces a clarified effluent and a sludge waste. The effluent is typically pH adjusted and discharged. The sludge is dewatered, stabilized (if necessary) and disposed of. Disposal options may consist of municipal landfill or dedicated cell.

There are two basic reactions typically used to convert dissolved metals to a solid form, sulfide and hydroxide. In the first, sulfide ions are added, usually using a liquid Sodium sulfide solution or Hydrogen sulfide gas. The resulting reaction produces insoluble metal sulfides. The advantage of sulfide addition is that very low effluent concentrations, independent of pH, of dissolved metals are achievable. Sulfide precipitation is not commonly used because of the high chemical cost, precise dosing requirements, and potential for odor.

The far more common reaction used in the industry is the hydroxide addition method. The chemicals used are lime, caustic soda and soda ash. In some cases these may be used in combinations with each other. With the addition of hydroxide ions, metal hydroxide solids are formed. Lime is generally used in larger plants and with higher levels of dissolved metals due to the low relative cost. Lime is the most difficult of the commonly used chemicals to handle and feed to the raw water. Very large users may buy lime as Calcium oxide and prepare a slurry using slaking equipment. Since this is labor intensive, most plants purchase dry slaked lime.

Caustic soda is normally sold as a liquid solution. While it is a hazardous chemical, it is relatively easy to handle and feed. The scale formation and clogging associated with lime addition do not occur with caustic soda. The disadvantages of caustic soda are cost and the high water content of sludge produced. Caustic soda is a by product of Chlorine gas production. The cost varies with Chlorine demand, but averages about twice the cost of lime for an equivalent dose. As the demand for Chlorine for disinfection of drinking and wastewater decreases, it is expected that the cost for caustic soda will increase.

The sludge solids produced using caustic soda contain more water and therefore are greater in volume, requiring larger capacity dewatering equipment.

The Argo Tunnel plant, near Idaho Springs, was originally designed for caustic soda use. The plant is currently being converted to use lime as the primary chemical.

Soda ash can be used in some cases as a primary chemical, but is more likely to be used in combination with lime to produce solids that are more easily separated resulting in a clearer effluent, reduced sludge volume and sludge characteristics allowing dewatering to a solids content of 40-50% without heating. One process that uses this combination is the Heavy Metals Removal (HMR) process.

Sludge solids from the clarification process may be recycled to the plant influent to produce sludge that will settle and dewater better. This is referred to as a High Density Sludge (HDS) process. Schematic drawings of typical hydroxide removal processes are shown in Figure II-B.

After the reaction is completed, the formed solids and water are separated. A gravity clarifier is usually used. This may be followed by a filter if needed to meet the discharge standards. The sludge flow from the clarifier is sent to a dewatering facility. Plate and frame presses are the most common equipment used. Sludge must pass a stability test (TCLP) and a dryness test (Paint filter) prior to disposal.

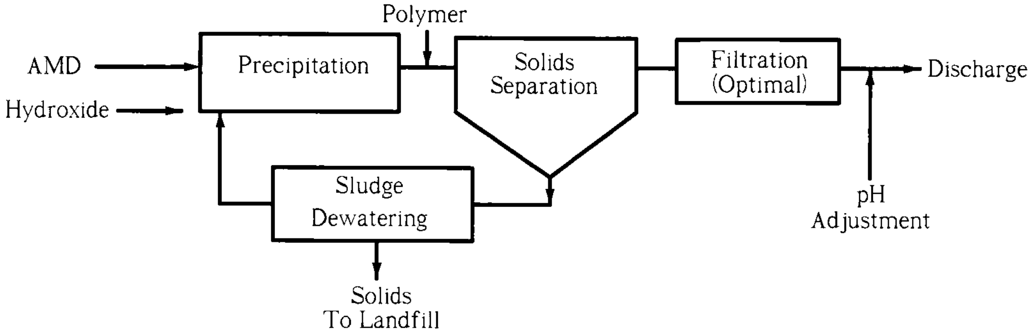
For treatment of the Nelson tunnel discharge, a process schematic using lime addition and reaction - followed by gravity clarifier - will be used for cost estimating. If hydroxide precipitation is selected as the preferred process, a plant using the HDS system with lime or an HMR system might be a viable alternative, and should be evaluated during final design phase.

The following table shows an estimate of Lime required for the Nelson Tunnel discharge.

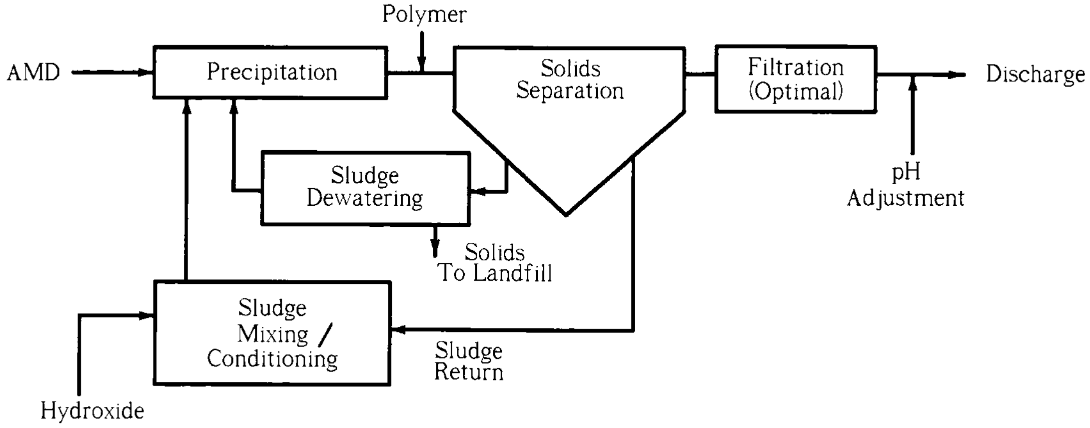
Figure II-B

Block Diagram Comparing Treatment Processes

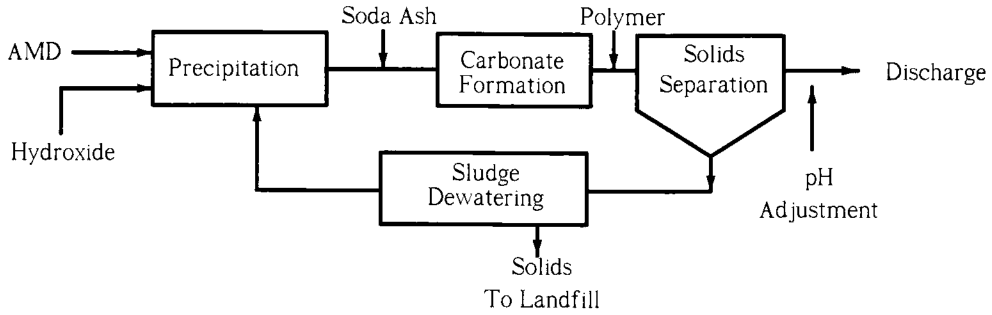
Conventional Precipitation



High Density Sludge Process (HDS)



Heavy Metal Removal Process (HMR)



Notes
- Hydroxide source is generally lime or caustic.
- Oxidation options are not shown.

DESIGN: RJM
DETAIL: RDL
CHECK: RJM
DATE: MAY, 2005

Nelson Tunnel - Water Mgmt. Feasibility Study

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WILLOW CREEK WATER RECLAMATION / FIGURE II-B.DWG / MAY 24,2005 / PROJ. 05-01-01P

Constituent	Quantity (lbs/day)	Lime Required (lbs/day)
Ph	---	150
Zinc	240	275
Mn	45	61
Pb	3	1
Fe	.6	1
Mg	90	140 (assume 50% removal)
Cd	1.5	1
Total	335	629

Acid quantity for final pH adjustment will be a function of the permit requirements. Assuming a discharge pH of 8, the plant would require approximately 80 pounds per day of hydrochloric acid. A polymer dose of 10 ppm would require 30 pounds per day. Total chemical demand for a 1 year period is summarized as follows:

Lime	- 115 tons per year
Acid	- 29,200 pounds per year (may not be required)
Polymer	- 11,000 pounds per year

Electrical/ Physical Treatment

Electrical treatment, or Electrocoagulation (EC) has been used for over 90 years, however the use is not widespread. Its use has been limited by cost and reliability issues. Recent improvements and technology have made the process more viable. The largest plant in Colorado is rated at 30 gpm and has been run at rates up to 42 gpm.

The process, as sold by Powell, passes water between a cathode and anode separated by metal plates, usually steel or aluminum. Dissolved contaminants are converted to solids and suspended solids are coagulated to form large floc particles which are separated from the water by settling. No chemical is used to accomplish this reaction. The metal plates are consumables and are replaced at regular intervals.

EC is effective at removing a wide range of contaminates from water, including heavy metals, hardness, silica, oils and some organics. The process is not selective, all contaminates treatable by EC will be removed.

Samples of Nelson Tunnel discharge were tested by Powell in June 2004 and February 2005. The samples in 2004 were tested for Cadmium, Manganese and Zinc. This test was not effective on the metals tested. In 2005, 3 new samples were tested for Zinc only. All tests showed complete removal to undetectable levels.

In addition to the metals removed, it is estimated that hardness was reduced by approximately 75 %, based on studied at other sites conducted by Powell. In the case of treatment at the Nelson Tunnel, this would be a disadvantage for two reasons. Hardness is a significant component of the discharge, approximately 840 pounds per day; for comparison, Zinc is the next largest load at 250 ppd, followed by Manganese at 45 ppd. Not only is removal of hardness not required, its removal increases the toxicity of heavy metals. The quantity of sludge produced due to the removal of hardness will exceed that of all other contaminates by a factor of about 2.

Since use of the EC process is not as extensive as the use of chemical processes, not as much data, information and experience are available to predict all the parameters required to thoroughly evaluate and design a system. Prior to final selection and design of an EC system, it is recommended that a pilot plant be operated for a period of time to evaluate performance on all constituents and quantify the production of sludge and maintenance requirements.

For purposes of evaluation we have used a power requirement of 7 kwh per 1,000 gallons treated and .2 pounds of sacrificial plates per 1000 gallons (about 72 lbs pounds per day), as provided by Frank Satterlee of Powell. The system requires an acid wash once or twice per day. Some ph adjustment may be required for discharge and acid neutralization.

Solid/liquid separation can be accomplished using conventional clarifiers and plate settlers. This is the same as the equipment used for chemical treatment. Powell has also used a vacuum type clarifier with success. For estimation, we have assumed a conventional clarifier because of simplicity, low operating cost and it is compatible with either chemical or EC systems. A schematic for this option is shown of Figure II-C.

Capital Cost Estimate

Table II-D is a summary of the preliminary cost estimate for both the EC and a Chemical Precipitation water treatment plans. This estimate does not include the cost for the electrical service. This item is included in the site evaluations, later in this report. Inlet and discharge structures and transmission pipelines are not included in this table.

The estimate assumes both systems are fully enclosed and will require similar size buildings. Sludge dewatering equipment (plate and frame press) is included for both options.

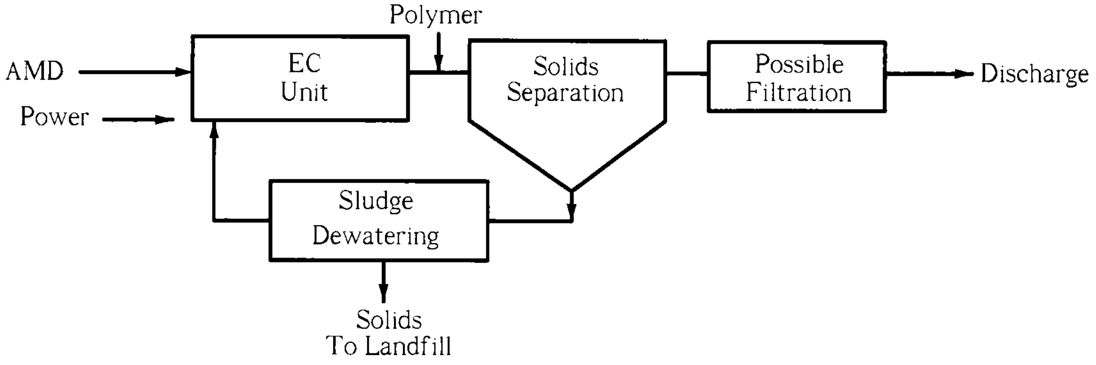
A budget of $1.728 million for the EC plant or $1.48 million for the Chemical plant is appropriate for capital construction.

Operating Cost Estimates

Table II-E is a summary of operating costs for both type plants. The table indicates that the chemical plant, while more labor intensive, has a lower total operating cost. The EC plant operating cost is approximately $.98 per 1000 gallons compared to $.68 per 1000 gallons for the chemical plant. This is primarily due to the high cost of power compared to the cost of chemicals.

Figure II-C

Block Diagram
Electro Coagulation System



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WILLOW CREEK WATER RECLAMATION / FIGURE II-B.DWG / MAY 24,2005 / PROJ. 05-01-01P

FIGURE II-D

COMPARATIVE CAPITAL COST ESTIMATES

ITEM	EC PLANT	CHEMICAL PLANT
Building 60 x 100	$150,000	$150,000
Silo	---	$60,000
Surge Tank	$15,000	---
Lime Conveyor	---	$22,000
Lime Feeder	---	$17,000
EC Unit	$340,000	---
Clarifier	$235,000	$235,000
Polymer System	---	$12,000
Filter Press	$270,000	$270,000
Lime Reactor Tank with Mixer	---	$70,000
HVAC	$65,000	$65,000
Controls/Meters	$95,000	$95,000
Electrical	$130,000	$75,000
Lab/Office	$30,000	$30,000
Piping/Valves	$93,000	$51,000
Acid Storage	$10,000	$20,000
Total	*$1,383,000*	*$1,187,000*
Recommended Budget	**$1,728,750**	**$1,483,750**

TABLE II-E

COMPARATIVE OPERATING COST ESTIMATES

(Does not include sludge disposal)

ITEM	EC PLANT	CHEMICAL PLANT
Lime $150/ton	---	$17,000
Polymer $2/lb	---	$22,000
Acid $.20/lb	$2,000	$6,000
Power $.09/kwh	$89,000	$7,000
Lab/Reporting	$3,000	$3,000
Labor $20/hour	$29,000	$38,000
Plates	$10,500	---
Maintenance	$5,000	$5,000
Total	**$138,500/yr**	**$98,000/yr**
Unit Cost	*$1.02/1,000 gallons*	*$.76/1,000 gallons*
Sludge Disposal & Hauling $15/cy	$6,500	$6,500

III. RECOVERY OF ENERGY, HYDROELECTRIC – PIPELINES

GENERAL

At the present rates the Town pays approximately $.09 per kwh for power, which results in annual power costs of about $35,000 per year. Most of the power is used at the sewage treatment plant ($8,200) and municipal wells ($19,000). If the power that could be generated from the project can be used to offset power that would normally be purchased, the maximum benefit will be realized. It would be difficult to utilize all the power produced due to the variable demand rate and the constant production rate. It is unlikely that it would be economical to sell the power to the utility since the cost of metering and management costs would likely exceed the revenue at the wholesale power rate.

POWER AVAILABLE

Following is a table showing the potential power production available for a hydroelectric generator located at the four proposed sites and the value of the power, assuming 100% utilization, at $.09 per kwh.

Location	Gross Head Available	Net Head Available at 250 gpm	KW	Annual Value
C	295	282	9.1	$7,100
T	335	318	10.2	$8,000
W	500	463	14.6	$11,520
F	575	516	15.9	$12,500

LOCATION

The location of the hydro generator could be at the treatment plant or at any location between the plant and the Nelson Tunnel. There would be some cost savings associated with both facilities being located in the same building, however. If the EC treatment plant were selected, 100% utilization of the generated power would be possible since the power requirement for the EC unit is far in excess of the power generated. The chemical plant electrical requirements would be approximately 5 KW with 10 to 15 KW peaks. Most of the remaining power could be used in Town buildings or at the sewage treatment plant. To use power at the sewage treatment plant, should the generator be located at the C or T site, a power line would be needed. The preliminary budget for a power line from the C site to the sewage treatment plant is $267,500. For a power line between site T and W the preliminary budget is $231,000.

The alternative locations evaluated (for both the treatment plant and hydro station) are described following.

Canyon Site (C) – This site is located on the east side of the road, between Willow Creek and the road approximately 4,200 feet downstream of the Nelson Tunnel. This site is north of the Fire Department Tunnel.

Town Hall Site (T) – This site is located just west of Town Hall on the opposite side of the road.

Wastewater Treatment Plant Site (W) – This location is near the existing sewage treatment plant, north of the lagoon.

Fish Hatchery Site (F) – This site is located at the presently unused fish hatchery near the Rio Grande River, approximately 2.5 miles south east of Town Hall.

The four sites and pipeline alignments are shown on the attached map.

COST ESTIMATES

All four of the sites have adequate space for the treatment plant and approximately equal cost of construction. The W and F site are larger and would have better access for trucks to bring chemicals or haul sludges.

Following is a cost estimate and recommended budget for the generator and controls. The estimate assumes the generator is located in the treatment plant building and no separate electrical service is required.

Item	Estimate Cost
Generator and Turbine	$18,000
Piping and Valves	$11,000
Building @ $25/sf	$3,750
Controls, Instrumentation	$15,000
Electrical	$4,000
Total Estimated Construction Cost	$51,750
Recommended Project Budget	$65,000

If the cost of power is roughly equal to the inflation rate, with an allowance for maintenance, the pay back period for the generator is approximately 7-10 years. As long as most of the power generated can be utilized, then the investment in the hydrogenerator is easily justified. Assuming that approximately 50% of the power generated can be used at the treatment plant and that at least 25% could be used by the Town at any site, then the construction of a power line to the STP from the T or C sites to utilize the remaining 25% or approximately $2,000 per year value would not justify the cost of over $100,000.

PIPELINES

A water transmission pipeline will be required to transmit flow from an intake at the Nelson Tunnel to the plant treatment plant/hydro site.

The pipeline alignment generally follows the road from the Nelson Tunnel to the sewage treatment plant, then follows the old railroad bed to the fish hatchery entrance road continuing to the hatchery. Pipeline costs are estimated to be $45/foot in the canyon and in town and $30/foot from W to F. The cost of insulating the line is estimated to be $15/foot. If the W or F sites were selected, there are several alternate alignments possible along Hwy 149 and Main Street. The distances are similar to the proposed alignment and the cost of the line using these alternates would also be similar. The use of the alternates should be investigated during final design if ROW problems or utility conflicts exist in the preferred alignment. Following is a cost estimate for the pipelines (total cost and budget includes intake, stream crossing and discharge structures):

ESTIMATED PIPELINE COST

Line Segment	Distance	Estimated Cost Uninsulated	Estimated Cost Insulated
NT-C	4,200 ft.	$189,000	$252,000
C-T	1,500 ft.	$67,500	$90,000
T-W	9,200 ft.	$339,000	$477,000
W-F	4,900 ft.	$147,000	$220,500

ESTIMATED TOTAL PIPELINE COST

Pipeline	Estimated Cost Uninsulated	Recommended Budget Uninsulated	Estimated Cost Insulated	Recommended Budget Insulated
NT-C	$216,000	$270,000	$279,000	$349,000
NT-T	$283,500	$354,500	$369,000	$461,000
NT-W	$595,500	$774,500	$819,000	$1,024,000
NT-F	$784,500	$980,500	$1,081,500	$1,352,000

IV. RECOVERY OF HEAT ENERGY

GENERAL

There are two possible uses for the heat contained in the Nelson Tunnel discharge. The warm treated water could be used to operate the fish hatchery, leased from the State by the Town of Creede or the heat could be used to heat Town buildings. The following table shows the temperature of the water at each of the proposed sites using insulated and uninsulated pipe:

Site	Estimated T, Insulated	Estimated T, Uninsulated
NT	60	60
C	58.3	54
T	57.6	52
W	56.0	46
F	52.0	42 (varies seasonally)

FISH HATCHERY

The Town leases the fish hatchery (Site F on the area map) for $1.00 per year. The lease expires in 2096. The hatchery was not used by the state primarily since the water supply was too cold to support the fish growth rate needed to be successful. According to John Alves, a biologist with DOW, a water temperature of 50 degrees F is ideal. The water produced by the treatment plant should be acceptable for direct use at the hatchery, however, a final filter might be added to the plant or some provision for temporary use of the existing supply should be provided in case of minor plant problems.

If the treatment plant were located at Site F and the water used directly, there would be no additional cost required to utilize the warm water. It is possible that some legal issues associated with water rights may have to be addressed. The estimated budget to build a pipeline from the next nearest site (W) is estimated to be $576,000. It is likely that an alternate supply of water, such as a deep well, could be developed at a lower cost.

BUILDING HEAT

By using liquid air or liquid to liquid heat pumps, the heat energy in the water can be used to heat buildings. At 250 gpm, by lowering the temperature from 58 to 40 degrees F, there are approximately 2 million BTUs/hr available. The efficiency of heat pumps at this temperature range can be as high as 4 to 1. The pumps require electrical power to operate, which is a higher cost per BTU than gas. However, such use is likely to be economical at Creede because of the absence of a natural gas distribution system.

At $1.40 per gallon for propane, using an 80% efficient furnace or boilder, the cost of heat is 52,000 BTU per dollar. The heat value of electricity is 38,000 BTU per dollar. Using the 4 to 1 efficiency, the heat pump would reduce the cost to heat a building by about 66%. The electrical cost could be somewhat reduced using any excess power from the proposed hydro generator.

Two million BTUs per hour is more than adequate to heat most public buildings, if desired. The largest practical units have capacity of approximately 350,000 BTUs per hour. Small units are available as small as 75,000 BTUs per hour. The cost of the heat pump for a 350,000 BTU per hour unit is about $24,000. The installation cost would depend on the distance to the building, space and power available. The installed cost could range from $50,000 to $100,000. The cost savings would then be approximately $4.50 per hour or $12,900 per heating season, assuming full operation for 4 months.

Ideally, the building being heated would be located near the hydro generator and use the low pressure water to run through the heat exchanger. However, it would be possible to use a higher pressure exchanger such that the Town Hall could be heated even if Site W were selected for the treatment plant and generator. The temperature of the water, even at 40 degrees would be sufficient to keep above freezing temperatures in the treatment plant.

V. CONCLUSIONS AND RECOMMENDATIONS

Based on the available information and technology, the chemical treatment plant option is the preferred alternative. Both the initial capital cost and operating cost is significantly lower than the electrocoagulation process. The lime precipitation process is in wide use and has well documented performance. EC plants of this size and type are not common. It is possible that improvements to the technology will reduce to power required and associated costs. It may be desirable to pilot an EC process prior to final design to confirm the actual power required to meet the water quality needed.

The preferred site is the Town Hall location (Site T). This is near the town shop and town hall and has a reasonable pipeline requirement. Excess power generated can be used at town facilities. The location is convenient for the town personnel to monitor and operate. The site is within the town limits and is controlled by the town. The site is accessible and demand for heat nearby, should heat recovery be utilized.

The sewage treatment plant (Site W) is also a good choice; however, heat recovery would be more expensive and pipeline costs are higher. The pipeline cost reduces the desirability of the fish hatchery (Site F). The canyon site (C) would be reasonable if heat recovery were not utilized. The benefit of the hydro generator would also be reduced since a power line would be needed to bring the excess power to town buildings. Accessibility may also be limited at Site C.

The construction of a hydro generator at the plant site is recommended. This will reduce power cost and provide excess power. The estimate payback period is 10 years.

Heat recovery using heat pump technology is also recommended. The construction of these facilities does not need to coincide with the treatment plant construction, if the construction is planned for in the final design. This capability can be added in phases at any time after the plant is built.

The cost estimate and recommended budget for the preferred system follows:

Item	Estimated Cost	Recommended Budget
Treatment Plant	$1,187,000	$1,483,750
Intake and Pipeline	$369,000	$461,000
Hydro Generator	$51,750	$65,000
Total	$1,607,750	$2,009,750

The estimated operating cost follows:

Item	
Chemicals	$45,000
Power	$1,000
Labor	$38,000
Maintenance	$5,000
Excess Power	($1,000)
Lab and Reporting	$7,000
Sludge Disposal	$6,500
Total	$101,500/yr

APPENDIX A

NELSON TUNNEL QUALITY DATA

Table 12. All data collected for inflows in the West Willow drainage. Units are in ( ). The prefixes "d" and "t" represent dissolved and total fractions. Values below the laboratory-determined detection limit are indicated by "<".

Date	Site	Flow (CFS)	pH	Temp (C)	Alk (mg/L)	Hard (mg/L)	Cond (uS/cm)	DO (mg/L)	TDS (mg/L)	TSS (mg/L)	DOC (mg/L)	NO3 (ug/L)	dSO4 (mg/L)	tSO4 (mg/L)	dCl (mg/L)	tCl (mg/L)	dCa (ug/L)	tCa (ug/L)	dMg (ug/L)	tMg (ug/L)	dSi (mg/L)	tSi (mg/L)	dK (mg/L)	tK (mg/L)	Na (mg/L)
9/19/99	WW-CT	0.04	5.85	5.5	2	88	246	8.55	180	5	1			122		4	21623	21443	2799	2730	27.7	27	2.8	2.8	
5/16/00	WW-CT	0.01	6.29	1.2	6	42	152	6.8	110	0				53		4	11899	11693	1446	1434	21.35	22.8		1.84	9.4
4/24/01	WW-CT												103.9		1.9		28300		12100						
11/7/02	WW-CT		7.38	1.4																					
9/18/99	WW-NT	0.77	3.73	16.5	0	708	1374	6.58	1300	5	1			708		2	157540	157939	15935	16313	34.8	29.3	5.2	4.2	
5/16/00	WW-NT	0.98	5.12	16.5	2	650	1314	7.07	1089	0				703		3	126304	125907	12397	12350	27.5	28.9		4.4	42.4
11/22/00	WW-NT																251900	271100	41520	46190					
1/22/01	WW-NT	0.58	4.36	17	0	920	1654						821				255200		49270						
2/12/01	WW-NT	0.54	4.34	17.1			1627						965				276600		40330						
3/15/01	WW-NT												879.5				308300		38410						
4/24/01	WW-NT												1518.8		1.2		314600		48980						
5/22/01	WW-NT		4.67	13.7	0							0		281		1	51622	51003	6238	6153					
7/6/01	WW-NT												860.5		0		205500		14000						
8/16/01	WW-NT												659.2		0		200200		13800						
9/27/01	WW-NT												995			1.1	245000								
5/2/02	WW-NT	0.47	4.3	16.8	0				1399	4				950		0	191997	191110	15876	15610	17	19.8	3.8	3.8	42.6
9/5/02	WW-NT	0.47	4.4	17.3		854	1625										324700		10500						
11/7/02	WW-NT	0.47	4.4	17.1																					
9/18/99	WW-Seep	0.04		8.2			851	8.5	810	5	1			553		4	52605	52512	10976	10721	23.3	22.8	3	3	
8/16/00	WW-Tail 1	0.03	7.05	11	24	152	391	7.8																	

Table 12 (cont.)

Date	Site	dAg (ug/L)	dAl (ug/L)	tAl (ug/L)	dAs (ug/L)	tAs (ug/L)	tBa (ug/L)	dCd (ug/L)	tCd (ug/L)	dCu (ug/L)	tCu (ug/L)	dFe (ug/L)	tFe (ug/L)	dMn (ug/L)	tMn (ug/L)	dPb (ug/L)	tPb (ug/L)	dSe (ug/L)	tSe (ug/L)	dZn (ug/L)	tZn (ug/L)
9/19/99	WW-CT		524	1297	<15	<15		103.9	103.3	37	41	86	572	3853	3831	46	80			9771	9701
5/16/00	WW-CT		69	117	<15	<15		23.87	23.5	4	5	10	33	789	773	7	17			3100	3055
4/24/01	WW-CT			899		16	25		40.3		56		406		3355		43				7718
11/7/02	WW-CT		54.5	267				7.1	7.4	5	6	67	114	589	596	8	13			2078	2089
9/18/99	WW-NT		1028	1065	<15	<15		241.8	243.4	107	107	281	1273	19290	19500	1440	1491			89800	90100
5/16/00	WW-NT		559	575	<15	<15		259.24	259	137	139	<10	418	14630	14730	1184	1206			32362	31890
11/22/00	WW-NT		<15	38	<1	56		54	88	23	62	91	108	13520	13700	<1	<1			5550	5610
1/22/01	WW-NT			923		74	452		66		42		1540		13580		417				6240
2/12/01	WW-NT			<15		53	11		81		43		1160		11300		284				7990
3/15/01	WW-NT			215		20	404		63		47		1750		11500		470				6050
4/24/01	WW-NT			775		16	22		57		56		1210		12032		364				81860
5/22/01	WW-NT		3956	4021	<15	<15		870.37	892.86	911	932	50	197	13380	13630	1044	1046	4	3	83100	85300
7/6/01	WW-NT		1347		15		29	61		71		1360		17130		300				47040	
8/16/01	WW-NT		262		19		6	104.7		70		1350		15388		406				77650	
9/27/01	WW-NT			267		21	0		64.1		48		1760		12427		334				62855
5/2/02	WW-NT		399	395	<15	<15		214	212.6	45.0	45.5	41.0	1632	16600	16710	1022	1057	6	5.5	88390	89960
9/5/02	WW-NT	<0.2	350		5			80.6		99		139		11690		412				11500	
11/7/02	WW-NT		480	571				121.5	127.4	33	31.9	33	1780	9993	13690	716	784			69970	71230
9/18/99	WW-Seep		3781	3934	<15	<15		862.6	905.3	872	920	23	116	19460	19430	1532	1509			154000	153700
8/16/00	WW-Tail 1	0						<0.15		10						104				6162	

Table 13. Comparison of loads between Nelson Tunnel and West Willow. Percentages are estimated assuming that the total load from Nelson Tunnel was transferred to West Willow.

Metal	Date	Load from Nelson Tunnel (lbs/day)	Load difference between WW-M and WW-A (lbs/day)	Percent of loading in West Willow attributable to Nelson Tunnel
Ca	September 1999	657	1291	51%
	May 2000	667	1242	54%
	May 2002	485	651	75%
Mg	September 1999	68	146	46%
	May 2000	65	131	50%
	May 2002	40	55	73%
Al	September 1999	4.4	16.8	26%
	May 2000	3.0	18.5	17%
	May 2002	1.0	2.3	43%
Cd	September 1999	1.0	2.3	45%
	May 2000	1.4	2.2	63%
	May 2002	0.5	0.9	61%
Cu	September 1999	0.4	1.7	26%
	May 2000	0.7	1.5	50%
	May 2002	0.1	0.4	32%
Fe	September 1999	5.3	12.3	43%
	May 2000	2.2	14.8	15%
	May 2002	4.1	3.2	129%
Mn	September 1999	81	99	82%
	May 2000	78	74	105%
	May 2002	42	46	93%
Pb	September 1999	6.2	9.7	64%
	May 2000	6.4	9.7	66%
	May 2002	2.7	3.9	69%
Zn	September 1999	375	562	67%
	May 2000	169	497	34%
	May 2002	229	311	74%