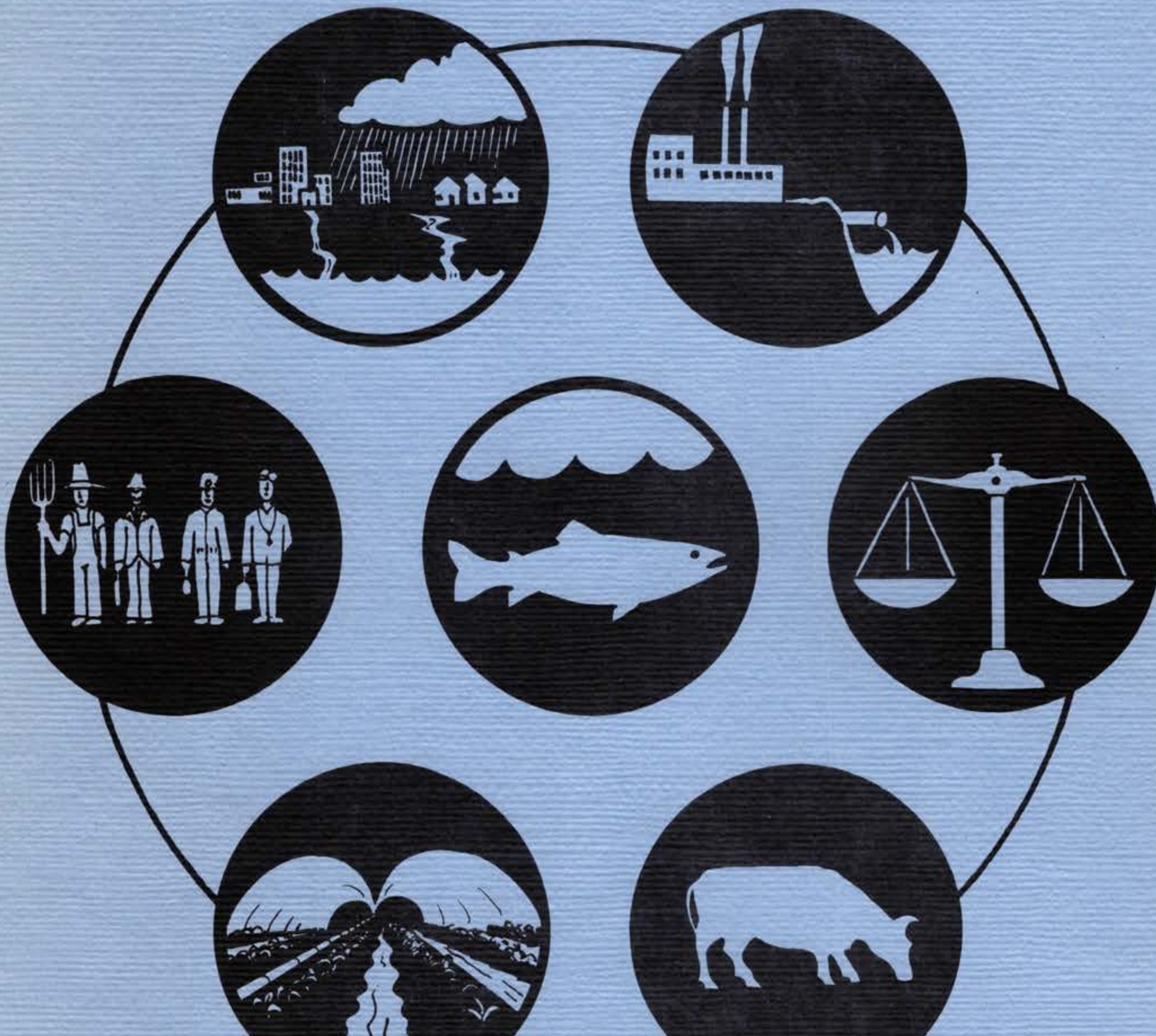
INTERIM REPORT — ENGINEERING

MUNICIPAL POINT SOURCE ANALYSIS

URBAN TRIANGLE AREA



Water Quality Management Plan

PREPARED FOR
LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS
LOVELAND, COLORADO

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BY
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LOVELAND, COLORADO

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LARIMER-WELD REGIONAL COUNCIL OF GOVERNMENTS

208 AREAWIDE WATER QUALITY MANAGEMENT PROGRAM

MUNICIPAL POINT SOURCE ANALYSIS - URBAN TRIANGLE AREA OF THE LARIMER-WELD REGION

Prepared For

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Council of Governments

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1.0 EXECUTIVE SUMMARY

The Municipal Point Source Analysis - Urban Triangle Area provides the results of analyses conducted of municipal waste water treatment requirements and alternatives in the Urban Triangle Area of the Larimer-Weld Region. This area includes Fort Collins, Loveland, Greeley, Windsor, Johnstown, Milliken, Boxelder Sanitation District, South Fort Collins Sanitation District, and the Evans Sanitation District. The area contains approximately 62 percent of the area's total population. This report presents alternative treatment and disposal plans which were developed as a result of applying existing stream standards and waste load allocations in the Urban Triangle Area. The report is primarily an informational document developed as part of the overall point source analysis of the 208 Plan.

Existing and future wastewater treatment requirements are based on the recommended 208 Land Use Plan (Larimer-Weld Region Land Use Alternatives - Analysis of 20-Year Growth Demands and Impacts, Interim Report No. 16), and the results of the waste load allocation process (Interim Report No. 20 - Waste Load Allocations and Water Quality Modeling - Major Rivers in the Larimer-Weld Region). No conclusions are presented in this report regarding the validity of treatment requirements defined in this manner. In addition to consideration of wastewater treatment alternatives, this report assesses several methods for achieving wastewater flow reduction including water conservation measures and infiltration/inflow reduction.

Strict application of waste load allocation procedures is defined in Federal and State water quality management regulations and results in the application of stringent waste treatment requirements for all municipal dischargers in the region with the exception of Milliken and Johnstown. Based on existing waste flows, Fort Collins No. 1, Windsor, Greeley First Avenue, and Loveland No. 2 treatment plants will have to provide for ammonia reduction to a level of 3 mg/l. Fort Collins No. 2 and Boxelder Sanitation District will have to provide for ammonia removal to a level of 1.5 mgl. Milliken, Johnstown, and Evans can meet water quality standards now and in the future by providing secondary treatment levels.

By the year 2000, ammonia removal to a level of 1.5 mg/l will be required at Fort Collins No. 1, Fort Collins No. 2, Boxelder Sanitation District, Windsor, the new Greeley Delta Plant, and the Loveland No. 2 Plant in order to meet existing warm water fisheries standards on the Cache la Poudre, Big Thompson, and South Platte Rivers.

In order to meet secondary treatment standards and additional capacity requirements, capital expenditures of $5.7 million will be required for wastewater treatment facilities in the Urban Triangle Area between now and the year 2000. Application of stringent treatment requirements to meet existing numeric water quality standards associated with the warm water fisheries stream classification would require an additional expenditure by municipal dischargers in the Triangle Area of $11.7 million.

In leiu of providing advanced waste treatment, the alternative of providing secondary treatment and applying wastewater to land was considered. It was assumed that secondary treatment with disinfection was a prerequisite to land application. Assuming that municipalities purchase land for disposal and the irrigation system on the land, capital expenditures for secondary treatment and land application would be $57.3 million over and above secondary treatment costs. If the municipalities did not purchase the land and were responsible for providing only winter storage capacity, transportation, and pumping facilities, cost of secondary treatment and land disposal would be $39.6 million over and above secondary treatment costs. The analysis indicates that land application is more costly than tertiary or advanced waste treatment and stream disposal in the Triangle Area. However, the results of this analysis should not preclude further evaluation of land application alternatives as part of future detailed facilities planning projects.

Wastewater flow reduction alternatives assessed included water system metering, installation of water-saving devices, grey water systems, and infiltration/inflow reduction. The general assessment indicates that implementation of water conservation measures for the purpose of reducing flows to wastewater treatment plants cannot be justified on that basis alone. Additional benefits such as reduced water demand must be considered in evaluation of these measures. It appears that the cost savings resulting from water conservation measures are greater at the water treatment plant than at the wastewater treatment plant. It is recommended that all communities in the Triangle Area evaluate the extent of their infiltration/inflow problems as part of the continuing facilities planning and before spending additional funds on expansion of wastewater treatment works.

2.0 EXISTING MUNICIPAL FACILITIES

An analysis of the municipal treatment facilities in the urban triangle area was conducted. These facilities are those of Fort Collins, Loveland, Boxelder Sanitation District, South Fort Collins Sanitation District, Evans Sanitation District, Greeley, Milliken Sanitation District, Johnstown, and Windsor (Figure 2.0-A). Table 2.0-A indicates the secondary capacity of each of these entities' treatment facilities, the projected flow rate in the year 2000, and the year the secondary capacity will probably be exceeded. The treatment facilities of each of the communities will be briefly described, along with other pertinent information.

2.1 CITY OF FORT COLLINS

Fort Collins has two treatment plants. The Fort Collins No. 1 plant is located adjacent to the Cache la Poudre River at Mulberry Street. The Fort Collins No. 2 plant is adjacent to the Cache la Poudre River at Drake Road. There is a trunk from the No. 1 plant to the No. 2 plant.

The Fort Collins No. 1 plant was recently upgraded, going on-line in late 1976. The trickling filter was renovated and an activated sludge basin and new clarifiers were installed. This plant is meeting standards at design flow rate.

The Fort Collins No. 2 plant is composed of two separate treatment facilities. The older facility is a 4.8 mgd activated sludge plant which is currently being upgraded. The new facility is a 12 mgd activated sludge plant which began operating in the spring of 1977. The aeration basins are designed for nitrification (ammonia conversion to nitrate).

The secondary capacity of the combined Fort Collins treatment plants is approximately 22 mgd, which is sufficient to meet treatment requirements through the year 2000 assuming infiltration/inflow (I/I) can be corrected. The theoretical tertiary capacity at Fort Collins is 12 mgd.

Fort Collins has a severe I/I problem, with summer flows being twice winter flows as a result of high ground waters. If the I/I problems are not corrected, the hydraulic capacity of the Fort Collins treatment plants will be exceeded by 1985.

2.2 CITY OF LOVELAND

Loveland's wastewater treatment plant has been recently upgraded and expanded, going on-line in the spring of 1977. It is located east of Loveland and discharges to the Big Thompson River. It utilizes activated sludge treatment followed by trickling filters for biological treatment. Dechlorination facilities are also provided. This plant has a design capacity of 7.7 mgd. The old trickling filter plant (Plant No. 1) has been abandoned.

INDEX NO.		EXISTING AVERAGE FLOW (mgd)
M-37	Boxelder S.D.	0.6
M-38	Evans S.D.	0.5
M-39	Fort Collins #1	5.0
M-40	Fort Collins #2	5.6
M-41	Greeley	6.2
M-42	Loveland	4.0
M-43	South Fort Collins S.D.	0.5
M-44	Windsor	0.6
M-14	Johnstown	0.22
M-20	Milliken S.D.	0.10

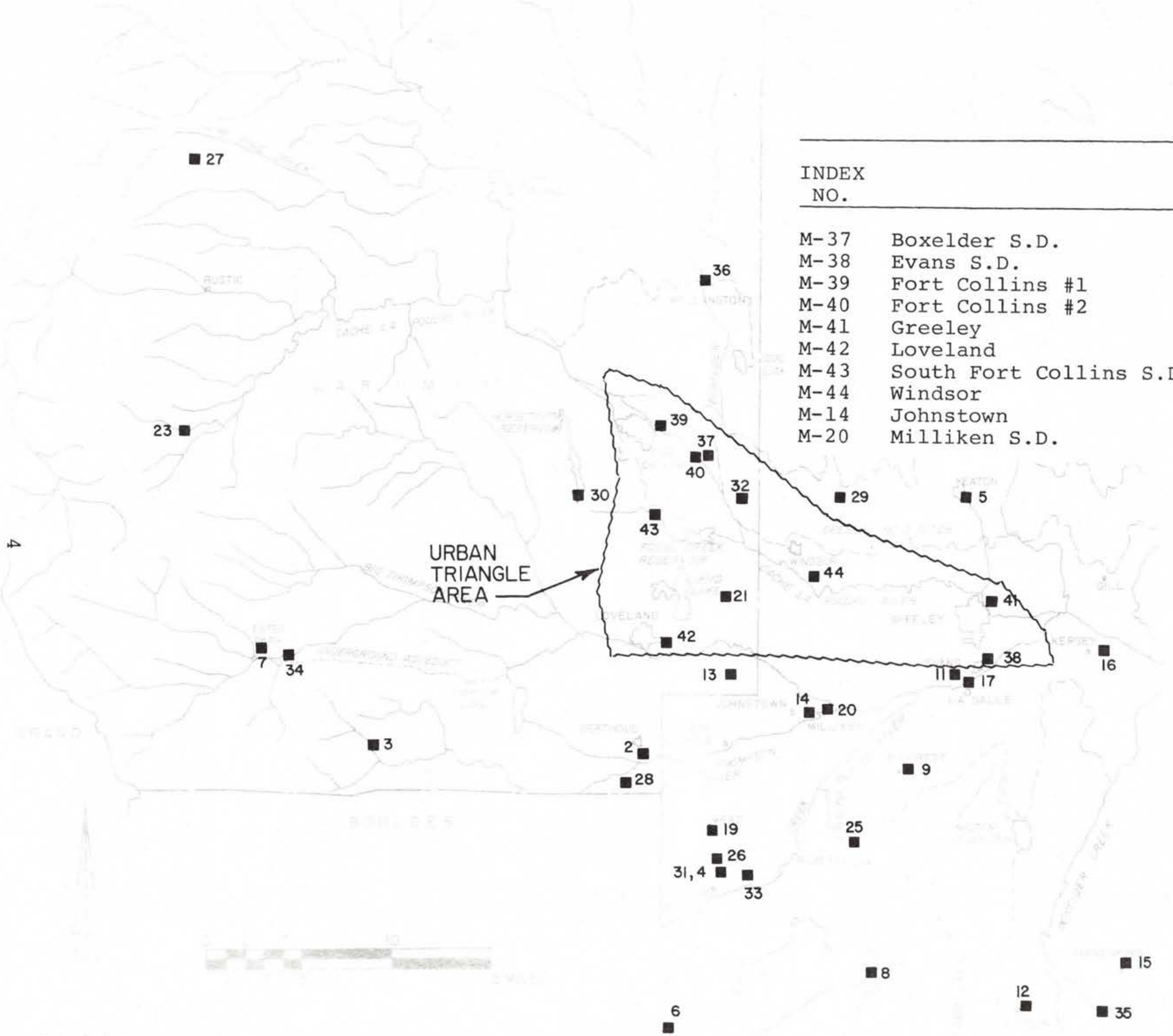

FIG. 2.0-A. SOURCES OF MUNICIPAL WASTE DISCHARGE - LARIMER - WELD REGION

TABLE 2.0-A WASTEWATER FLOW PROJECTIONS AND YEAR UPGRADING IS NEEDED

COMMUNITY	EXISTING PLANT CAPACITY (mgd)	YEAR 2000 FLOW (a)	SECONDARY TREATMENT CAPACITY EXCEEDED (b)
Ft. Collins	21.8	15	1992 (c)
Loveland	7.7	6.1	
Boxelder S.D.	0.75	1.0	1985
So. Ft. Collins S.D.	1.5	1.35 (d)	
Evans S.D. (e)	0.9	0.9	
Greeley (f)	6.0	11.5	
Windsor (g)	0.6	1.7	Presently Exceeded
Milliken S.D.	0.28	0.4	Presently Exceeded
Johnstown	0.25	0.38	Presently Exceeded

(a) Assumes I/I is corrected.
(b) Straight-line growth rates were used to determine expansion date.
(c) This is the year the tertiary treatment capacity will be exceeded--secondary capacity will not be exceeded prior to 2000 A.D. with I/I element.
(d) Includes .35 mgd from Spring Canyon S.D.
(e) Greeley 201 calls for Evans to be served by Greeley by 1995.
(f) The 201 Wastewater Facilities Plan recommends a 4 mgd plant expansion immediately and in 1989; an 8 mgd expansion is anticipated in 1995. The plan may be amended to increase the capacity of the first stage construction project. This will change the anticipated scheduling of future incremental expansions. Preliminary evaluation of the factors affecting the time phasing of initial plant capacity indicate that a 6 mgd first stage construction should be considered in lieu of the 4 mgd facility.
(g) Flows assume 670,000 gpd domestic flow comes from Kodak, but these workers do not live in Windsor (3,200 employees now).

2.3 BOXELDER SANITATION DISTRICT

The Boxelder Sanitation District (S.D.) treatment facility consists of three-cell stabilization pond system which was installed in 1973. The cells are operated in series; the first two are aerated. The lagoons are followed by a rock filter (for algae removal) and chlorination. The design capacity of the plant is 0.75 mgd.

Along with a residential population of about 2,700 people, the Boxelder S.D. serves many commercial facilities, including several restaurants and motels. These commercial establishments contribute about 40 percent of the wastewater to the treatment plant. The service area is conducive to commercial establishments, so this trend is likely to continue. Projected wastewater flows assume the ratio of commercial to residential flow volumes will be the same in the year 2000 as now.

2.4 SOUTH FORT COLLINS SANITATION DISTRICT

A new wastewater treatment facility to serve the South Fort Collins Sanitation District was constructed in 1976. This is a 1.5 mgd activated sludge plant followed by multimedia filters and chlorination. This plant has sufficient capacity to treat the wastewater generated through the year 2000. The discharge is to Fossil Creek Reservoir.

2.5 EVANS SANITATION DISTRICT

Evans is served by an aerated stabilization pond system which was recently upgraded. The stabilization ponds are followed by a rock filter (for algae removal) and chlorination. The design capacity of this system is 0.9 mgd, which is sufficient to treat the wastewater generated through 1998.

The Greeley 201 Facilities Plan calls for Evans S.D. to be served by Greeley by 1995. This plan recommends that an interceptor be constructed from Evans to the Delta site.

2.6 CITY OF GREELEY

Greeley's domestic waste is currently being treated at the First Avenue plant. This facility consists of two separate plants--the North Side and the South Side. The North Side plant is an activated sludge plant; the South Side is a trickling filter plant. The effluents are combined prior to disinfection with chlorine. The combined treatment capacity is 6 mgd.

A 201 facilities plan has recently been completed. This plan calls for upgrading the First Avenue plant and building a 4 mgd plant at the "Delta site" (junction of the Cache la Poudre River and the South Platte River). An additional 4 mgd unit is to be constructed in 1989. The plan calls for the construction of another 8 mgd increment at the Delta site in 1995. At that time an interceptor would be constructed to transmit wastewater from Evans Sanitation District and Hill-n-Park Sanitation District. Preliminary evaluation of the factors affecting the time phasing of initial plant capacity conducted by the City of Greeley indicate that a 6 mgd first stage construction should be considered in lieu of the 4 mgd facility.

2.7 CITY OF WINDSOR

Windsor is served by a two-cell stabilization pond system. The first cell is aerated. Wastewater is disinfected with chlorine prior to discharge to the Cache la Poudre River. The design capacity of this system is 0.6 mgd.

The waste treatment plant serves the community of Windsor and the domestic wastewater from the Eastman Kodak Company plant. Kodak currently employs about 3,200 people, most of whom do not live in Windsor.

2.8 TOWN OF JOHNSTOWN

A two-cell stabilization pond system is utilized to obtain wastewater treatment by the Town of Johnstown. Two floating aerators are used on the first, although they are too small to aerate and mix the entire pond. The design capacity is 0.25 mgd.

2.9 MILLIKEN SANITATION DISTRICT

A mechanical extended aeration plant serves the Milliken Sanitation District. A thorough evaluation and recommendation for upgrading and expansion of this facility is presented in a separate technical plan (Toups Corporation, 1977). This plan was prepared specifically for the use of the district.

3.0 WATER QUALITY STANDARDS AND STREAM CLASSIFICATIONS

Water quality standards applicable to waters of the Larimer-Weld Region include limitations on the quality of effluent discharged by municipalities and industries, stream classifications applied by the Water Quality Control Commission to streams within the region, and the numerical water quality standards associated with stream classifications. This section defines effluent guidelines, stream classifications, and water quality standards as they are currently applied to the Larimer-Weld Region.

3.1 Effluent Guidelines for Municipalities and Industries

The specific standards applicable to all wastewaters discharged in Colorado are listed in Table 3.1-A.

TABLE 3.1-A SPECIFIC STANDARDS FOR DISCHARGE OF WASTE TO STATE OF COLORADO WATERS

Constituent	Allowable Level in Discharge
Suspended Solids (1)	30 mg/l
BOD_5	30 mg/l
pH	Between 6.0 and 9.0
Fecal Coliform	Determined individually
Chlorine	0.5 mg/l (max.)
Oil and Grease	10 mg/l

(1) A relaxed standard is proposed for communities with a flow rate less than 2.0 mgd which are served by a stabilization pond.

These standards represent the allowable constituent concentrations that can be discharged to waters of the State. In addition, rules and regulations specify that no toxic substance may be discharged in a quantity resulting in a toxic concentration in the stream. This applies to a wide variety of biological and chemical constituents and provides the State with a mechanism for controlling those discharges. The toxic element most commonly found in municipal discharges is ammonia. The Environmental Protection Agency has determined that an ammonia concentration in excess of 1.5 mg/l in the stream is toxic to aquatic life (Willingham, 1976). Although the toxicity is extremely sensitive to changes in pH and temperature, the value is generally accepted as the in-stream limit by the State of Colorado and the EPA.

Additional limitations have been established for specific categories of industries which exhibit common discharge characteristics. A number of major industries in the region, i.e., electronics, meat packing, etc., discharge waste to municipal treatment systems. In these cases, industries must meet pretreatment requirements to eliminate constituents not commonly removed by municipal wastewater treatment works. The municipalities are then subject to limitations described above, or more stringent limitations depending on instream water quality standards.

3.2 Stream Classifications and Standards

The State of Colorado has established water quality classifications for all waters of the State. These classifications include Classes A_1, A_2, B_1, B_2 and C. Class A waters are suitable for all beneficial uses including primary contact recreation, such as swimming and water skiing. Class B waters are suitable for all beneficial uses except primary contact recreation. The subscripts 1 and 2 denote cold water and warm water classifications respectively. Class C waters are those waters which have been excepted from A or B classifications on a case by case basis by the Water Quality Control Commission.

Associated with the classifications are numerical standards to insure that beneficial uses can be maintained within the class. These standards are shown in Table 3.2-A. In addition, toxic elements in toxic concentrations are prohibited in all Class A and B streams in the State. Table 3.2-B shows how these classifications have been applied in the Larimer-Weld Region. All streams are classified as B_1 and B_2 streams. Generally the B_1 streams (cold water fishery) are located in the mountainous areas and the B_2 streams (warm water fishery) are located in the plains areas.

State water quality standards specify that the design frequency and duration for water quality standards is a seven day/ten year low flow. That is a minimum seven day average flow which occurs on the average of once in ten years. This implies that low flows in streams may cause stream violations under drought conditions which occur very rarely, i.e., one week in ten years.

TABLE 3.2-A SUMMARY OF COLORADO WATER QUALITY STANDARDS (a)

STANDARD	CLASS A_1	CLASS A_2	CLASS B_1	CLASS B_2
Settleable Solids	Free From	Free From	Free From	Free From
Floating Solids	Free From	Free From	Free From	Free From
Taste, Odor, Color	Free From	Free From	Free From	Free From
Toxic Materials	Free From	Free From	Free From	Free From
Oil and Grease	Cause a film or other discolor-ation	Cause a film or other discolor-ation	Cause a film or other discolor-ation	Cause a film or other discolor-ation
Radioactive Material	Drinking Water Standards	Drinking Water Standards	Drinking Water Standards	Drinking Water Standards
Fecal Coliform Bacteria	Geometric Mean of <200/100 ml from five samples in 30-day period	Geometric Mean of <200/100 ml from five samples in 30-day period	Geometric Mean of <1000/100 ml from five samples in 30-day period	Geometric Mean of <1000/100 ml from five samples in 30-day period
Trubidity	No increase of more than 10 JTU	No increase of more than 10 JTU	No increase of more than 10 JTU	No increase of more than 10 JTU
Dissolved Oxygen	6 mg/1 minimum	5 mg/1 minimum	6 mg/1 minimum	5 mg/1 minimum
pH	6.5 - 8.5	6.5 - 8.5	6.0 - 9.0	6.0 - 9.0
Ammonia	1.5 mg/1 maximum	1.5 mg/1 maximum	1.5 mg/1 maximum	1.5 mg/1 maximum
Temperature	Maximum 68°F. Maximum Change 2°F.	Maximum 90°F. Maximum Change: Streams - 5°F. Lakes - 3°F.	Maximum 68°F. Maximum Change 2°F.	Maximum 90°F. Maximum Change: Streams - 5°F.. Lakes - 3°F.
Fecal Streptococcus	Monthly average of <20/100 ml from five samples in 30-day period	Monthly average of <20/100 ml from five samples in 30-day period	-----	-----

(a) Water Quality Control Commission, Colorado Department of Health.

TABLE 3.2-B CLASSIFICATION OF WATERS IN THE LARIMER-WELD REGION

RIVER	CLASS
Headwaters of Cache la Poudre to River mile 56 (Greeley Water Treatment Plant Diversion)	B_1
Remainder of Cache la Poudre River	B_2
Headwaters of Big Thompson to River mile 35.8 (Loveland Water Treatment Plant)	B_1
Remainder of Big Thompson River	B_2
South Platte River	B_2
Boulder Creek	B_2
St. Vrain Creek	B_2
Little Thompson River to River mile 24.5 (Culver Ditch)	B_1
Remainder of Little Thompson River	B_2

4.0 WASTE LOAD ALLOCATIONS

The establishment of maximum allowable wasteloads which can be discharged to rivers by municipal and industrial point source dischargers traditionally has been considered a fundamental element in water quality management planning. The wasteload allocation process had previously been applied in the Larimer-Weld Region in the development of the "Comprehensive Water Quality Management Plan - South Platte River Basin" by the State of Colorado. Establishment of maximum allowable wasteloads which can be discharged to rivers and still result in the attainment of water quality standards essentially determines wastewater treatment plant discharge requirements, treatment levels, and wastewater treatment costs for municipal and industrial dischargers. The underlying assumption in this procedure is that if treatment level requirements defined in the wasteload allocation process are achieved then the water quality goals associated with in-stream standards will also be achieved. Although this assumption is invalid in the Triangle Area (Interim WQMP Report No. 20), establishment of maximum allowable wasteloads through the wasteload allocation process is a fundamental requirement of 208 Planning, and it is with this objective that this effort was carried out. For the purpose of this report, it is assumed that the allocation process is a valid means of determining wastewater treatment levels in the Triangle Area.

Treatment level requirements for municipal and industrial dischargers were defined at three levels of treatment - secondary treatment, tertiary treatment, and advanced waste treatment. Associated discharge qualities of these three levels of treatment are shown in Table 4.0-A.

Table 4.0-A LEVELS OF TREATMENT APPLIED TO MEET WATER QUALITY STANDARDS

Treatment Level	BOD5 mg/l	Ammonia mg/l	DO mg/l
Secondary	30.0	15.	2.0
Tertiary	20.0	3.0	2.0
Advanced	10.0	1.5	2.0

Violation of either the dissolved oxygen or ammonia standards would cause municipal and industrial dischargers to go to the next higher level of treatment. In a number of cases, the ammonia standard was violated and dissolved oxygen standard was not violated; however, reduction of BOD levels is considered necessary from a practical standpoint in order to reduce ammonia concentrations in effluent discharges.

Table 4.0-B shows the treatment level requirements to meet stream standards defined by applying existing and projected (year 2000) wasteloads to streams in the region. The required treatment levels determine the cost of treatment facilities in the Triangle Area as defined in this report.

TABLE 4.0-B TREATMENT LEVELS NECESSARY TO MEET PRESENT WATER QUALITY STANDARDS BY MUNICIPAL DISCHARGERS

Discharger	Existing Treatment Level Requirement	Year 2000 Treatment Level Requirement
Fort Collins No. 1	Tertiary	Advanced
Fort Collins No. 2	Advanced	Advanced
Boxelder S.D.	Advanced	Advanced
Windsor	Tertiary	Advanced
Greeley-First Avenue	Tertiary	Closed
Greeley-Delta	-	Advanced
Loveland No. 2	Tertiary	Advanced
Milliken	Secondary	Secondary
Johnstown	Secondary	Secondary
Evans S.D.	Secondary	Secondary

5.0 ALTERNATIVE PLANS FOR TREATMENT AND DISPOSAL

This section includes a discussion of upgrading costs to achieve secondary treatment, and costs to achieve tertiary treatment, advanced treatment, or land application where required, based on the wasteload allocations.

5.1 SECONDARY TREATMENT AND STREAM DISPOSAL

All communities in the region must at least meet secondary treatment standards. Table 5.1-A indicates which communities will require secondary capacity expansion prior to 2000.

Table 5.1-B illustrates the present worth cost of providing additional required secondary treatment capacity.

TABLE 5.1-A COMMUNITIES REQUIRING ADDITIONAL SECONDARY CAPACITY BEFORE 2000 A.D.

AGENCY
Boxelder Sanitation District
Windsor
Johnstown
Milliken
Greeley

Greeley has already begun the process of expanding its wastewater treatment system. According to the recently completed Greeley 201 facilities plan, the First Avenue plant would be upgraded to treat 6.0 mgd, and a new 4.0 mgd facility would be constructed at the Delta site, which is the confluence of the Cache la Poudre and South Platte Rivers. The plan calls for a 4.0 mgd expansion of the Delta plant in 1989, and an additional 8.0 mgd expansion of this plant in 1995. In 1995 the communities of Evans and Hill-n-Park are to be served at the Delta plant. Preliminary evaluation (by the City) of the factors affecting the time phasing of initial plant capacity suggest that a 6 mgd first stage construction should be considered in lieu of the 4 mgd facility.

TABLE 5.1-B PRESENT WORTH COST OF PROVIDING SECONDARY TREATMENT

COMMUNITY	EXISTING CONDITIONS FLOW (mgd)	DESIGN CAPACITY (mgd)	COST (a) ($1000)
Ft. Collins	10.6	21.8	-
Loveland	4.0	7.7	-
Boxelder S.D.	0.6	0.75	43
S. Ft. Collins	0.5	1.5	-
Windsor	0.6	0.6	330
Milliken	0.1	0.07	410
Johnstown	0.33	0.25	105
Greeley	6.2	6.0	4800
TOTAL			5688

(a) Source: Water Pollution Abatement Technology Capabilities and Costs; Metcalf and Eddy, Inc. PB-250 690. March, 1976.

5.2 ADVANCED TREATMENT AND STREAM DISPOSAL

As indicated in Chapter 4.0, the treatment facilities of Greeley, Fort Collins, Loveland, Boxelder Sanitation District, and Windsor will require at least tertiary treatment of the wastewater in order to comply with existing stream standards for warm water fisheries classifications. Tertiary treatment involves nitrification, which refers to the conversion of ammonia, which is toxic to aquatic life, to nitrate, which is not toxic to aquatic life. If Greeley discharges wastewater from the First Avenue plant to the Cache la Poudre River, tertiary treatment will also be required. The Delta plant will discharge to the South Platte River. If appropriate pipeline facilities are constructed, the First Avenue plant will have the option of discharging either to the Cache la Poudre or to Ogilvy Ditch. If the discharge is to Ogilvy Ditch, tertiary treatment is not required.

In addition to achieving intermediate nitrification through tertiary treatment (which reduces ammonia to about 3 mg/l), all of the aforementioned plants except Greeley-First Avenue must achieve complete nitrification (effluent NH_3 = 1.5 mg/l) through application of advanced treatment. This is because the stream flow conditions are such that the discharge constitutes almost all of the stream flow under critical conditions. Therefore, effluent quality levels must be equal to the required receiving water quality standards, according to the waste load allocation process.

As discussed in Chapter 2.0, Fort Collins has two treatment facilities. The No. 2 plant on Drake Road has a theoretical tertiary treatment capacity of 12.0 mgd. Assuming the No. 1 plant is always operated at full capacity (5.0 mgd), the intermediate nitrification capacity of the No. 2 plant will not be exceeded prior to the year 2000. However, as stated above, advanced nitrification is required at the No. 2 plant. This results in the requirement for construction of advanced treatment facilities at the Fort Collins No. 2 plant.

The present worth cost of tertiary and advanced treatment in the region, over and above the cost of secondary treatment, is $16,400,000, as shown in Tables 5.2-A and 5.3-B, respectively. These tables also indicate the capital cost of construction and the present worth of the O & M costs.

TABLE 5.2-A PRESENT WORTH COSTS FOR INTERMEDIATE NITRIFICATION (3.0 mg/l) TERTIARY TREATMENT FACILITIES (a)

COMMUNITY	PRESENT WORTH (Millions of Dollars) CAPITAL COST	O & M	TOTAL
Ft. Collins No. 1	1.2	0.4	1.6
Ft. Collins No. 2(b)	0	0	0
Loveland	1.6	.53	2.13
Boxelder S.D.	0.38	0.1	0.48
Milliken S.D.	NR	NR	NR
Johnstown	NR	NR	NR
Windsor	0.55	0.17	0.72
Greeley-1st Ave.	1.4	0.48	1.9
Greeley-Delta site	1.80	0.55	2.35
TOTAL	6.9	2.2	9.1

NR = Not Required

(a) Costs represent an incremental increase to secondary costs. Costs are additive.

(b) Tertiary treatment currently takes place in the activated sludge basin.

TABLE 5.2-B PRESENT WORTH COSTS FOR COMPLETE NITRIFICATION (1.5 mg/l) ADVANCED TREATMENT FACILITIES (a)

COMMUNITY	PRESENT WORTH (Millions of Dollars) CAPITAL COST	O & M	TOTAL
Ft. Collins No. 1	0.7	0.42	1.1
Ft. Collins No. 2	1.4	0.72	2.1
Loveland	0.72	0.43	1.2
Boxelder S.D.	.25	.07	.32
Milliken	NR	NR	NR
Johnstown	NR	NR	NR
Windsor	0.34	0.10	.44
Greeley-1st Ave.	NR (b)	NR	NR
Greeley-Delta site	1.4	0.72	2.1
TOTAL	4.8	2.5	7.3

(a) Costs represent an <u>incremental increase</u> to nitrification costs presented in Table 5.3-A, and secondary costs. Costs are additive.

(b) NR = Not required if discharge is to Ogilvy.

5.3 SECONDARY TREATMENT AND LAND APPLICATION

An alternative to tertiary or advanced treatment to meet stream standards is land application of effluent so that no discharge of wastewater to the stream occurs. Wastewater should be treated to secondary standards prior to land application for public health reasons and to reduce adverse aesthetic effects such as odors. The Colorado Department of Health currently requires secondary treatment with disinfection as a prerequisite to land application. The Governors Science and Technical Advisory Council, published on July 20, 1977, an evaluation of the feasibility of land treatment in Colorado. The reader is referred to this document for further discussion of the land treatment alternative.

Table 5.3-A illustrates the present worth of capital and O & M costs of a land application system which is intended for crop irrigation. Revenue produced by crop production resulting from this system is shown in Table 5.3-B. This estimate is based on information from the Boulder, Colorado, land application project. The estimated revenue amounted to $25.00 per ton and a production of 4 tons of alfalfa per acre, or $100.00 per irrigated acre. Table 5.3-C shows the net cost of a land application system to a community. The net cost is $70,100,000.

These numbers assume the municipality purchases the land and irrigation systems and runs the farming operation. These costs can be substantially reduced by simply trading water rights with a nearby irrigator. In this situation a municipality may have to supply little more than water storage capability and a pipeline to transport the reclaimed water to the irrigator's ditch system. Table 5.3-D shows the cost of providing storage capacity, transmission, and pumping. This would cost approximately $39,600,000.

5.4 COMPARISON OF ALTERNATIVE DISPOSAL OPTIONS

As previously stated, all communities in the region are required to provide secondary treatment. Some of the communities in the triangle area already provide sufficient secondary treatment, while others need immediate upgrading. The capital cost of providing secondary capacity where needed in the Triangle Area is $5,700,000.

If it is required that the streams in the region be capable of supporting fish despite the fact that natural stream flows are zero in many reaches during the irrigation season, additional treatment must be provided at many plants.

A comparison of Table 5.2-A, 5.2-B and 5.3-C indicates that tertiary and advanced treatment is much less expensive than land application, assuming the community supplies all land, equipment, and labor. If it is possible to trade water with an irrigator, the cost of land application decreases, but is still more costly than is tertiary and advanced treatment. The alternatives of land treatment versus tertiary and advanced treatment are compared in Table 5.4-A and 5.4-B.

TABLE 5.3-A PRESENT WORTH COSTS OF LAND APPLICATION SYSTEMS

COMMUNITY	COSTS (Millions of Dollars)		
	CC	O & M	TOTAL
Ft. Collins	22.0	9.5	31.5
Loveland	9.5	4.2	13.7
Boxelder S.D.	2.3	0.91	3.2
Milliken S.D.	NR	NR	NR
Johnstown	NR	NR	NR
Windsor	3.4	1.4	4.8
Greeley-First Avenue	8.0	4.2	12.2
Greeley-Delta site	12.1	4.6	16.7
TOTAL	57.3	24.8	82.1

NR = Not Required.

TABLE 5.3-B CROP REVENUE FROM LAND APPLICATION

COMMUNITY	REVENUE (Thousand of Dollars)
Ft. Collins	4,950
Loveland	2,013
Boxelder S.D.	330
Milliken	NR
Johnstown	NR
Windsor	560
Greeley-First Avenue	1,979
Greeley-Delta Site	2,127
TOTAL	11,959

NR = Not Required.

TABLE 5.3-C NET PRESENT WORTH COSTS OF LAND APPLICATION SYSTEM

COMMUNITY	COST (Millions of Dollars)
Fort Collins	26.5
Loveland	11.7
Boxelder S.D.	2.9
Milliken S.D.	NR
Windsor	4.2
Greeley-1st Ave.	10.2
Greeley-Delta site	14.6
TOTAL	70.1

NR = Not Required

TABLE 5.3-D PRESENT WORTH COST OF TRANSMISSION AND STORAGE FOR LAND APPLICATION

	COST (Millions of Dollars)		
COMMUNITY	CC	O & M	TOTAL
Fort Collins	10.0	2.0	12.0
Loveland	4.4	.8	5.2
Boxelder S.D.	1.1	.17	1.3
Milliken S.D.	NR	NR	NR
Windsor	1.6	.28	1.9
Greeley-1st Ave.	4.2	.8	5.0
Greeley-Delta plant	12.0	2.2	14.2
TOTAL	33.3	6.3	39.6

NR = Not Required.

TABLE 5.4-A COMPARISON OF PRESENT WORTH COSTS

		PRESENT WORTH COSTS (MILLIONS OF DOLLARS)			
		PROJECTED COST		TOTAL COST (a)	
POPULATION PROJECTION	SECONDARY TREATMENT	SECONDARY + NITRIFICATION (b)	SECONDARY + LAND APPLICATION	SECONDARY + NITRIFICATION (b)	SECONDARY + LAND APPLICATION
Recommended, Triangle Area	5.7	17.4	29.7	22.1	36.2

(a) Excludes O & M costs for secondary treatment.
(b) As required to meet existing steam standards, per wasteload allocation model.

TABLE 5.4-B TOTAL TREATMENT COSTS FOR LARIMER-WELD REGION (MILLIONS OF DOLLARS) AT RECOMMENDED POPULATION PROJECTIONS (a)

	SECONDARY TREATMENT			SECONDARY + NITRIFICATION (b)		
AREA	CAPITAL COST	PRESENT WORTH	ANNUAL COST	CAPITAL COST	PRESENT WORTH	ANNUAL COST
Triangle Area	7.1 (c)	5.7 (c)	.58 (c)	18.9 (d)	22.1 (d)	2.25(d)
Outlying Area	4.8 (e)	4.2 (e)	.43 (e)	8.0 (f)	12.6 (f)	1.28(f)
TOTAL	11.9	9.9	1.01	26.9	34.7	3.53

(a) As required to meet existing stream standards, per wasteload allocation model.
(b) O & M costs for secondary treatment are excluded.
(c) See Table 5.1-B.
(d) See Table 5.2-A and 5.2-B.
(e) See Table 8.3-A of Point Source Analysis; assumes adoption of Best Waste Stabilization Pond Standards.
(f) Cost assumes stabilization pond standards are not adopted.

6.0 WASTEWATER FLOW REDUCTION

In this section, various water saving devices and systems are described, general costs of achieving specific per capita wastewater production rates are developed, and the feasibility of initiating and maintaining a water conservation program is discussed. The term "grey water" refers to the wastewater produced by all water appliances/ functions except toilets which produce "black water

6.1 ALTERNATIVES FOR CONSERVING WATER

Three means of reducing wastewater flow will be discussed. The first two alternatives are methods of obtaining water conservation. The final method is by eliminating excessive groundwater and stream water from entering the wastewater collection systems.

6.1.1 Water System Metering

One of the least expensive and most effective means of reducing water consumption is by metering of potable water systems. The consumer has an economic incentive to conserve water simply because his total cost of water increases as his consumption increases. The city of Boulder installed water meters in 1962. Since then, the average indoor water consumption has decreased by 36 percent and outside use (lawn watering, car washing, etc.) dropped by 50 percent. It is reported that the per capita daily water consumption in cities with water meters is 185 gallons compared to 330 gallons in cities without meters (Robie, 1975).

The biggest disadvantage associated with water metering is that public utility costs may increase because of the need for meter installation, meter readers, and increased billing procedures. This may be offset by the reduced consumption of water.

Many communities are hesitant to meter water because of the high initial cost of purchasing meters. Realizing that at some point in time the installation and reading of meters will be inevitable, the communities should consider requiring the installation of water meters on all new homes. Initially they do not have to read the meters, but they will be available. This would be particularly helpful to communities with a high growth rate.

6.1.2 Water Saving Devices

The impact of a specific water saving device is greatest when the device is applied to an appliance or function which uses large quantities of water. Table 6.1.2-A describes the water consumption for the various household functions typical of the average family of three in the United States. It is apparent that almost 70 percent of the total water consumed in a household is used for toilet flushing and bathing. There are two basic levels of water saving devices/appliances which are currently available. The first level which involves modification of existing fixtures can achieve a 30 percent to 50 percent reduction while the second level achieves a 50 percent to 70 percent water use reduction by replacing fixtures with completely new fixtures.

6.1.2.1 Modification of Existing Fixtures

Orifice type flow controllers, pressure reduction valves, displacement or low volume flushing device for toilets, and low water use appliances (suds saver washing machines) can be employed at a minimum cost to reduce water consumption by 30 percent to 50 percent.

TABLE 6.1.2-A DAILY WATER USAGE OF VARIOUS HOUSEHOLD FUNCTIONS/APPLIANCES FOR AVERAGE THREE MEMBER HOUSEHOLD IN UNITED STATES (a)

FUNCTION/APPLIANCE	U.S. AVERAGE GALLONS/DAY
Toilet	75
Bathing	60
Laundry	25
Kitchen/Utility	15
Lavatory	8
Drinking/Cooking	12
TOTAL	195
Per Capita	65

(a) U.S. average values obtained from Linaweaver, 1967.

6.1.2.1.a Bathing

Reduction in bathing water usage can be achieved for showers through flow restrictors in shower heads. Conventional shower flow rates of 5 to 10 gpm can be reduced to 2.5 to 3.5 gpm. When flows have been reduced to values less than 2.5 gpm with conventional shower heads, longer times are required to achieve acceptable degrees of cleanliness. This tends to increase overall water consumption. Approximate installed costs of modification devices along with reduced water usage for the various function/appliances are presented in Table 6.1.2-B. It should be noted that reduction in bathing water usage also results in a substantial savings in energy due to hot water conservation.

TABLE 6.1.2-B. INSTALLED COSTS FOR WATER SAVING DEVICES

	CONVENTIONAL WATER USAGE (gpd)	PERCENT SAVINGS	REDUCED WATER USAGE (gpd)	COST $
Bathing	45	50-70	14-22	5-30
Toilets	58	20-55	25-47	2-300
Laundry	20	20-30	14-16	50-400 [a]
Kitchen/Utility	12	10-20	10-11	5-30
Lavatory	6	20-50	3-5	5-30
Drinking/Cooking	9	0	9	0
Total	150	---	85-110	$70-700

[a] Represents a range of costs from the additional cost of suds-saver to a complete unit.

6.1.2.1.b Toilets

Various reduced flow types are currently available including several which use no water. Under the modification alternatives being considered in the first level of water conservation, reduction of 20 percent to 50 percent are possible for modifying siphon design, tank capacity, and flushing mechanism. Several schemes are as simple as installation of bricks or sand-filled plastic bottles to modify tank capacity. Another scheme involves conversion of the tank/flushing valves to achieve two flushing volumes, a low volume for urine and a large volume for fecal matter.

For new or replacement installations conventional toilets are now available which use a maximum of 3 gallons per flush which is significantly less than the conventional 5 to 7 gallons per flush. Several municipalities have adopted building codes which require installation of low volume toilets in all new applications. The installed costs of modification/conventional low use toilets are presented in Table 6.1.2-B.

6.1.2.1.c Clothes Washing Machines

Front loading washing machines use approximately 22 to 33 gallons per load while top loading machines require 35 to 50 gallons per load. Sud-saving devices on top loading machines can reduce water consumption by 10 gallons per load.

6.1.2.1.d Others

Flow restricting devices can be installed on all faucets thereby reducing usage for both kitchen/utility and lavatory applications. Approximate information is presented in Table 6.1.2-B.

Overall modification of existing fixtures or replacement of appliances with conventional low water use appliances can reduce water consumption (wastewater production) to 75-110 gpd for a family of three at a cost of $70 to $700. This is equivalent to per capita wastewater flow rates of 25-37 gpd.

6.1.2.2 Replacement with Minimum Use Fixtures/Appliances

Various low water use systems are available which can greatly reduce overall water consumption. In general, these systems cost from several hundred to several thousand dollars. Currently available are minimum water use systems for bathing and toilet functions.

6.1.2.2.a Toilets

There are three general classes of water conservation toilets currently available: 1) devices which use less than 0.5 gallons per flush; 2) systems or devices which use no water but require disposal of a sludge or other material stored in a vault; 3) systems producing no waste but an ash. The costs and overall suitability of several available facilities are described in Table 6.1.2-C.

The first category includes vacuum, compressed air, trap door or any of several other type toilets. Total water usage for flushing can be reduced to less than 7 gpd for a typical family of three.

TABLE 6.1.2-C. COST AND SUITABILITY OF ALTERNATIVES [a]

DESCRIPTION	CAPITAL COST	ESTIMATED O&M (YEARLY)	MANUFACTURER	COMMENTS	PUBLIC ACCEPTANCE	ENVIRONMENTAL IMPACT
Chemical Toilet	$330	$50	Monogram Industries Redondo Beach, California	2% of normal toilet water consumption Must use special tissue Must be emptied approximately each 10 days.	Negative: Odors Maintenance Aesthetic	Negative Chemical Strong Effluent
Pressurized Flush	700	10	Micropore Willets, California	10% of normal toilet water consumption	Positive: Aesthetic	Positive Low Energy Low Water Use
Oil Flush	2000-5000	175 (Elec., Chemical, Maint.)	Monogram Industries Monterey Park, California	No water use. Requires storage & annual pumpout	Positive: Aesthetic	Negative Scarce Resource
Incinerator	550	150 (Elec. Propane)	LaMere Industries Walworth, Wisconsin	No water use.	Negative: Op. Cost Cleaning	Negative Energy Use

[a] References: "Residential Water Conservation", Murray Milne, et. al., California Resources Center, University of California, Davis, Report #35, March, 1976.

Personal contact with manufacturers.

In the second category are toilet systems which produce compost or recycle oil which acts as the flushing agent. Such systems completely segregate human wastes from the grey water.

No liquid wastes are produced by the incinerator toilets which use electrical or natural gas/propane to completely evaporate water and oxidize organics. These systems also permit complete segregation of grey waters from human wastes.

The minimum installed cost of a toilet utilizing 7 gpd or less for an average family of three ranges between $1,500 and $4,000.

6.1.2.2.b Bathing

Showers have been developed which use less than 0.5 gpm of water in a dual fluid nozzle. The other fluid, air, is supplied by a small compressor. This system can reduce the bathing water requirements for a family of three to less than 10 gpd while at the same time achieving significant energy conservation. Installation of the shower system involves considerable modification of existing plumbing since an electrical in-line water heater is required if the shower is not located directly adjacent to a conventional water heater. At a flow rate of 0.5 gpm, the water will never get hot at distances greater than 25 feet from the water heater due to heat losses in the piping.

The total installed cost of the dual fluid, low water use shower system ranges between $750 and $1,500, depending on the extent of modifications required.

From the above discussions it can be concluded that water consumption for bathing and toilets can be reduced to less than 10 to 20 gpd for a family of three for $2,250 to $5,500. This can reduce the total household water consumption of 45 gpd or 15 gpcd.

6.1.2.3 Grey Water Systems

Water used in residences perform various functions which have different requirements for initial purity and result in different degrees of contamination. Several systems have been developed which utilize the wastewater generated in the bathing, laundry, and kitchen functions to flush conventional toilets. Such applications are referred to as grey water systems.

A typical grey water system is illustrated in Figure 6.1.2-A. The numbers on Figure 6.1.2-A indicate the daily water consumption for an average family. The illustrated water consumptions are based on conventional water use fixtures.

The grey water system illustrated only reduced water consumption by the amounts used for flushing. When the costs ($1,500 to $3,000) and the operational requirements of the grey water system (storage tank, filter, pump, and pressure tanks) are compared with those of chemical/incinerator toilets which achieve the same degree of water conservation, it is obvious that grey water systems are not practical in general.

6.1.3 Infiltration/Inflow Reduction

The final method of reduction of wastewater flow investigated is by reduction of the quantity of groundwater or stormwater which enters the wastewater system. Groundwater that enters the collection system is called infiltration. Inflow refers to stormwater which enters directly into the collection system through open manholes, sump pumps, roof drains, etc. Combined, this is referred to as infiltration/inflow (I/I).

I/I is a very severe problem in the Larimer-Weld region. Fort Collins, Loveland, Windsor, and the Milliken Sanitation District have particularly severe I/I problems. Summer wastewater flows increase substantially over winter flows because the groundwater table elevation increases when irrigation ditches are full. Inflow at Fort Collins and Loveland is so severe that in the past, there were times when wastewater could not flow through the treatment plants because the hydraulic loads were so great. Both communities have expanded their wastewater treatment plants, but these I/I problems have not been corrected. As these communities continue to grow, the adverse effects of excessive I/I will again be apparent.

While these four communities were mentioned as having particularly severe problems, every community in the triangle area has substantial I/I which might be economically reduced.

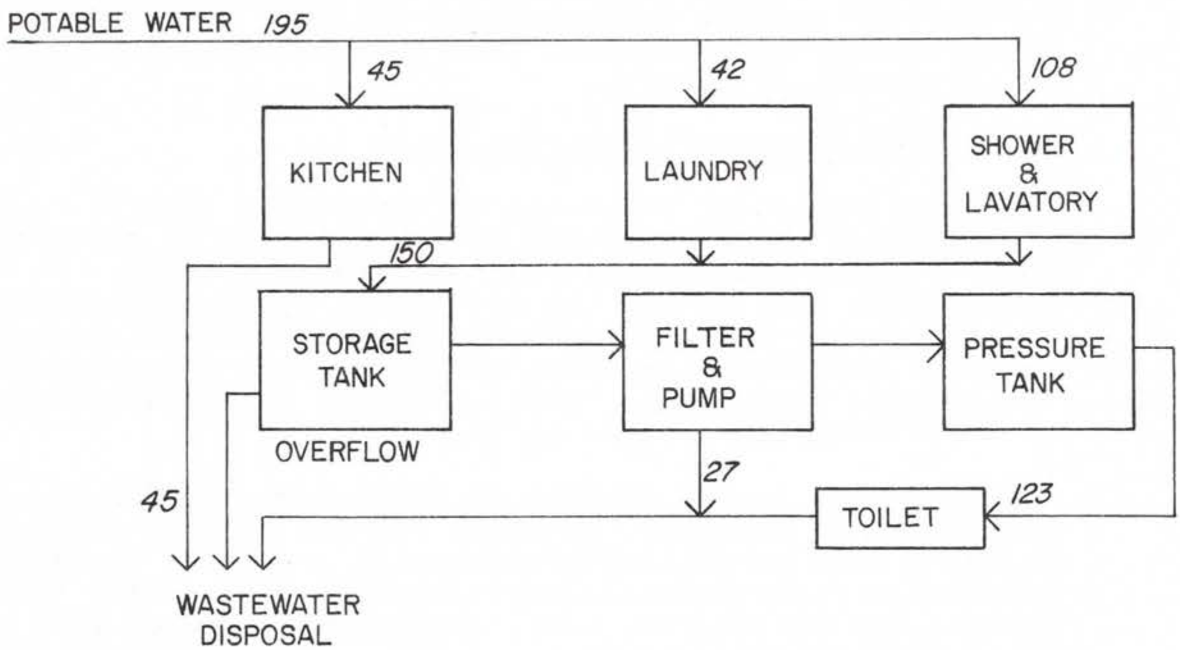

FIGURE 6.1.2-A. TYPICAL GREY WATER SYSTEM - Numbers indicate daily water consumption (gallons) for an average family of three.

6.2 IMPACTS ON TREATMENT FACILITY CAPACITIES

The overall impact of water conservation and I/I correction on the wastewater collection system and treatment facilities is dependent on the nature of the facilities employed. In general, sewer sizes cannot be reduced due to water conservation, although I/I can utilize a large percentage of sewer line capacity. Therefore, water conservation will not affect sewer sizes.

Excessive I/I uses a large percentage of the hydraulic capacity of a treatment works. While an in-depth analysis of the actual source of these problems in the communities is beyond the scope of this report, it is probable that correction of many I/I problems can be economically achieved, and potential solutions should be thoroughly investigated before spending large sums of money on expansion of wastewater treatment works.

Water conservation can have a significant impact on particular treatment/disposal processes. The impact will be greatest on those processes or systems whose size is related primarily to wastewater volume and not strength. For example, while the size of an aerated stabilization pond having a 30-day detention time could be significantly reduced by water conservation, the aeration requirements would be unaffected since water conservation does not affect per capita BOD_5 wasteloads. Controlled biological systems such as activated sludge or trickling filter plants would be minimally affected since capacity is dependent on both strength and volume of wastewater. Water conservation reduces the volume of wastewater while simultaneously increasing its strength. Hydraulically-overloaded wastewater treatment plants benefit significantly from flow reduction achieved through water conservation programs.

6.3 RECOMMENDATIONS

It is recommended that all communities in the Triangle Area evaluate the extent of their I/I problems. Some assessment of the extent of the problem can be made by simply comparing winter flow records with summer flow records. Flow records taken during and immediately following rain storms can be compared to dry weather flow conditions to further determine the extent of I/I problems.

The lack of meters in the water distribution systems serving most Larimer-Weld communities make it difficult, if not impossible, to enforce water conservation programs. While building codes can require that water conservation devices be installed, there are no means of requiring proper maintenance of the devices.

The majority of the currently available water conservation devices do require periodic maintenance. In many instances, it would be easier for individuals to bypass the flow reduction devices than to repair them.

If dwelling units are served by gravity or pressure sewers, there are no means for monitoring individual dwelling contributions other than water consumption. Without means for enforcing water conservation, it cannot be recommended that reduced wastewater loading rates be used in the design of treatment or collection facilities.

Even using water meters cannot be economically justified by reduced wastewater treatment costs alone. However, there are obviously other savings other than reduced wastewater treatment costs. Less raw water must be treated to potable water quality, reducing treatment and pumping costs. The cost savings is substantially greater at the potable water treatment plant than at the wastewater plant.

BIBLIOGRAPHY

Colorado Department of Health. Water Quality Control Commission. Colorado Water Quality Standards

Governor's Science and Technical Advisory Council. Report of the Task Force on the Land Application Treatment of Wastewater to the Governor's Science and Technical Advisory Committee. July 20, 1977.

Linaweaver, R. P. and Howe. The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure. Department of Environmental Engineering Science, The John Hopkins University, 1967.

Metcalf and Eddy, Inc. Water Pollution Abatement Technology Capabilities and Costs. PB-250.690. March 1976.

Robie, Ronald. The Trend of Mighty Armies. Paper presented at "Watercare Conference." 1975.

Toups Corporation and Briscoe, Maphis, Murray, and Lamont, Inc. Milliken Sanitation District, Colorado, Plan for Wastewater Treatment Works. May 1977.

Willingham, William T. Ammonia Toxicity. U.S. Environmental Protection Agency, Control Technology Branch, Water Division, Region VIII. EPA-908/3-76-001. February 1976.