Feasibility Study: Reclaimed Wastewater for Groundwater Recharge at Moscow, Idaho

Mark Nadler

for C.E. 502: Directed Studies
under the Supervision of Prof. A. T. Wallace

September, 1981

In some regions of the United States water has always been regarded as a precious commodity. In the near future the same high regard for water will be transferred to an ever increasing number of Americans. This is because we frequently are withdrawing our water at a faster rate than nature can replenish it. Thus, according to the laws of supply and demand, as the demand outstrips the supply, the value of the remaining supply increases. This trend can continue only until the time when the supply is finally exhausted, then the commodity in question becomes virtually priceless.

This unpleasant scenario has physical, as well as economic implications, especially in regard to ground water aquifers. At several locations along the California coast overpumping of aquifers has caused the intrusion of sea water into the aquifer. This saline water, if not checked, could potentially render an aquifer and its water useless--at least until the price of water rises high enough to make desalination economical. At many places in both Texas and Florida overpumping of aquifers has caused severe ground surface subsidence.[1] This subsidence can be of the form where a whole region subsides together only a few feet, thereby not causing a catastrophe; or as in Florida, it could be an entire city block dropping many feet in a period of days, destroying homes and property. On the other hand the results of overpumping can be more insidious, such as in many agricultural areas of Midwestern America. These areas are heavily dependent on groundwater to supply their irrigation water. Unfortunately, heavy usage of these aquifers without corresponding recharge has caused a net decrease in the recoverable amount of water in the aquifer.

So-called "mining" of groundwater has many profound long term ramifications which have been discussed at great length in many of the national publications, and therefore will be excluded from the scope of this discussion. The preceding discussion has local, as well as national interest as it is commonly accepted that groundwater "mining" is being practiced in the Moscow-Pullman region.

Moscow, like so many other American cities, is dependent entirely upon groundwater for its municipal water supply. The city operates essentially four wells to provide the supply. Two of these wells are deep wells which tap a relatively high quality aquifer, and the water produced requires little or no treatment. Consequently, the city takes the bulk of its water from these wells. The other two wells are shallow wells and are not of such good quality. The water from these wells is high in iron and manganese. In order to utilize this water the city was forced to build a water treatment plant to remove these metals. Operation of the treatment plant costs more money than pumping water out of the deeper wells, so the city uses the deeper wells during the periods of low demand, and shallow wells only to provide for peaking demand.

The summers in Moscow are warm and relatively dry, causing many people, businesses, and institutions to practice extensive turf irrigation. This practice represents a significant demand, to the point that the two shallow wells are pumped extensively in the summer months (usually about three months). During the winter there is no sprinkling of lawns, thus the demands are lower and the shallow wells are not used. Since the water treatment plant is used only to treat the water from the shallow wells, it too is used only during the summer months.

The City of Moscow has a 3.5 MGD secondary wastewater treatment plant which produces an exceptionally good quality effluent. In fact the quality of water it discharges to Paradise Creek is generally better than the quality of the water in Paradise Creek. Monthly summaries of the effluent quality for the Moscow wastewater treatment plant for the year 1980 are shown in Appendix A, in Table I. The University of Idaho, located adjacent to the wastewater treatment plant, uses a part of the effluent from the treatment to irrigate lawns, atheletic fields and a golf course during the summer. This usage constitutes about 1 MGD of the average 1.75 MGD summertime effluent discharge. During the fall, winter and spring this effluent is merely discarded into Paradise Creek. This constitutes a definite waste, because the effort and money that is expended in the treatment process renders the wastewater literally too valuable to throw away.

The surplus of effluent during the winter months, and the availability of an idle water treatment plant during the same time period seems to suggest the possibility of using the water treatment plant to provide tertiary treatment for the surplus wastewater treatment plant effluent, followed by reuse of the effluent. This reclaimed water could have many uses, but the two most likely involve groundwater recharge and non-potable "dual system" use.

Either alternative would require the construction of a force main from the wastewater treatment plant to the water treatment plant. The first alternative would further require the construction of a force main from the water treatment plant to the site of an injection well. Due to the location of the water treatment plant (ie. downtown) both of these force mains would have to pass through the city. With the force mains in place, those areas of the city adjacent to the force mains would have access to a dual water system. This would allow the use of the reclaimed effluent for lawn watering, fire fighting, or perhaps for some commercial or industrial non-potable usage in these areas. The force mains would serve as the non-potable water distribution system.

The reclaimed water not used for the non-potable uses listed would then be available for injection into the ground for groundwater recharge. The objective of the groundwater recharge scheme is the recharge of the more shallow of the aquifers that the city pumps from (Well #2 and Well #3). There are many good reasons for the support of such a recharge scheme. The most important is simply that the City of Moscow will be dependent upon its wells for some time to come. Stevens, Thompson and Runyan, Inc.[2] studied several alternative plans for the supply of water to Moscow. Their findings are that no matter where the city gets its water from, that the most viable scheme for water supply utilizes the city's water wells conjunctively with some surface source of supply. Further Stevens, Thompson and Runyan, Inc.[3] in a later study said that drawdown records from Well #2 and Well #3 indicate significantly lower pumping levels during periods of sustained use. If future demands require such extensive use and lower the pumping level of the water within the wells, the quantity of the water discharged from the pumps will be reduced proportionately. If measures are taken to maintain the same discharge as the water level recedes, the power cost will increase and eventually the yield of the well will decrease. For these reasons it would seem important to the maintenance of an adequate supply of water for the city of Moscow, to maintain the levels of the water within the wells. One way to do this is to put some of the water back in the aquifer after using it. The following is an in-depth discussion of this idea.

The idea of water reuse is very old. Reuse has been and is being practiced all over the globe. Sebastian[4] reports that a U. S. Government survey of 155 cities with populations over 25,000 using surface water showed that 145 have some raw waste in their water supply. Concentrations of raw waste were found to range up to 18.5% during dry seasons. Haney[5] points out many instances of wastewater reuse on the Missouri River where one town discharges wastewater treatment plant effluent a short distance upstream of the water supply intake of another town. All of these instances are examples of inadvertent wastewater reuse. Instances of this sort are very common in Europe (e.g. along the Rhine River). Eventually, according to Stevens, Thompson and Runyan, Inc.[2] this will be true for Moscow also. S.T.R. concludes that ultimately surface supplied water will be used in Moscow, and that control of upstream usage of that water will be economically unfeasible.

The key to successful water reuse is good dependable monitored water treatment. This is presently being practiced in Windhoek, South Africa where 25% of the city's water supply is directly recycled wastewater. According to Sebastian[4], there have been no ill-health effects reported there. The situation at Windhoek is different from that proposed for Moscow. At Windhoek the water is directly recycled, that is the sewage is treated and placed directly back into the water system. The scheme proposed for Moscow calls for an amount of the wastewater treatment plant effluent to be dosed with a coagulant, pressure filtered, chlorinated and then injected into the groundwater aquifer some distance from the city's wells. In the aquifer the water will undergo further purification and dilution before being withdrawn, retreated, and ultimately used again.

The reclamation system begins at the wastewater treatment plant. There are not many guidelines available today regarding the minimum requirements for water to be used for injection recharge. Table II in Appendix A shows the guidelines used by one agency in California.[6] From Table II one can see that the majority of the substances regulated in the recharge water are metals. Almost all of these metals are solely contributed to the wastewater by heavy industry. The Moscow area has no heavy industry to place these contaminants in their wastewater. Preliminary investigations show that metals concentrations in the wastewater treatment plant effluent are on the order of 10^{-3}mg/l. This is below the maximum limitations shown in Table II. Further comparison of Table II with Table I shows basically two things. First, if this reuse scheme were to be implemented, there would have to be increased monitoring of the wastewater treatment plant effluent to check for metals content. Second, the overall quality of the treatment plant effluent is good and would make a choice supply of raw water to be treated and used for groundwater recharge.

In order for the treatment plant effluent to be used for groundwater recharge it would need treatment to accomplish the following things. The BOD and suspended solids concentrations should both be removed to a remaining concentration of approximately 1 mg/l. The BOD is not as critical as the suspended solids because the suspended solids could possibly cause some blinding in the aquifer. Total coliform counts should be reduced to not more than 2.2 MPN/100ml. This requirement is in the interest of conservatism. Inasmuch as little is known about the removal of pathogens in the aquifer environment, it is felt that only a highly disinfected water be injected into the aquifer. Chlorine should then be added to the water to form a stable chlorine residual to help insure a low pathogen content of the water. Additionally, although not presently shown in the wastewater treatment plant summaries, the nitrogen and total hardness should be monitored and corrected if necessary.

Excluding the nitrogen and hardness, these treatment objectives would be accomplished by adding a coagulant to the wastewater and then passing the wastewater through the pressure filters at the water treatment plant to remove the suspended solids and some of the BOD. Lastly the chlorination facilities at the water treatment plant would be used to provide a chlorine residual.

The resulting water would receive at least three types of further treatment in the aquifer. First, the water would be physically filtered through the soil particles removing any solids. Second, the water would be placed in contact with soil which would act as an adsorbant, and thus provide removal of some dissolved substances, and remaining pathogens, including viruses. Third, the soil could act as a reactor for chemical treatment phenomena. Caution should be exercised in the assessment of the soil as a purification system, because in some cases the purification is reversible. Culp[7] discusses some of these instances and gives clues as to how they might possibly be minimized. For instance viruses adsorbed onto the soil have a tendency to desorb under under certain conditions when subjected to sudden flow increases, however Culp points out that this largely happens only when the flow is horizontal instead of vertical. Therefore if water is pumped from an elevation lower than the injection well the reclaimed water has a high probability of being free of viruses.

Another point worthy of consideration is the nature of the aquifer itself. Referring to the boring logs for Moscow City Wells #2 and #3, one can ascertain that the strata encountered are not necessarily soils. Both wells penetrate about 150 feet of hard basalt and fractured basalt. Any water located in this layer would not be subjected to much treatment of the type discussed above. However, below the basalt the wells encounter shale and sand. In these layers water would receive some degree of treatment as described above. This means that water withdrawn from the fractured basalt layer might possibly have short circuited the percolation treatment that it would have gotten in the sand layers.

The possible limitations of treatment by percolation should be born in mind, although in the case of this scheme at least, at the outset they don't seem serious. This is for several reasons. First, the reclaimed water that this plan proposes to inject is of a relatively high quality, certainly at least as good as most of the surface water available throughout the Moscow area. Second, this water will be mixed with native groundwater which will offer some purification by way of dilution. Most importantly, when this water is pumped back up through Wells #2 and #3 again during the summer months it will be treated with potassium permanganate and chlorine, and then be pressure filtered. This process can be adjusted to provide a very high quality water. Lastly this water will be put into the Moscow water distribution system where it will become further diluted with water from the deep well aquifers.

Therefore, it appears be safe to conclude that the reclaimed water would not adversely affect the quality of water in Moscow. In some ways this water may actually improve the quality of water in Moscow. Presently the water being withdrawn from City Wells #2 and #3 is high in iron and manganese, and is quite corrosive. The effluent from the Moscow wastewater treatment plant is not high in iron or manganese because the City water treatment plant has removed these metals when the water was originally withdrawn from the aquifer. The water is also not as corrosive as the water originally withdrawn from the wells, as can be seen from the pH values listed on the wastewater treatment plant monthly summary sheets in Table I. By injecting this high quality effluent into the aquifer, the existing water in the aquifer will undergo some dilution with better water and as such it will have its own quality raised. These are the primary reasons for the selection of the shallow aquifer, feeding Wells #2 and #3, as the aquifer to be recharged.

A serious problem to be addressed in any water reuse scheme is that of quality assurance. For the proposed scheme for Moscow, quality assurance would take the form of increased monitoring of the wastewater treatment plant effluent as described above. In the event that a problem should arise with the quality of the water, the system would simply be shut down. During this time the wastewater treatment plant effluent would be discharged again into Paradise Creek. The problem would be corrected and the system restarted. System shut downs would not be as disastrous for this system as they would be for direct reuse schemes where reclaimed water is used for municipal water supply, or for process water for heavy industry.

There is the potential for some small scale environmental impacts with this system. At this time it does not appear that they are worthy of much discussion. The flow below the wastewater treatment plant in Paradise Creek would be decreased in the fall, winter, and spring months, but the decrease in flow would only be 1.5 MGD. The availability of reclaimed water, possibly at an attractive price may attract some types of industry. Also the introduction of reclaimed water into the shallow aquifer, if not done properly might degrade the quality of the aquifer.

From the above discussions it appears that the project is technically feasible, however, no mention has yet been made of the economics. Appendix B contains the reconnaissance level feasibility study done for this project. These calculations indicate that the cost of the reclaimed water would be substantially less than either the cost of water imported from the Snake River or the price for water that the City of Moscow is charging for water now. In addition, these calculations show that the City of Moscow could potentially realize some cost savings by using the reclaimed water for watering of lawns in two of its parks. It should be pointed out that the City of Moscow does not receive revenue for water used in the parks. However, if less expensive reclaimed water were used, the potable water would be available for domestic use at the higher price. The net effect would be that the City could realize additional revenue, and that can be construed as a cost savings.

The final aspect of this reuse scheme to be analyzed by the author is the effect of the recharge on the static water level in Wells #2 and #3.

Examination of the existing static levels in the wells over the last five years does not indicate any definite trend in the static levels. However, by calculating the amount of water that this scheme proposes to inject and comparing it to the amount of water that the City is withdrawing, one can see that the net change in the amount of water in the aquifer will be an increase (see Appendix B). This increase will not be noticed immediately, however, because the travel time between the injection well and the withdrawal wells may very likely be on the order of months or years.

In conclusion, it appears that the concept of reusing water in the City of Moscow may be technically and economically feasible, and that many benefits could arise from the institution of a water reuse program. The availability of reclaimed effluent could possibly attract new industry, and the easing of the water demand could allow for a greater number of people to be served by the existing water wells. At the very least this sort of a conservation measure could make the existing water supply last longer. Therefore, the recommendation can be made that Moscow continue to study the potential for water reuse within the community.

Items requiring further investigation are such things as possible sources of government funding to help bear the cost of implementing the reuse plan. It is possible that support may be available at the federal level. Also the quality of the effluent at the wastewater treatment plant should receive careful observation; concentrating on such things as ammonium and nitrogen concentrations and hardness. A bench scale pilot test should be run on the wastewater treatment plant effluent in order to gain a better idea of the potential viability of the plan. State regulatory agencies should be contacted to find out any requirements that may exist for this operation. Finally, the public sentiment for water reuse as a potential source of supply should be investigated at a very early stage.

References Cited

1. "America the Dry", Life Magazine, 4, No. 7 (July, 1981).
2. Stevens, Thompson and Runyan, Inc., Engineers/Planners, "Water Supply Study," (August, 1970).
3. Stevens, Thompson and Runyan, Inc., "Water Treatment. An Alternative Analysis for Moscow, Idaho," (April 1972).
4. Sebastian, F. P., "Purified Wastewater - the Untrapped Water Resource," Journal WPCF, 46, No. 2, (Feb, 1974).
5. Haney, P. D. "Water Reuse for Public Supply," Journal AWWA, (Feb., 1969).
6. "Evaluation of Needs and Potential," Municipal Water Reuse News, 29, (Feb., 1980).
7. Culp, R. L., "Selecting Treatment Processes to Meet Water Reuse Requirements," Municipal Wastewater Reuse News, 26, (November, 1979).
8. Camp, Dresser and McKee, Inc., EPA - Guidelines for Water Reuse, (August, 1980).

APPENDIX A

TABLE I. MOSCOW STP EFFLUENT DATA (1980)

Paramater	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
BOD	15.0	16.5	14.0	13.1	12.6	9.5	11.2	12.5	14.9	14.5	13.1	12.3
Suspended Solids	11.7	13.6	11.0	9.5	12.3	10.6	8.9	9.2	10.3	8.5	10.7	9.9
Settleable Solids	0	0	0	0	0	0	0	0	0	0	0	0
DO	8.4	7.9	7.8	7.5	7.4	7.6	7.4	7.3	7.2	7.0	7.3	8.1
pH (pH units)	7.7	7.6	7.6	7.5	7.5	7.5	7.4	7.6	7.5	8.1	7.6	7.5
#Cl_2/day	42.9	55.9	44.8	42.0	47.4	44.8	31.9	38.5	46.0	46.1	38.7	39.5
Cl_2 Residual	0.9	0.9	0.8	0.8	0.9	1.2	0.8	0.9	1.1	1.2	0.9	0.9
Temp ^oF	50	54	55	59	61	63	67	66	66	65	61	62.2
Fecal Col./100 ml	12.9	6.8	7.7	6.8	6.0	33.1	11.0	8.3	13.3	3.7	4	5.3
Total Col./100 ml	36.9	19.0	22.0	14.4	46.4	48.7	40.0	24.8	20.7	13.3	26.6	5.9
Flow, average (MGD)	2.25	2.65	2.58	2.31	2.23	1.88	1.70	1.70	2.09	1.94	1.89	2.02
Flow, high (MGD)	4.33	3.98	3.46	2.57	3.12	2.44	1.99	1.99	2.67	2.35	2.96	3.06
Flow, low (MGD)	1.23	2.22	2.03	1.89	1.71	1.33	1.26	1.40	1.52	1.49	1.51	1.65
Flow average (MGD) from a year ago	1.65	3.39	2.84	2.61	2.38	1.71	1.58	1.70	1.88	2.09	1.78	1.94

All values are given in mg/l unless noted otherwise.

TABLE II. REGULATORY AGENCY REQUIREMENTS FOR INJECTION WATER FROM THE ORANGE COUNTY WATER DISTRICT[6]

Sodium	110.0	Mercury	0.005
Total Hardness ($CaCO_3$)	220.0	Phenol	0.001
Chloride	120.0	Selenium	0.01
Sulfate	125.0	Silver	0.05
Ammonium	1.0	E.C.	900 μmhos/cm
Total Nitrogen	10.0	pH	6.5 to 8.0
Fluoride	0.8	Odor	None
Boron	0.5	Taste	None
MBAS	0.5	Foam	None
Arsenic	0.05	Color	None
Barium	1.0	Filter Effluent Turbidity	1.0 jTU
Cadmium	0.01		
Chromium Hexavalent	0.05	Carbon Adsorption Effluent COD	30
Copper	1.0	Chlorine Contact Basin Effluent	Free Chlorine Residual
Cyanide	0.2		
Iron	0.3	(All units are mg/l	
Lead	0.05	unless noted otherwise)	
Manganese	0.05		

Reclaimed water must be blended at least 50% with desalted sea water, or deep well water.

EXHIBIT A-1

RESOLUTION #383 Effective Date 11-8-80

A. INSTALLATION COSTS OF METERS:

1. 5/8" Meter - $295.00 ea.
2. 1" Meter - $360.00 ea.
3. 1-1/2" Meter - $500.00 ea.
4. 2" Meter - $625.00 ea.
5. Other Meters - Negotiated Rate

B. MINIMUM SERVICE CHARGE for Maintenance of Water System - $2.00 per month for each meter service connection.

C. WATER RATE CHARGE FOR WATER FURNISHED WITHIN BOUNDARIES OF CITY.

1. For the first 1000 cubic feet of water a rate of $.60 per hundred cubic feet.
2. In excess of 1,000 cubic feet a rate of $.45 per hundred cubic feet.

D. WATER RATE CHARGE FOR WATER FURNISHED OUTSIDE BOUNDARIES OF CITY - 200% of the minimum service charge and water rate defined in paragraphs B and C above.

E. WATER RATE CHARGE FOR MOSCOW CEMETERY MAINTENANCE DISTRICT - $.15 per hundred cubic feet.

F. WATER RATE CHARGE FOR THE UNIVERSITY OF IDAHO WATER SYSTEM - $.15 per hundred cubic feet.

G. CONNECTION FEE

1. 5/8" Meter - $ 95.00
2. 1" Meter - $135.00
3. 1-1/2" Meter - $215.00
4. 2" Meter - $270.00
5. Other Meters - Negotiated Rate

H. LATE WATER CHARGES

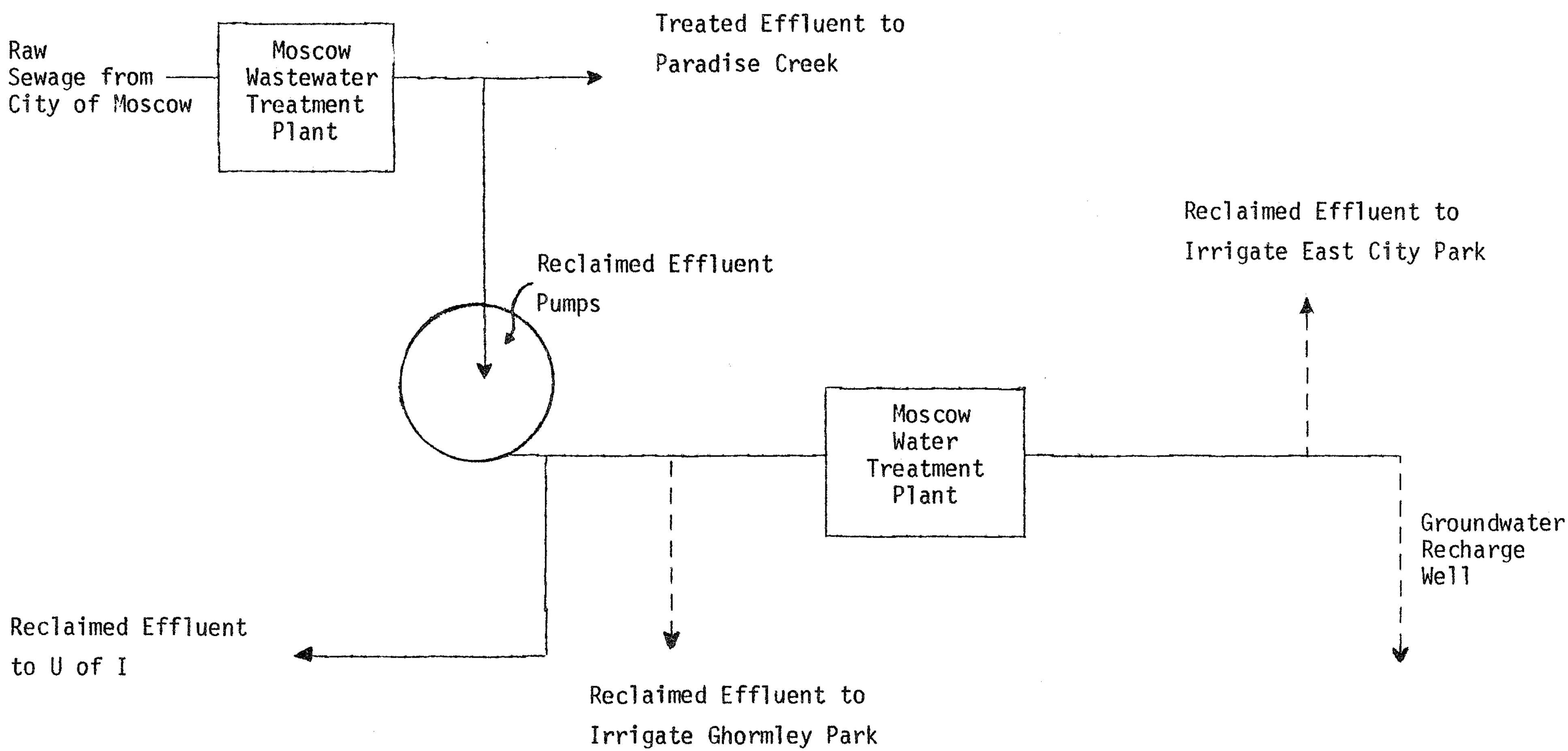
1. Accounts not paid by the 10th of the month - $1.00.

I. DEPOSITS - $20.00

To be required of residential renters.
May be required for other applicants.

APPENDIX B

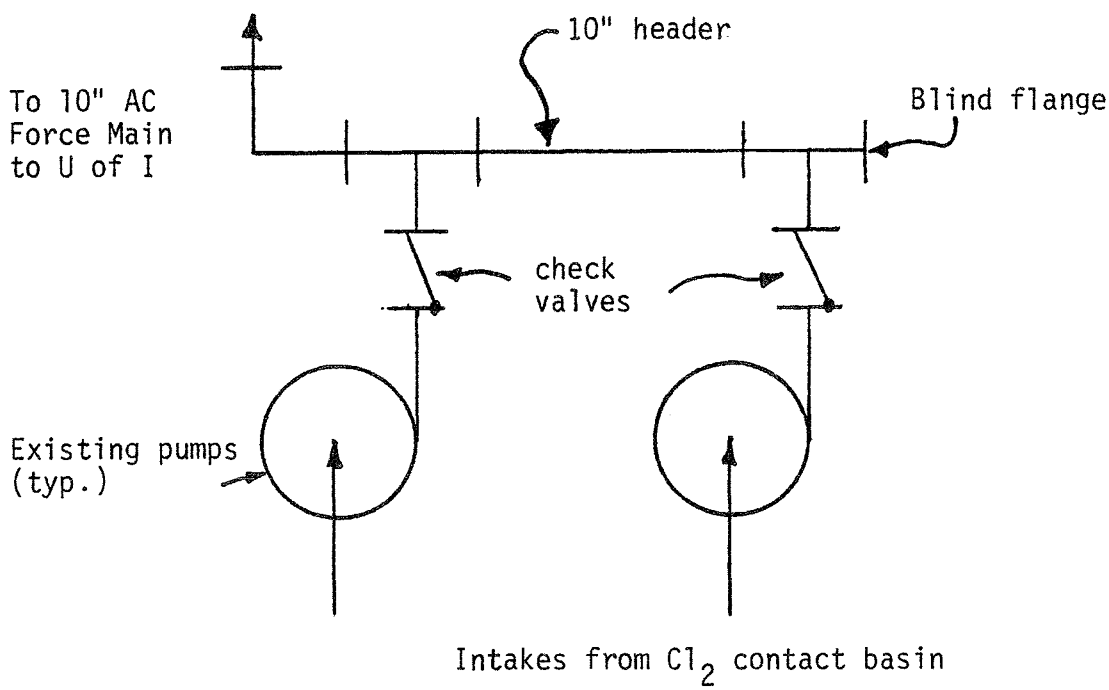
OVERALL SCHEMATIC



WATER REUSE SCHEMATIC

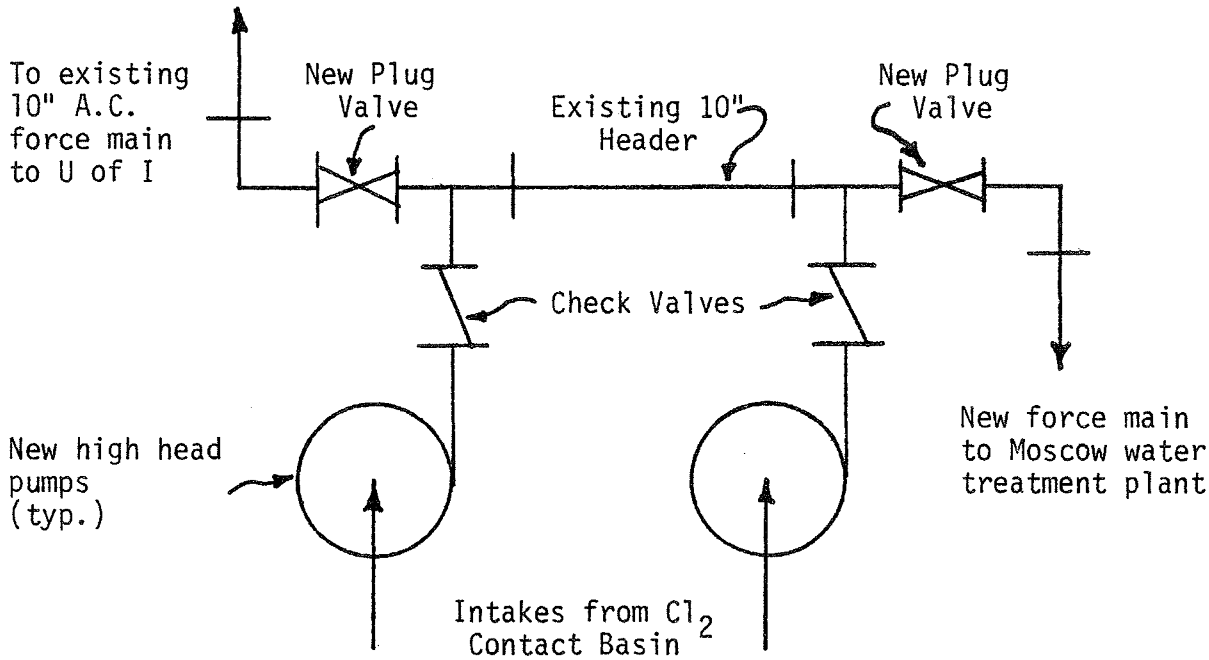
I. Interception of Flow at WWTP

The University of Idaho is currently withdrawing reclaimed effluent from the tail end of the chlorine contact chamber at the Moscow WWTP. Two pumps are used in parallel discharging into a 10" flanged C. I. header. The header has a 90^{o} bend on one end connected to the force main, and a blind flange on the other.



EXISTING PUMPING ARRANGEMENT

It is possible to change out the existing pumps and replace them with pumps capable of sufficient head for the recharge scheme under consideration, without having to significantly change the installation. The revised schematic would be as shown below.



PROPOSED REVISED PUMPING ARRANGEMENT

The proposed revisions would include the installation of 2 control valves and a new elbow to route reclaimed effluent to the existing city water treatment plant.

Estimated costs for this are:

2 Pumps @ $10,000 ea.		$20,000
Valves, fittings & Installation		2,000
	TOTAL	$22,000

II. Transmission System from WWTP to WTP and from WTP to Site of Injection Well

This system would consists of 2 segments of force main.

From U.S.G.S. topo map:

(1) Distance from WWTP to WTP ≈ 8100 LF

(2) El. @ WWTP = 2540 ft.

(3) El. @ WTP = 2560 ft.

Assume:

(1) Distance from WTP to Injection Well ≈ 10,000 Ft.

(2) El. @ Injection Well = 2640 ft.

Calculation:

Strive for velocity of 4 fps at average flow of 1.5 mgd in pipe, solve for pipe diameter

$D = \sqrt{0.32Q}$, D = pipe dia (ft.) & Q = flow (cfs)

1.5 mgd = 2.32 cfs

$D = \sqrt{(0.32)(2.32)} = 0.86$ ft. ∵ try 10" pipe

Velocity @ 1.5 mgd in 10" pipe = 4.3 fps (O.K.)

Assuming Hazen-Williams "C" Value of cast iron pipe is about 120:

The head loss due to pipe friction is 7.75 ft/1000 ft. at 1.5 mgd in 10" C.I. pipe.

Friction Loss in Pipe:

(8100 + 10,000) (1/1000) (7.75) = 140.3, say 140 ft.

Estimate friction loss through fittings and filters to be ≈ 100 ft.

Static Head ≈ 2640 - 2540 = 100 ft.

Therefore TDH ≈ 140 + 100 + 100 = 340 ft.

Assuming the existing pumps at the WWTP are about 130 ft., they would almost certainly have to be replaced in view of the estimated TDH above.

Cost of Piping:

From WWTP to site of Injection Well.

EPA cost data indicates a general figure of \$33/LF of 10" ϕ force main (including installation)

(8100 + 10,000) (33) = <u>\$597,300</u>

This number does not include allowances for any "dual water system" type usages enroute such as fire hydrants or irrigation service connections.

III. Change over at WTP

The costs of revisions to the water treatment plant as compared to the total capital costs of the entire project will be small. In view of the margin of error inherent in a reconnaissance level feasibility study of this type, the costs of the water treatment plant conversion are incidental. Therefore no attempt will be made at this time to identify and total each cost.

IV. Injection Well

Using a purely heuristic approach to well drilling and development costs, assume $100/vertical ft. as cost of facility.

Assume that in order to reach the desired aquifer (ie. that of City Wells #2 & #3), the well must be drilled to a depth of 400 ft.

Therefore capital costs = ($100) (400 ft.) = $40,000
Assuming that the injection well will be located on city land (possibly East-City Park) there will be no land acquisition cost.
Therefore total capital cost = $40,000

V. Total Capital Cost

The EPA Cost Curves used to prepare the estimates of capital costs shown have already included allowances for engineering and legal services and construction contingency:

(1) Pumping System		$ 22,000
(2) Force Main System		597,300
(3) Injection Well		40,000
	TOTAL	$659,300

VI. Cost of Coagulant Addition

From EPA Cost Curve = $4000/year based on flow of 1.5 mgd.

The EPA Cost Curve used is titled Costs of Coagulant Addition and Flocculation, this implies that their cost includes upkeep on a flocculation basin. The scheme being evaluated in this study assumes that the filter vessels themselves will be used for the flocculation reactor. Since the amount of money that would be designated for the upkeep of the flocculating basin would be small, no allowance (deduction in cost) will be made in the use of the EPA numbers for the lack of the flocculating basin.

(4000 $/yr.) (1/365 yr./day) (1/1.5 day/mgd) 1/1000 mg/thous. gal.)

= cost/thous. gal.

= $0.0073/1000 gal.

This number includes the cost of chemical based on dose of 20 mg/l alum. which is deemed to be sufficient for removal of the small quantity of suspended solids present.

VII. <u>Cost of Filtration</u>

From EPA Cost Curve = 30,000 \$/yr. based on flow of 1.5 mgd.

(\$30,000) (1/365) (1/1.5) (1/1000) = <u>\$0.0547/1000 gal.</u>

The pumps to be installed at the WWTP will be sized to provide the the necessary head to drive the water through the pressure filters.

VIII. <u>Costs of Chlorination</u>

From EPA Cost Curve = \$19,000/yr. based on flow of 1.5 mgd and chlorination to residual of 10 mg/1 after 30 min.

(19,000) (1/365) (1/1.5) (1/1000) = \$0.0347/1000 gal.

IX. <u>Pumping Costs</u>

From EPA Cost Curve = \$7000/year exclusive of power cost. (ie. reflecting only O & M).

(7000) (1/270) (1/1.5) (1/1000) = \$0.0173/1000 gal.

Computation of power cost will be based on rate schedule shown below.

Up to 5800 Kwhr.,	1.598¢/Kwhr.	Consumption Charge (Monthly basis)
Beyond 5800 Kwhr.,	1.253¢/Kwhr.	

Up to 50 Kw, \$135	Demand Charge (Monthly basis)
Above 50 Kw, \$1.50/Kw	

Horsepower required per 1000 gal., assuming combined efficienty of 85%:

$$HP = \frac{Q \times TDH}{3400} \quad \text{where } Q = \text{discharge in gpm.}$$

1.5 mgd = 1041.67 gpm

$$HP = \frac{(1041.67)(340)}{3400} = 104.17 \text{ HP}$$

At 1041.67 gpm it would take (1000/1041.67) min to pump 1000 gal., or:

$$\left(\frac{1000}{1041.67}\right)\left(\frac{1}{60} \text{ hr./min.}\right) = 0.016 \text{ hr.}$$

Then the power consumed would be:

(104.2) (0.075) (0.016) (0.01598) = $0.0020/1000 gal.

Since this rate of consumption will not exceed 5800 Kwhr./month, the higher price was used in computations. Also, this power demand is below 50 Kw, therefore the demand charge will only be $135/mo.

$$\left[(1{,}500{,}000)\ (30)\ (1/1000)\right]^{-1} (135) = \$0.003/1000 \text{ gal.}$$

Therefore the total pumping cost is given by:

Pumping Cost = 0.0173 + 0.0020 + 0.003 = <u>$0.0223/1000 gal.</u>

X. Amortization of Capital Costs

EPA offers a factor of 0.10 for annual amortized capital cost. This is based on a 15-20 yr. service life and an interest rate of 7%.

EPA uses a factor of 0.08 for amortizing force mains based on their service of life of 40-50 yr. and 7% interest.

(1) Pumping System	(0.10)(22,000) =	$ 2,200
(2) Force Mains	(0.08)(597,300) =	47,784
(3) Injection Well	(0.10)(40,000) =	4,000
		$53,984/year

Since system will only operate for 9 mos. of the year the following cost/1000 gal. is found.

$$(0.75)\ (365)\ (1.5) = 410{,}625{,}000 \text{ gal/yr.}$$

$$\frac{53{,}984}{410{,}625} = \underline{\$0.131/1000 \text{ gal. Amortization}}$$

XI. Total Cost of Reclaimed Water

(1) Coagulation	$0.0073
(2) Filtration	0.0547
(3) Chlorination	0.0347
(4) Pumping Cost	0.0223
(5) Amortization of Capital Costs	0.131
	$0.2500/1000 gal.

Total Cost = 25¢/1000 gal.

XII. Comparison of Costs

In order to assess the economic feasibility of using this reclaimed water for some commercial or industrial purpose the cost of the reclaimed water will be compared to the price the City of Moscow charges for water, and to the projected price that S.T.R.[2] calculated for water supplied from the Snake River.

Included in Appendix A is a copy of the water rate schedule for the City of Moscow in effect during August 1981. The lowest price the city charges its bulk customers is 45¢/100 $ft.^3$ Converting this to a per 1000 gal. basis: 45¢/100 $ft.^3$ = \$0.602/1000 gal.

$0.602/1000 gal. > \$0.250/1000 gal.

The least cost scheme that S.T.R.[2] found for supplying water to the City of Moscow involved a regional approach which would supply water to both Moscow, Idaho and Pullman, Wash. This water comes from the Snake River, and if the project had been executed after the study, the estimated cost of water in Moscow, in 1975 was \$0.318/1000 gal.

The costs for the reclaimed water as computed above were computed using EPA cost data at an ENR index of 3000. According to ENR, the cost index for the year 1975 was ≈ 2150. In order to compare the two costs, the S.T.R. costs from 1975 (ENR 2150) must be brought to ENR 3000.

$$(0.318)\left(\frac{3000}{2150}\right) = \$0.444/1000 \text{ gal.}$$

\$0.444/1000 gal. > \$0.250/1000 gal.