N.9 Zone B to Tailings Impoundment, Lost Use to GSL

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No: 9

SUBJECT: Cost Estimate for Disposal of Reverse Osmosis By-product
Alternative F.1
Zone B Discharge to Tailings Impoundment
Lost Use Discharge to Great Salt Lake

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Mark Atencio

DATE: April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of pumping the Zone B RO by-product to the existing KUCC Tailings Impoundment in a 20 mile long, 8-inch diameter pipeline using three pump stations. The Lost Use RO by-product would be pumped 24 miles in a 6-inch diameter pipeline to the south arm of Great Salt Lake. The net present value cost for disposal of Zone B and Lost Use RO by-product is $15.6 million. This includes a capital cost of $15.0 million and an operation cost of $33,000 per year.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	TDS Concentration	Selenium Concentration
	(cfs)	(mg/L)	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe the methods used to estimate the cost of disposing of Zone B to the KUCC Tailings Impoundment and Lost Use RO by-product to Great Salt Lake in pipelines from the Zone B Lost Use Treatment Plant in West Jordan KUCC Tailings Impoundment and to the south arm of Great Salt Lake near Salt Air.

AUTHOR'S CREDENTIALS

I am a registered professional engineer specializing in the area of water resources. I have completed Bachelor and Master of Science degrees in civil engineering. Following graduation I have been working at Jordan Valley Water Conservancy District as a civil engineer. My current title is senior engineer, in which I fill project management and

supervisory roles. I have been studying and investigating various membrane and TDS reduction treatments for eight years. I have completed a number of well drilling and construction projects. I have completed three years of pilot testing using various membrane and reverse osmosis processes. I have been filling the role of a technical engineer for the District on the Southwest Groundwater Remediation and Treatment Project since 1999.

DESCRIPTION OF ALTERNATIVE

See the attached Drawing of Alternative F.1 for a visual representation of the alternative.

This alternative consists of a 20.0 mile long, 8-inch diameter PVC pipeline and a 23.7 mile long, 6-inch diameter PVC pipeline constructed from the Zone B Lost Use Reverse Osmosis (RO) Plant in West Jordan to the Tailings Impoundment Great Salt Lake near Salt Air. Discharge into the lake would be through a new outfall pipeline. Three pump stations would be required; one at the RO plant, the second at 7 to 8 miles from the plant, and the third at 15 to 16 miles from the plant.

SCALING CONCERNS

The RO by-product contains a high concentration of salts, consisting mostly of calcium sulfate (gypsum) and calcium carbonate (calcite IE Timpanogos Cave). The solutions are super-saturated and on the verge of precipitating. This means that if the fluid were to stop moving a scale would start to form on the interior of the pipeline. In the RO plant an antiscalant chemical prevents scale formation; however, the chemical does not last for more than approximately 24 hours.

The formation of scale or precipitation of salts is the same process that occurs in the Great Salt Lake as the tributaries to the lake bring in salts into the lake. In this case the salts are concentrated due to evaporation until the point that saturation is reached and the salts form particles (precipitation) and settle to the bottom. In order to prevent this type of scaling from occurring, the pipelines need to be kept in continuous operation or drained.

PIPELINE MATERIAL

Polyvinyl chloride (PVC) was selected as material of choice after considering ductile iron, steel, high density polypropylene (HDPE), and PVC. This took into account the actual internal diameter of the various types of pipeline, the working pressure of the pipelines, the hydraulic characteristics of the pipeline materials (friction factor) and the construction cost. Each pipeline material option was evaluated in a large spreadsheet. A copy of this spreadsheet is attached to this memo. The limitations of the pipeline

material options considered affected the number and cost of pump stations required, the pressure loss required to be overcome by a pump, pipeline construction cost, and pump station operating cost.

PIPELINE DIAMETER

Six-inch, 8-inch, 10-inch, and 12-inch diameter pipelines were evaluated in the spreadsheet identified above. The size of the pipeline options evaluated affected the pressure loss (smaller pipe = higher pressure loss), the detention time in the pipeline (larger pipe = longer time in transit), pipeline construction cost, and pump station operating cost.

PIPELINE ALIGNMENT

Multiple alignments were considered for this alternative. First, an alignment extending westward, then northward was considered. Second a northern then westward alignment was evaluated. The two alignments were of comparable length. Due to the topography the first alignment required additional pumping to move the fluid uphill, then downhill towards Great Salt Lake. Both alignments utilized property owned by Kennecott Utah Copper Corporation (KUCC) along the east and north sides of its tailings impoundment in the northwest section of Salt Lake County.

SELECTION OF PREFERRED PIPELINE OPTION

Selection of the preferred pipeline option took into account the concerns with scaling and the effects of pipeline material, diameter, and alignment on the capital and operating cost.

The alignment selected for this alternative utilizes public right-of-way and private property, most of which is owned by KUCC. The alignment generally follows an elevation contour line to the north along 1300 West and then to the west along 1300 South to the KUCC tailings impoundment. The pipeline to the tailings impoundment diverses at 3100 South when it extends westward. The GSL pipeline then extends to the north and west until reaching Great Salt Lake. This alignment allows for utilizing existing right–of-way corridors. This alignment stays at almost the same elevation along its length. The alignment also avoids increasing in elevation, thereby avoiding additional pumping cost and making it easier to drain the pipeline with a backup pump in the event of a power failure.

Selection of 8-inch and 6-inch PVC pipelines with three pump stations allows for the concerns expressed in this memo to be met will obtaining the lowest capital and net present value cost.

REQUIRED FACILITIES

- 20.0 mile long, 8-inch diameter PVC pipeline
- 23.7 mile long, 6-inch diameter PVC pipeline
- 3 pump stations
- Outfall pipeline

LEGALITY

The legality of this alternative was considered. The Zone B RO by-product meets the existing KUCC Tailings Impoundment GSL discharge permit. A review of existing information indicated that a permit for discharge of Lost Use RO by-product to GSL could be issued which would be protective of Great Salt Lake.

The water quality of the RO by-product was compared against standards for the Jordan River. All of the water quality parameters of the by-product were below the Jordan River standards, with the exception of total dissolved solids (TDS) and selenium. Comparing the TDS of the by-product (8,300) to Great Salt Lake (100,000 plus) it was apparent that TDS in the by-product would not be a concern. In order to understand if the selenium concentration in the by-product would be a concern I researched the files of the Utah State Division of Water Quality. Although selenium is an essential trace element, it has the potential to cause harm to humans or wildlife at very high concentrations. There is an existing permit for a discharge from KUCC to Great Salt Lake with a 54 µg/L (ppb) selenium limitation. The files of the Division contained substantial documentation of the methods used to derive this limitation. The limit required by the Division was based on limiting selenium absorption by algae in Great Salt Lake, which algae are consumed by brine shrimp, which shrimp are then consumed by waterfowl. By limiting selenium accumulation in Great Salt Lake algae the Division of Water Quality is able to prevent reproductive failure in waterfowl that consume Great Salt Lake brine shrimp.

The files also contained concerns expressed by others regarding the permit limitations and responses to these concerns. The issue of selenium has been well researched and a permit limit was already established. The conclusion of my research was that a selenium permit limit for discharge into Great Salt Lake on a firm basis was already established. Comparing the RO by-product selenium concentration of 32-47 µg/L against an existing permit limitation of 54 µg/L indicates that Zone B and Lost Use RO by-product will meet a limit for discharge to Great Salt Lake.

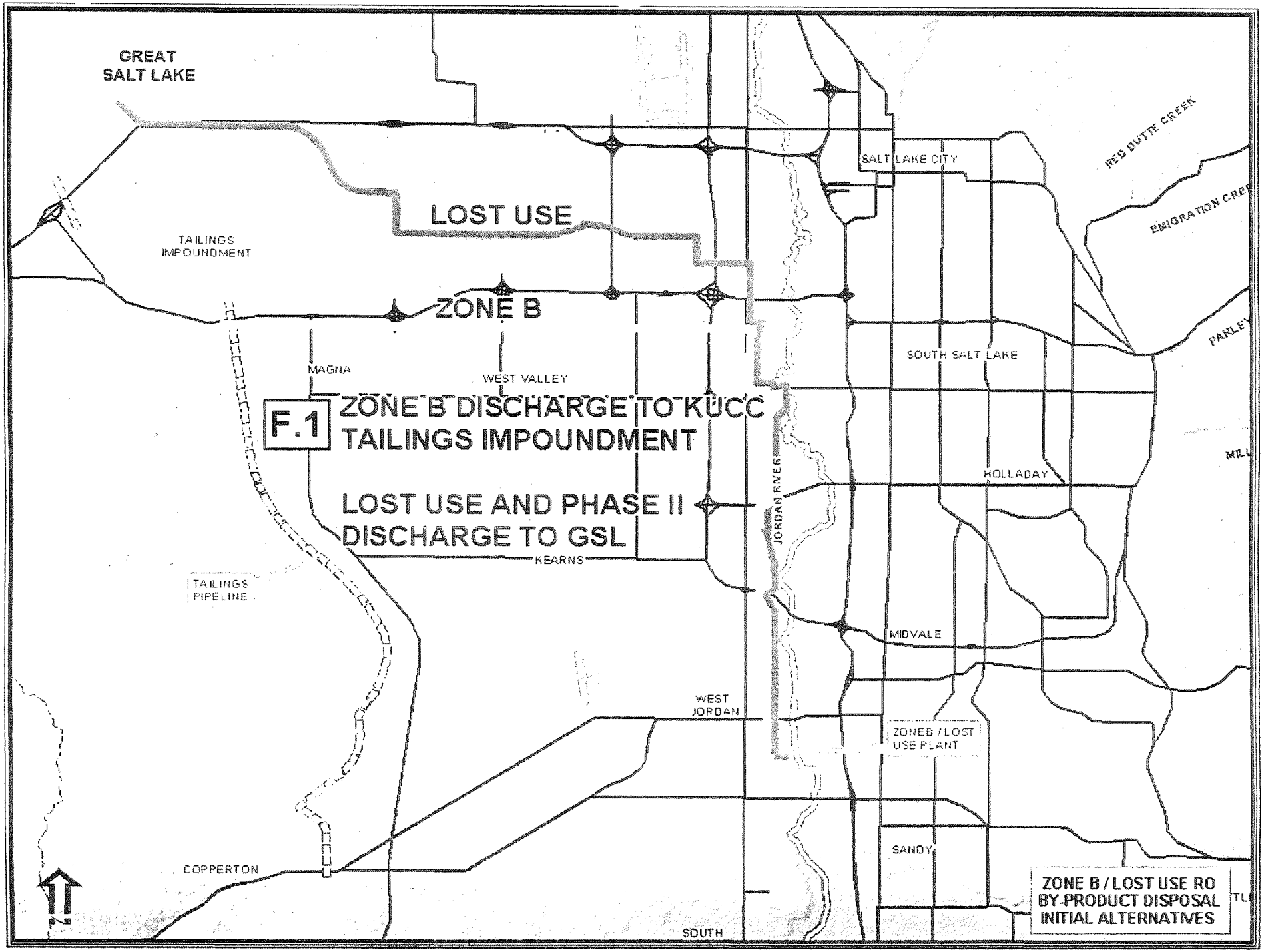
ASSUMPTIONS

- Pump Efficiency: 85%
- Motor Efficiency: 90%
- Pump Station Capital Cost: $500,000 each
- NPV interest rate: 4%
- 25 feet wide easement cost: $14.35/ foot ($50,000/acre)
- Pipeline in roadways installation cost: $39.90/ft (8-in), $35.21/ft. (6-in)
- Pipeline in open areas installation cost: $18.65/ft (8-in), $16.09/ft. (6-in)
- Pipeline costs from two contractors and MWH Engineers
- RO plant operates 330 days per year
- Power Cost $0.055/kW hr

COST ESTIMATE

The cost estimate for this alternative took into account the size of the pipelines, number of pump stations, pumping costs, length of pipelines, length of pipelines in roadways, length of pipelines in open areas, easement acquisition costs, dewatering costs, and engineering costs. The net present value cost for disposal of Zone B and Lost Use RO by-product is $15.6 million. This includes a capital cost of $15.0 million and an operation cost of $33,000 per year.

See the attached spreadsheet for details and calculations of the cost estimate.


GREAT SALT LAKE
LOST USE
TAILINGS IMPOUNDMENT
ZONE B
MAGNA
WEST VALLEY
F.1
ZONE B DISCHARGE TO KUCC TAILINGS IMPOUNDMENT
LOST USE AND PHASE II DISCHARGE TO GSL
KEARNS
TAILINGS PIPELINE
COPPERTON
SALT LAKE CITY
SOUTH SALT LAKE
HOLLADAY
MIDVALE
WEST JORDAN
SANDY
SOUTH
JORDAN RIVER
ZONE B / LOST USE PLANT
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL INITIAL ALTERNATIVES

SOUTHWEST GROUNDWATER
REVERSE OSMOSIS BY-PRODUCT DISPOSAL OPTIONS

Alternative F.1
Zone B Discharge to KUCC Tailings Impoundment
Lost Use Discharge to GSL

Alt. No.	Disposal Alternative	Project Yield (AF/yr)	Pipeline Material	Pipeline Actual Inside Diameter (Inches)	Zone A Yield (AF/yr)	Zone B Yield (AF/yr)	Zone B Production Rate (cfs)	Lost Use Yield (AF/yr)	Lost Use Production Rate (cfs)	Future Shallow Wells Yield (AF/yr)	Future Shallow Wells Production Rate (cfs)
F.1 ZB	Zone B to Tailings Impoundment Lost Use to GSL	3500	PVC C-909	8.29	0	3500	5.35	0	0	0	0
F.1 LU	Lost Use & Totals	9300	PVC C-909	6.3	3500	0	0	2300	3.51	0	0

By-product Flow Rate (cfs)	Number of Pipelines (#)	Pressure Rating (psi)	Pipeline Hazen Williams C-factor	Pipeline in Roadways Length (ft)	Roadway Pipeline Unit Cost ($/ft)	Pipeline In Open Field Length (ft)	Open Pipeline Unit Cost ($/ft)	Total Pipeline Length (ft)	Total Pipeline Length (miles)	Dewatering Length (ft)	Dewatering Unit Cost ($/ft)
1.23	1	200	120	88,440	40	17,050	18.65	105,490	20.0	36,850	2.00
0.51	1	200	120	90,290	35	34,850	16.09	125,140	23.7	42,770	2.00

Pipeline Boring & Additional Costs ($)	Easement Length Required (ft)	Easement Cost ($)	Total Pipeline Cost ($mill)	Velocity (ft/sec)	Detention Time OK? (hrs)	Max Head Loss between Pump Stations (ft)	Max Distance between Pump Stations (ft)	Max Distance between Pump Stations (miles)	Calculated Number of Pump Stations (ft)	Actual Number of Pump Stations (ft)	Total Pump Station Cost ($mill)
231,000	1,850	26,548	4.2	3.29	8.9	416	69,018	13.1	1.5	2	1.0
0	1,850	26,548	3.9	2.35	14.8	416	93,354	17.7	1.3	2	1.0

Total Const Cost ($mill)	Eng Cost ($mill)	20% Contingency ($mill)	**Total Capital Cost ($mill)**	Discharge Hydraulic Gradeline (ft)	Static Pump Lift (ft)	Head Loss (ft)	Total Pump Lift (ft)	Pump Size (HP)	**Annual Pumping Cost ($)**	**NPV of Pumping Costs ($mill)**	**Total NPV Cost ($mill)**
5.178	0.777	1.786	**7.741**	4,270	-212	636	424	78	**25,375**	**0.502**	**8.244**
4.852	0.728	1.674	**14.995**	4,215	-267	557	290	22	**32,548**	**0.644**	**15.640**

N.10 Zone B to Tailings Impoundment, Lost Use to KUC GSL Discharge

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No: 10

SUBJECT: Cost Estimate for Disposal of Reverse Osmosis By-product
Alternative F.2 - Discharge Zone B to KUCC Tailings Impoundment
Discharge Lost Use to KUCC GSL Outfall

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Mark Atencio

DATE: April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of pumping the Zone B RO by-product to the existing KUCC Tailings Impoundment in a 20 mile long, 8-inch diameter pipeline using three pump stations. The Lost Use RO by-product would be pumped 24 miles in a 6-inch to the KUCC GSL outfall. The net present value cost for disposal of Zone B and Lost Use RO by-product is $16.1 million. This includes a capital cost of $15.4 million and an operation cost of $34,000 per year.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	TDS Concentration	Selenium Concentration
	(cfs)	(mg/L)	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe the methods used to estimate the cost of disposing of Zone B to the KUCC Tailings impoundment and Lost Use RO by-product to the KUCC GSL outfall in pipelines from the Zone B Lost Use Treatment Plant in West Jordan.

AUTHOR'S CREDENTIALS

I am a registered professional engineer specializing in the area of water resources. I have completed Bachelor and Master of Science degrees in civil engineering. Following graduation I have been working at Jordan Valley Water Conservancy District as a civil engineer. My current title is senior engineer, in which I fill project management and

supervisory roles. I have been studying and investigating various membrane and TDS reduction treatments for eight years. I have completed a number of well drilling and construction projects. I have completed three years of pilot testing using various membrane and reverse osmosis. I have been filling the role of a technical engineer for the District on the Southwest Groundwater Remediation and Treatment Project since 1999.

DESCRIPTION OF ALTERNATIVE

See the attached Drawing of Alternative F.2 for a visual representation of the alternative.

This alternative consists of a 20.0 mile long, 8-inch diameter pipeline and a 26.7 mile long, 6-inch diameter PVC pipeline constructed from the Zone B Lost Use Reverse Osmosis (RO) Plant in West Jordan. Three pump stations would be required; one the RO plant, the second at 7 to 8 miles from the plant, and the third at 15 to 16 miles from the plant.

SCALING CONCERNS

The RO by-product contains a high concentration of salts, consisting mostly of calcium sulfate (gypsum) and calcium carbonate (calcite IE Timpanogos Cave). The solutions are super-saturated and on the verge of precipitating. This means that if the fluid were to stop moving a scale would start to form on the interior of the pipeline. In the RO plant an antiscalant chemical prevents scale formation; however, the chemical does not last for more than approximately 24 hours.

The formation of scale or precipitation of salts is the same process that occurs in the Great Salt Lake as the tributaries to the lake bring in salts into the lake. In this case the salts are concentrated due to evaporation until the point that saturation is reached and the salts form particles (precipitation) and settle to the bottom. In order to prevent this type of scaling from occurring, the pipeline needs to be kept in continuous operation or drained.

PIPELINE MATERIAL

Polyvinyl chloride (PVC) was selected as material of choice after considering ductile iron, steel, high density polypropylene (HDPE), and PVC. This took into account the actual internal diameter of the various types of pipeline, the working pressure of the pipelines, the hydraulic characteristics of the pipeline materials (friction factor) and the construction cost. Each pipeline material option was evaluated in a large spreadsheet. A copy of this spreadsheet is attached to this memo. The limitations of the pipeline material options considered affected the number and cost of pump stations required, the

pressure loss required to be overcome by a pump, pipeline construction cost, and pump station operating cost.

PIPELINE DIAMETER

Six-inch, 8-inch, 10-inch, and 12-inch diameter pipelines were evaluated in the spreadsheet identified above. The size of the pipeline options evaluated affected the pressure loss (smaller pipe = higher pressure loss), the detention time in the pipeline (larger pipe = longer time in transit), pipeline construction cost, and pump station operating cost.

PIPELINE ALIGNMENT

Multiple alignments were considered for this alternative. First, an alignment extending westward, then northward was considered. Second a northern then westward alignment was evaluated. The two alignments were of comparable length. Due to the topography the first alignment required additional pumping to move the fluid uphill, then downhill towards Great Salt Lake. Both alignments utilized property owned by Kennecott Utah Copper Corporation (KUCC) along the east and north sides of its tailings impoundment in the northwest section of Salt Lake County.

SELECTION OF PREFERRED PIPELINE OPTION

Selection of the preferred pipeline option took into account the concerns with scaling and the effects of pipeline material, diameter, and alignment on the capital and operating cost.

The alignment selected for this alternative utilizes public right-of-way and private property, most of which is owned by KUCC. The alignment generally follows an elevation contour line to the north along 1300 West and then to the west along 1300 South to the KUCC tailings impoundment. The pipeline to the tailings impoundment diverges at 3100 South when it extends westward. The GLS pipeline then extends to the north and west until reaching Great Salt Lake. This alignment allows for utilizing existing right–of-way corridors. This alignment stays at almost the same elevation along its length. The alignment also avoids increasing in elevation, thereby avoiding additional pumping cost and making it easier to drain the pipeline with a backup pump in the event of a power failure.

Selection of 8-inch and 6-inch diameter PVC pipelines with three pump stations allows for the concerns expressed in this memo to be met will obtaining the lowest capital and net present value cost.

REQUIRED FACILITIES

- 20.0 mile long, 8-inch diameter PVC pipeline
- 26.7 mile long, 6-inch diameter PVC pipeline
- 3 pump stations

LEGALITY

The legality of this alternative was considered. The Zone B RO by-product meets the existing KUCC Tailings Impoundment GSL discharge permit. A review of existing information indicated that a permit for discharge of RO by-product to GSL could be issued which would be protective of Great Salt Lake.

The water quality of the RO by-product was compared against standards for the Jordan River. All of the water quality parameters of the by-product were below the Jordan River standards, with the exception of total dissolved solids (TDS) and selenium. Comparing the TDS of the by-product (8,300) to Great Salt Lake (100,000 plus) it was apparent that TDS in the by-product would not be a concern. In order to understand if the selenium concentration in the by-product would be a concern I researched the files of the Utah State Division of Water Quality. Although selenium is an essential trace element, it has the potential to cause harm to humans or wildlife at very high concentrations. There is an existing permit for a discharge from KUCC to Great Salt Lake with a 54 µg/L (ppb) selenium limitation. The files of the Division contained substantial documentation of the methods used to derive this limitation. The limit required by the Division was based on limiting selenium absorption by algae in Great Salt Lake, which algae are consumed by brine shrimp, which shrimp are then consumed by waterfowl. By limiting selenium accumulation in Great Salt Lake algae the Division of Water Quality is able to prevent reproductive failure in waterfowl that consume Great Salt Lake brine shrimp.

The files also contained concerns expressed by others regarding the permit limitations and responses to these concerns. The issue of selenium has been well researched and a permit limit was already established. The conclusion of my research was that a selenium permit limit for discharge into Great Salt Lake on a firm basis was already established. Comparing the RO by-product selenium concentration of 32-47 µg/L against an existing permit limitation of 54 µg/L indicates that Zone B and Lost Use RO by-product will meet a limit for discharge to Great Salt Lake.

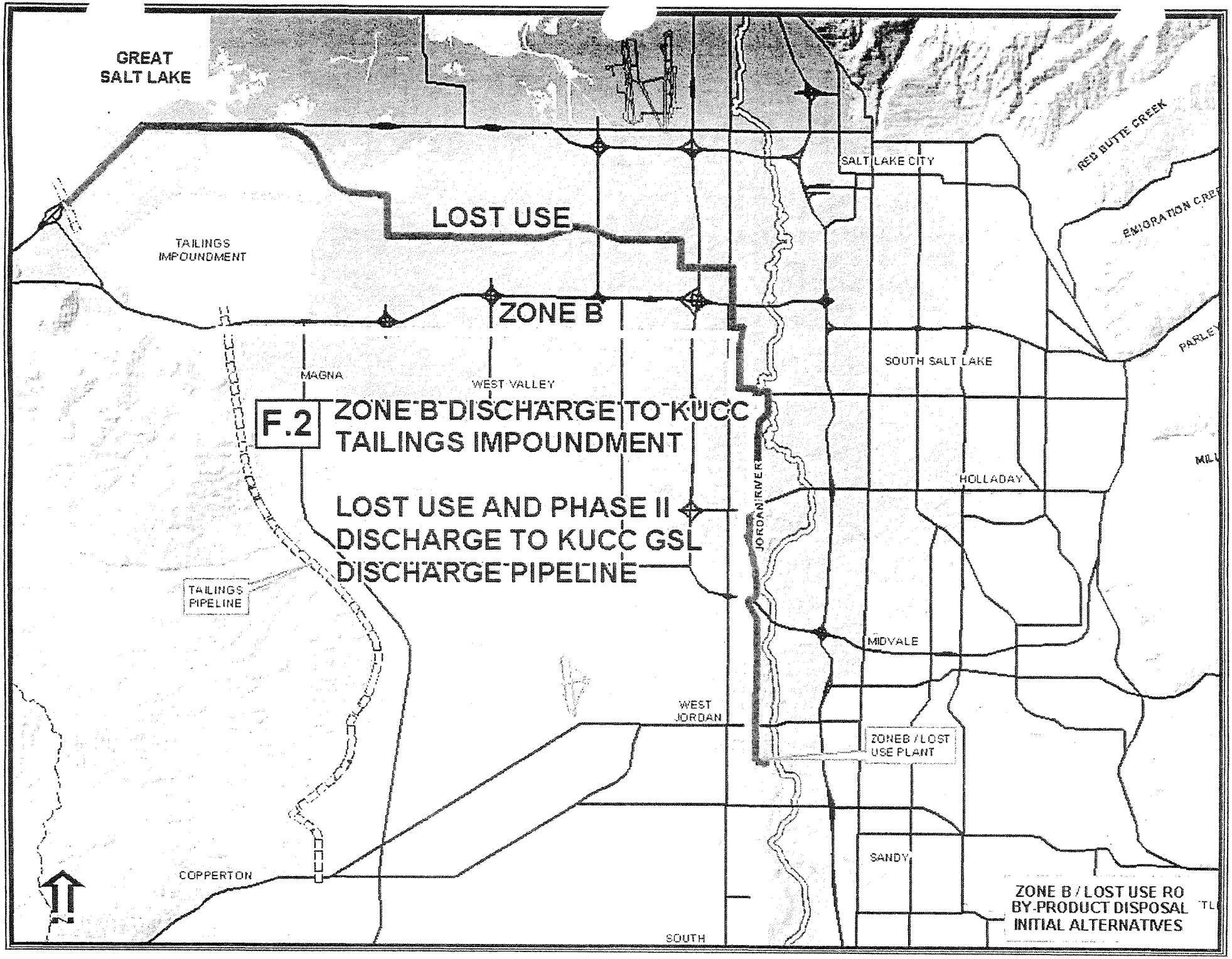
ASSUMPTIONS

- Pump Efficiency: 85%
- Motor Efficiency: 90%
- Pump Station Capital Cost: $500,000 each
- NPV interest rate: 4%
- 25 feet wide easement cost: $14.35/ foot ($50,000/acre)
- Pipeline in roadways installation cost: $39.90ft (8-in), $35.21ft (6-in)
- Pipeline in open areas installation cost: $18.65 ft (8-in, $16.09 ft (6-in)
- Pipeline costs from two contractors and MWH Engineers
- RO plant operates 330 days per year
- Power Cost $0.055/kW hr

COST ESTIMATE

The cost estimate for this alternative took into account the size of the pipelines, number of pump stations, pumping costs, length of pipelines, length of pipelines in roadways, length of pipelines in open areas, easement acquisition costs, dewatering costs, and engineering costs. The net present value cost for disposal of Zone B and Lost Use RO by-product is $16.1 million. This includes a capital cost of $15.4 million and an operation cost of $34,000 per year.

See the attached spreadsheet for details and calculations of the cost estimate.


GREAT SALT LAKE
LOST USE
TAILINGS IMPOUNDMENT
ZONE B
MAGNA
WEST VALLEY
F.2
ZONE B DISCHARGE TO KUCC TAILINGS IMPOUNDMENT
LOST USE AND PHASE II DISCHARGE TO KUCC GSL DISCHARGE PIPELINE
TAILINGS PIPELINE
COPPERTON
SALT LAKE CITY
RED BUTTE CREEK
EMIGRATION CREEK
SOUTH SALT LAKE
HOLLADAY
JORDAN RIVER
MIDVALE
WEST JORDAN
ZONEB / LOST USE PLANT
SANDY
SOUTH
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL INITIAL ALTERNATIVES

SOUTHWEST GROUNDWATER
REVERSE OSMOSIS BY-PRODUCT DISPOSAL OPTIONS

Alternative F.2
Zone B Discharge to KUCC Tailings Impoundment
Lost Use Discharge to KUCC GSL Outfall

Alt. No.	Disposal Alternative	Project Yield (AF/yr)	Pipeline Material	Pipeline Actual Inside Diameter (Inches)	Zone A Yield (AF/yr)	Zone B Yield (AF/yr)	Zone B Production Rate (cfs)	Lost Use Yield (AF/yr)	Lost Use Production Rate (cfs)	Future Shallow Wells Yield (AF/yr)	Future Shallow Wells Production Rate (cfs)
F.2 ZB	Zone B to Tailings Impoundment Lost Use to KUCC GSL	3500	PVC C-909	8.29	0	3500	5.35	0	0	0	0
F.2 LU	Lost Use & Totals	9300	PVC C-909	6.3	3500	0	0	2300	3.51	0	0

By-product Flow Rate (cfs)	Number of Pipelines (#)	Pressure Rating (psi)	Pipeline Hazen Williams C-factor	Pipeline in Roadways Length (ft)	Roadway Pipeline Unit Cost ($/ft)	Pipeline In Open Field Length (ft)	Open Pipeline Unit Cost ($/ft)	Total Pipeline Length (ft)	Total Pipeline Length (miles)	Dewatering Length (ft)	Dewatering Unit Cost ($/ft)
1.23	1	200	120	88,440	39.90	17,050	18.65	105,490	20.0	36,850	2.00
0.51	1	200	120	90,290	35.21	50,690	16.09	140,980	26.7	58,610	2.00

Pipeline Boring & Additional Costs ($)	Easement Length Required (ft)	Easement Cost ($)	Total Pipeline Cost ($mill)	Velocity (ft/sec)	Detention Time OK? (hrs)	Max Head Loss between Pump Stations (ft)	Max Distance between Pump Stations (ft)	Max Distance between Pump Stations (miles)	Calculated Number of Pump Stations (ft)	Actual Number of Pump Stations (ft)	Total Pump Station Cost ($mill)
231,000	1,850	26,548	4.178	3.29	8.9	416	69,018	13.1	1.5	2	1.000
0.00	1,850	26,548	4.139	2.35	16.7	416	93,354	17.7	1.5	2	1.000

Total Const Cost ($mill)	Eng Cost ($mill)	20% Contingency ($mill)	**Total Capital Cost ($mill)**	Discharge Hydraulic Gradeline (ft)	Static Pump Lift (ft)	Head Loss (ft)	Total Pump Lift (ft)	Pump Size (HP)	**Annual Pumping Cost ($)**	**NPV of Pumping Costs ($mill)**	**Total NPV Cost ($mill)**
5.178	0.777	1.786	**7.741**	4,270	-212	636	424	78	**25,375**	**0.502**	**8.244**
5.139	0.771	1.773	**15.424**	4,215	-267	628	361	27	**34,291**	**0.679**	**16.102**

N.11 Zone B to Tailings Impoundment, Lost Use Distillation

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No: 11

SUBJECT: Cost Estimate for Disposal of Reverse Osmosis By-product
Alternative F.3 - Zone B Discharge to KUCC Tailings Impoundment Lost Use Distillation

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Mark Atencio

DATE: April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of pumping the Zone B RO by-product to the KUCC Tailings Impoundment in a 20.0 mile long, 8-inch diameter pipeline using three pump stations. The Lost Use RO by-product would be distilled at the RO treatment plant in West Jordan. This would create a solid product. The net present value cost for disposal of Zone B and Lost Use RO by-product is $40.4 million. This includes a capital cost of $18.1 million and an operation cost of $1,125,000 per year.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe the methods used to estimate the cost of disposing of Zone B and Lost Use RO by-product to the KUCC Tailings Impoundment in a pipeline from the Zone B Lost Use Treatment Plant in West Jordan and distillation of Lost Use RO by-product to a solid product.

AUTHOR'S CREDENTIALS

I am a registered professional engineer specializing in the area of water resources. I have completed Bachelor and Master of Science degrees in civil engineering. Following graduation I have been working at Jordan Valley Water Conservancy District as a civil engineer. My current title is senior engineer, in which I fill project management and

supervisory roles. I have been studying and investigating various membrane and TDS reduction treatments for eight years. I have completed a number of well drilling and construction projects. I have completed three years of pilot testing using various membrane and reverse osmosis processes. I have been filling the role of a technical engineer for the District on the Southwest Groundwater Remediation and Treatment Project since 1999.

DESCRIPTION OF ALTERNATIVE

See the attached Drawing of Alternative F.3 for a visual representation of the alternative.

This alternative consists of a 20.0 mile long, 8-inch diameter PVC pipeline constructed from the Zone B Lost Use Reverse Osmosis (RO) Plant in West Jordan to the Tailings Impoundment. Three pump stations would be required; one at the RO plant, the second at 7 to 8 miles from the plant, and the third at 15 to 16 miles from the plant. A distillation plant would be constructed adjacent to the RO plant in order to create a solid product from the Lost Use by-product.

SCALING CONCERNS

The RO by-product contains a high concentration of salts, consisting mostly of calcium sulfate (gypsum) and calcium carbonate (calcite IE Timpanogos Cave). The solutions are super-saturated and on the verge of precipitating. This means that if the fluid were to stop moving a scale would start to form on the interior of the pipeline. In the RO plant an antiscalant chemical prevents scale formation; however, the chemical does not last for more than approximately 24 hours.

The formation of scale or precipitation of salts is the same process that occurs in the Great Salt Lake as the tributaries to the lake bring in salts into the lake. In this case the salts are concentrated due to evaporation until the point that saturation is reached and the salts form particles (precipitation) and settle to the bottom. In order to prevent this type of scaling from occurring in the pipeline the RO by-product needs to be kept in continuous operation or drained.

PIPELINE MATERIAL

Polyvinyl chloride (PVC) was selected as material of choice after considering ductile iron, steel, high density polypropylene (HDPE), and PVC. This took into account the actual internal diameter of the various types of pipeline, the working pressure of the pipelines, the hydraulic characteristics of the pipeline materials (friction factor) and the construction cost. Each pipeline material option was evaluated in a large spreadsheet. A copy of this spreadsheet is attached to this memo. The limitations of the pipeline

material options considered affected the number and cost of pump stations required, the pressure loss required to be overcome by a pump, pipeline construction cost, and pump station operating cost.

PIPELINE DIAMETER

Six-inch, 8-inch, 10-inch, and 12-inch diameter pipelines were evaluated in the spreadsheet identified above. The size of the pipeline options evaluated affected the pressure loss (smaller pipe = higher pressure loss), the detention time in the pipeline (larger pipe = longer time in transit), pipeline construction cost, and pump station operating cost.

PIPELINE ALIGNMENT

Multiple alignments were considered for this alternative. First, an alignment extending westward, then northward was considered. Second a northern then westward alignment was evaluated. The two alignments were of comparable length. Due to the topography the first alignment required additional pumping to move the fluid uphill, then downhill towards Great Salt Lake. Both alignments utilized property owned by Kennecott Utah Copper Corporation (KUCC) along the east and north sides of its tailings impoundment in the northwest section of Salt Lake County.

SELECTION OF PREFERRED PIPELINE OPTION

Selection of the preferred pipeline option took into account the concerns with scaling and the effects of pipeline material, diameter, and alignment on the capital and operating cost.

The alignment selected for this alternative utilizes public right-of-way and private property, most of which is owned by KUCC. The alignment generally follows an elevation contour line to the north along 1300 West and then to the west along 1300 South to the KUCC tailings impoundment. The pipeline to the tailings impoundment diverges at 3100 South when it extends westward. This alignment allows for utilizing existing right–of-way corridors. This alignment stays at almost the same elevation along its length. The alignment also avoids increasing in elevation, thereby avoiding additional pumping cost and making it easier to drain the pipeline with a backup pump in the event of a power failure.

Selection of the a 8-inch diameter PVC pipeline with three pump stations allows for the concerns expressed in this memo to be met will obtaining the lowest capital and net present value cost.

DISTILLATION PLANT

See memorandum number six by Tom Seacord for a description of the Lost Use distillation plant and estimated cost.

REQUIRED FACILITIES

- 20.0 mile long, 8-inch diameter PVC pipeline
- 3 pump stations
- Lost Use distillation plant

LEGALITY

The legality of this alternative was considered. The Zone B RO by-product meets the existing KUCC Tailings Impoundment GSL discharge permit. A separate memo by Gary Colgan addresses the legality of disposing of solid Lost Use by-product to a municipal landfill. His conclusion was that it is acceptable.

ASSUMPTIONS

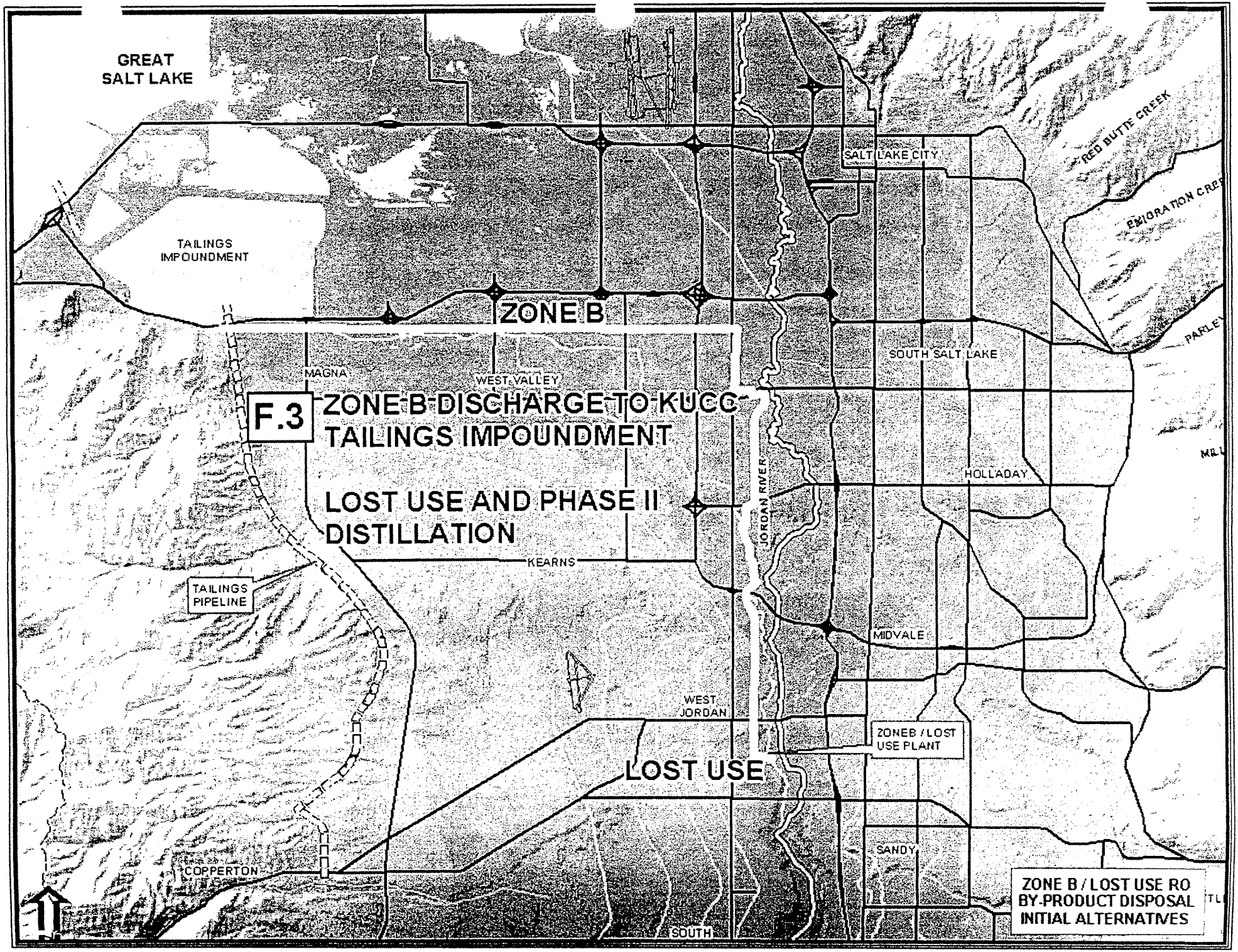
- Pump Efficiency: 85%
- Motor Efficiency: 90%
- Pump Station Capital Cost: $500,000 each
- NPV interest rate: 4%
- 25 feet wide easement cost: $14.35/ foot ($50,000/acre)
- Pipeline in roadways installation cost: $_____/ft
- Pipeline in open areas installation cost: $_____/ft
- Pipeline costs from two contractors and MWH Engineers
- RO plant operates 330 days per year
- Power Cost $0.055/kW hr

COST ESTIMATE

The cost estimate for this alternative took into account the size of the pipeline, number of pump stations, pumping costs, length of pipeline, length of pipeline in roadways, length of pipeline in open areas, easement acquisition costs, dewatering costs, and engineering costs. It also took into account the distillation equipment necessary to treat the Lost Use RO by-product to a solid product. The net present value cost for disposal

of Zone B and Lost Use RO by-product is $40.4 million. This includes a capital cost of $18.1 million and an operation cost of $1,125,000 per year.

See the attached spreadsheet for details and calculations of the cost estimate.


GREAT SALT LAKE
TAILINGS IMPOUNDMENT
ZONE B
SALT LAKE CITY
RED BUTTE CREEK
EMIGRATION CREEK
SOUTH SALT LAKE
MAGNA
WEST VALLEY
F.3
ZONE B DISCHARGE TO KUCC TAILINGS IMPOUNDMENT
LOST USE AND PHASE II DISTILLATION
JORDAN RIVER
HOLLADAY
KEARNS
TAILINGS PIPELINE
MIDVALE
WEST JORDAN
ZONEB / LOST USE PLANT
LOST USE
SANDY
COPPERTON
SOUTH
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL INITIAL ALTERNATIVES

SOUTHWEST GROUNDWATER
REVERSE OSMOSIS BY-PRODUCT DISPOSAL OPTIONS

Alternative F.3
Zone B Discharge to KUCC Tailings Impoundment
Lost Use Distillation

Alt. No.	Disposal Alternative	Project Yield (AF/yr)	Pipeline Material	Pipeline Actual Inside Diameter (Inches)	Zone A Yield (AF/yr)	Zone B Yield (AF/yr)	Zone B Production Rate (cfs)	Lost Use Yield (AF/yr)	Lost Use Production Rate (cfs)	Future Shallow Wells Yield (AF/yr)	Future Shallow Wells Production Rate (cfs)
Zone B to Tailings Impoundment Lost Use to Distillation & Totals	3500	PVC C-909	8.29	0	3500	5.35	0	0	0	0	1.23
	9300	PVC C-909	0	3500	0	0	2300	3.51	0	0	0.51

By-product Flow Rate (cfs)	Number of Pipelines (#)	Pressure Rating (psi)	Pipeline Hazen Williams C-factor	Pipeline in Roadways Length (ft)	Roadway Pipeline Unit Cost ($/ft)	Pipeline In Open Field Length (ft)	Open Pipeline Unit Cost ($/ft)	Total Pipeline Length (ft)	Total Pipeline Length (miles)	Dewatering Length (ft)	Dewatering Unit Cost ($/ft)
1.23	1	200	120	88,440	39.90	17,050	18.65	105,490	20.0	36,850	2.00
0.51	1	200	120	0.00	0.00	0	0.00	0	0.0	0	0.00

Pipeline Boring & Additional Costs ($)	Easement Length Required (ft)	Easement Cost ($)	Total Pipeline Cost ($mill)	Velocity (ft/sec)	Detention Time OK? (hrs)	Max Head Loss between Pump Stations (ft)	Max Distance between Pump Stations (ft)	Max Distance between Pump Stations (miles)	Calculated Number of Pump Stations (ft)	Actual Number of Pump Stations (ft)	Total Pump Station Cost ($mill)
231,000	1,850	26,548	4.178	3.29	8.9	416	69,017.6	13.1	1.5	2	1.000
0	0	0	0.000	#DIV/0!	#DIV/0!	416	0.0	0.0	#DIV/0!	#DIV/0!	#DIV/0!

Total Const Cost ($mill)	Eng Cost ($mill)	20% Contingency ($mill)	**Total Capital Cost ($mill)**	Discharge Hydraulic Gradeline (ft)	Static Pump Lift (ft)	Head Loss (ft)	Total Pump Lift (ft)	Pump Size (HP)	**Annual Pumping Cost ($)**	**NPV of Pumping Costs ($mill)**	**Total NPV Cost ($mill)**
5.178	0.777	1.786	7.741	4,270	-212	636	424	78	**25,375**	**0.502**	**8.244**
#DIV/0!	#DIV/0!	#DIV/0!	18.141	4,215	-267	#DIV/0!	#DIV/0!	#DIV/0!	**1,125,375**	**22.274**	**40.416**

N.12 Zone B to Tailings Impoundment, Lost Use to GSL

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No: 12

SUBJECT: Cost Estimate for Disposal of Reverse Osmosis By-product
Alternative I.1- Zone B Discharge to the KUCC Tailings Pipeline
Lost Use Discharge to GSL

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Mark Atencio

DATE: April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of pumping the Zone B RO by-product to the KUCC Tailings Pipeline in a 9.4 mile, 8-inch diameter pipeline and the Lost Use RO by-product to the south arm of the Great Salt Lake in a 23.7 mile long, 6-inch diameter pipeline using three pump stations. The net present value cost for disposal of Zone B and Lost Use RO by-product is $13.1 million. This includes a capital cost of $11.6 million and an operation cost of $79,000 per year.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe the methods used to estimate the cost of disposing of Zone B RO by-product to the KUCC Tailings Pipeline and Lost Use RO by-product to Great Salt Lake in pipelines from the Zone B Lost Use Treatment Plant in West Jordan.

AUTHOR'S CREDENTIALS

I am a registered professional engineer specializing in the area of water resources. I have completed Bachelor and Master of Science degrees in civil engineering. Following graduation I have been working at Jordan Valley Water Conservancy District as a civil engineer. My current title is senior engineer, in which I fill project management and

supervisory roles. I have been studying and investigating various membrane and TDS reduction treatments for eight years. I have completed a number of well drilling and construction projects. I have completed three years of pilot testing using various membrane and reverse osmosis processes. I have been filling the role of a technical engineer for the District on the Southwest Groundwater Remediation and Treatment Project since 1999.

DESCRIPTION OF ALTERNATIVE

See the attached Drawing of alternative I.2 for a visual representation of the alternative.

This alternative consists of a 9.4 mile long, 8-inch PVC pipeline and a 23.7 mile long, 6-inch diameter PVC pipeline constructed from the Zone B Lost Use Reverse Osmosis (RO) Plant in West Jordan. Discharge into the lake would be through a new outfall pipeline. Three pump stations would be required for the 23.7 pipeline; one at the RO plant, the second at 7 to 8 miles from the plant, and the third at 15 to 16 miles from the plant. Two pump stations would be required for the 9.4 mile long pipeline; one at the plant.

SCALING CONCERNS

The RO by-product contains a high concentration of salts, consisting mostly of calcium sulfate (gypsum) and calcium carbonate (calcite IE Timpanogos Cave). The solutions are super-saturated and on the verge of precipitating. This means that if the fluid were to stop moving a scale would start to form on the interior of the pipelines. In the RO plant an antiscalant chemical prevents scale formation; however, the chemical does not last for more than approximately 24 hours.

The formation of scale or precipitation of salts is the same process that occurs in the Great Salt Lake as the tributaries to the lake bring in salts into the lake. In this case the salts are concentrated due to evaporation until the point that saturation is reached and the salts form particles (precipitation) and settle to the bottom. In order to prevent this type of scaling from occurring, the pipeline needs to be kept in continuous operation or drained.

PIPELINE MATERIAL

Polyvinyl chloride (PVC) was selected as material of choice after considering ductile iron, steel, high density polypropylene (HDPE), and PVC. This took into account the actual internal diameter of the various types of pipeline, the working pressure of the pipelines, the hydraulic characteristics of the pipeline materials (friction factor) and the construction cost. Each pipeline material option was evaluated in a large spreadsheet. A copy of this spreadsheet is attached to this memo. The limitations of the pipeline

material options considered affected the number and cost of pump stations required, the pressure loss required to be overcome by a pump, pipeline construction cost, and pump station operating cost.

PIPELINE DIAMETER

Six-inch, 8-inch, 10-inch, and 12-inch diameter pipelines were evaluated in the spreadsheet identified above. The size of the pipeline options evaluated affected the pressure loss (smaller pipe = higher pressure loss), the detention time in the pipeline (larger pipe = longer time in transit), pipeline construction cost, and pump station operating cost.

PIPELINE ALIGNMENT

One alignment was considered for the 8-inch pipeline to the tailings pipeline, the shortest distance and an existing corridor, 7800 South. This roadway is currently being expanded. A review of the plans shows limited space for new utilities. Other potential corridors include 9000 South and 7000 South.

Multiple alignments were considered for the pipeline to Great Salt Lake. First, an alignment extending westward, then northward was considered. Second, a northern then westward alignment was evaluated. The two alignments were of comparable length. Due to the topography, the first alignment required additional pumping to move the fluid uphill, then downhill towards Great Salt Lake. Both alignments utilized property owned by Kennecott Utah Copper Corporation (KUCC) along the east and north sides of its tailings impoundment in the northwest section of Salt Lake County.

SELECTION OF PREFERRED PIPELINE OPTION

Selection of the preferred pipeline option took into account the concerns with scaling and the effects of pipeline material, diameter, and alignment on the capital and operating cost.

The alignments selected for this alternative utilizes public right-of-way and private property, most of which is owned by KUCC. The pipeline to the tailings pipeline follows 7800 South. The other pipeline generally follows an elevation contour line to the north along 1300 West and then to the west along 1300 South to the KUCC tailings impoundment. The alignment then extends to the north and west until reaching Great Salt Lake. This alignment allows for utilizing existing right–of-way corridors. This alignment stays at almost the same elevation along its length. The alignment also avoids increasing in elevation, thereby avoiding additional pumping cost and making it easier to drain the pipeline with a backup pump in the event of a power failure.

Selection of an 8-inch diameter and a 6-inch diameter PVC pipelines with four pump stations allows for the concerns expressed in this memo to be met will obtaining the lowest capital and net present value cost.

REQUIRED FACILITIES

- 9.4 mile long, 8-inch diameter PVC pipeline
- 23.7 mile long, 10-inch diameter PVC pipeline
- four pump stations
- Outfall pipeline

LEGALITY

The legality of this alternative was considered. KUCC has an existing discharge permit to Great Salt Lake. The water quality of the Zone B RO by-product meets these permit limits. A review of existing information indicated that a permit for discharge of Lost Use RO by-product to GSL could be issued which would be protective of Great Salt Lake.

The water quality of the RO by-product was compared against standards for the Jordan River. All of the water quality parameters of the by-product were below the Jordan River standards, with the exception of total dissolved solids (TDS) and selenium. Comparing the TDS of the by-product (8,300) to Great Salt Lake (100,000 plus) it was apparent that TDS in the by-product would not be a concern. In order to understand if the selenium concentration in the by-product would be a concern I researched the files of the Utah State Division of Water Quality. Although selenium is an essential trace element, it has the potential to cause harm to humans or wildlife at very high concentrations. There is an existing permit for a discharge from KUCC to Great Salt Lake with a 54 µg/L (ppb) selenium limitation. The files of the Division contained substantial documentation of the methods used to derive this limitation. The limit required by the Division was based on limiting selenium absorption by algae in Great Salt Lake, which algae are consumed by brine shrimp, which shrimp are then consumed by waterfowl. By limiting selenium accumulation in Great Salt Lake algae the Division of Water Quality is able to prevent reproductive failure in waterfowl that consume Great Salt Lake brine shrimp.

The files also contained concerns expressed by others regarding the permit limitations and responses to these concerns. The issue of selenium has been well researched and a permit limit was already established. The conclusion of my research was that a selenium permit limit for discharge into Great Salt Lake on a firm basis was already

established. Comparing the RO by-product selenium concentration of 32-47 µg/L against an existing permit limitation of 54 µg/L indicates that Zone B and Lost Use RO by-product will meet a limit for discharge to Great Salt Lake.

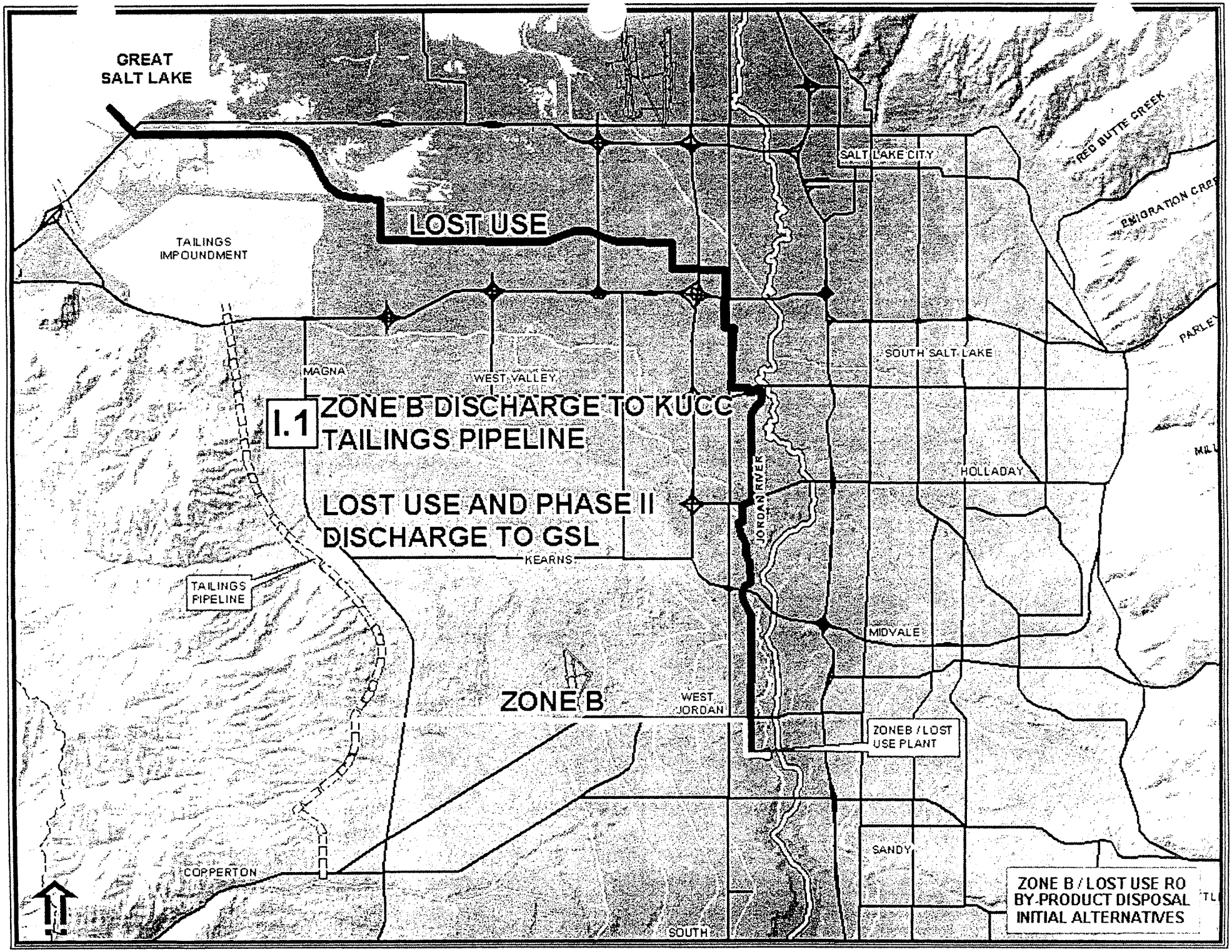
ASSUMPTIONS

- Pump Efficiency: 85%
- Motor Efficiency: 90%
- Pump Station Capital Cost: $500,000 each
- NPV interest rate: 4%
- 25 feet wide easement cost: $14.35/ foot ($50,000/acre)
- Pipeline in roadways installation cost: $39.90/ft (8-inch), $35.21/ft (6-inch)
- Pipeline in open areas installation cost: $18.65/ft (8-inch), $16.09/ft (6-inch)
- Pipeline costs from two contractors and MWH Engineers
- RO plant operates 330 days per year
- Power Cost $0.055/kW hr

COST ESTIMATE

The cost estimate for this alternative took into account the size of the pipelines, number of pump stations, pumping costs, length of pipelines, length of pipelines in roadways, length of pipelines in open areas, easement acquisition costs, dewatering costs, and engineering costs. The net present value cost for disposal of Zone B and Lost Use RO by-product is $13.1 million. This includes a capital cost of $11.6 million and an operation cost of $79,000 per year.

See the attached spreadsheet for details and calculations of the cost estimate.


GREAT SALT LAKE
LOST USE
TAILINGS IMPOUNDMENT
SALT LAKE CITY
RED BUTTE CREEK
EMIGRATION CREEK
PARLEY
SOUTH SALT LAKE
MAGNA
WEST VALLEY
I.1
ZONE B DISCHARGE TO KUCC TAILINGS PIPELINE
LOST USE AND PHASE II DISCHARGE TO GSL
HOLLADAY
JORDAN RIVER
KEARNS
TAILINGS PIPELINE
MIDVALE
ZONE B
WEST JORDAN
ZONEB / LOST USE PLANT
SANDY
COPPERTON
SOUTH
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL INITIAL ALTERNATIVES

SOUTHWEST GROUNDWATER
REVERSE OSMOSIS BY-PRODUCT DISPOSAL OPTIONS

Alternative I.1
Zone B Discharge to Tailings Pipeline
Lost Use Discharge to GSL

Alt. No.	Disposal Alternative	Project Yield (AF/yr)	Pipeline Material	Pipeline Actual Inside Diameter (Inches)	Zone A Yield (AF/yr)	Zone B Yield (AF/yr)	Zone B Production Rate (cfs)	Lost Use Yield (AF/yr)	Lost Use Production Rate (cfs)	Future Shallow Wells Yield (AF/yr)	Future Shallow Wells Production Rate (cfs)
I.1 ZB	Zone B to Tailings Pipeline Lost Use to GSL	3500	PVC C-909	8.29	0	3500	5.35	0	0	0	0
I.1 LU	Lost Use & Totals	9300	PVC C-909	6.3	3500	0	0	2300	3.51	0	0

By-product Flow Rate (cfs)	Number of Pipelines (#)	Pressure Rating (psi)	Pipeline Hazen Williams C-factor	Pipeline in Roadways Length (ft)	Roadway Pipeline Unit Cost ($/ft)	Pipeline In Open Field Length (ft)	Open Pipeline Unit Cost ($/ft)	Total Pipeline Length (ft)	Total Pipeline Length (miles)	Dewatering Length (ft)	Dewatering Unit Cost ($/ft)
1.23	1	200	120	38,544	39.90	10,850	18.65	49,394	9.4	1,850	2.00
0.51	1	200	120	90,290	35.21	34,850	16.09	125,140	23.7	42,770	2.00

Pipeline Boring & Additional Costs ($)	Easement Length Required (ft)	Easement Cost ($)	Total Pipeline Cost ($mill)	Velocity (ft/sec)	Detention Time OK? (hrs)	Max Head Loss between Pump Stations (ft)	Max Distance between Pump Stations (ft)	Max Distance between Pump Stations (miles)	Calculated Number of Pump Stations (ft)	Actual Number of Pump Stations (ft)	Total Pump Station Cost ($mill)
134,750	0	0	1.879	3.29	4.2	416	69,018	13.1	0.7	2	1.000
0	1,850	26,548	3.852	2.35	14.8	416	93,354	17.7	1.3	2	1.000

Total Const Cost ($mill)	Eng Cost ($mill)	20% Contingency ($mill)	**Total Capital Cost ($mill)**	Discharge Hydraulic Gradeline (ft)	Static Pump Lift (ft)	Head Loss (ft)	Total Pump Lift (ft)	Pump Size (HP)	**Annual Pumping Cost ($)**	**NPV of Pumping Costs ($mill)**	**Total NPV Cost ($mill)**
2.879	0.432	0.993	**4.304**	5,385	903	298	1,201	220	**71,929**	**1.424**	**5.727**
4.852	0.728	1.674	**11.558**	4,215	-267	557	290	22	**79,103**	**1.566**	**13.124**

N.13 Zone B to Tailings Pipeline, Lost Use to KUC GSL Outfall

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No: 13

SUBJECT: Cost Estimate for Disposal of Reverse Osmosis By-product
Alternative I.2 - Zone B Discharge to KUCC Tailings Pipeline
Lost Use Discharge to KUCC GSL Outfall

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Mark Atencio

DATE: April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of pumping the Zone B RO by-product to the KUCC Tailings Pipeline in a 9.4 mile long 8-inch diameter pipeline and Lost Use RO by-product to the KUCC GSL outfall in a 26.7 mile long, 6-inch diameter pipeline using four pump stations. The net present value cost for disposal of Zone B and Lost Use RO by-product is $13.6 million. This includes a capital cost of $12.0 million and an operation cost of $81,000 per year.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and

- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe the methods used to estimate the cost of disposing of Zone B to the KUCC Tailings Pipeline and Lost Use RO by-product to the KUCC GSL outfall in pipelines from the Zone B Lost Use Treatment Plant in West Jordan.

AUTHOR'S CREDENTIALS

I am a registered professional engineer specializing in the area of water resources. I have completed Bachelor and Master of Science degrees in civil engineering. Following graduation I have been working at Jordan Valley Water Conservancy District as a civil engineer. My current title is senior engineer, in which I fill project management and supervisory roles. I have been studying and investigating various membrane and TDS reduction treatments for eight years. I have completed a number of well drilling and construction projects. I have completed three years of pilot testing using various membrane and reverse osmosis processes. I have been filling the role of a technical engineer for the District on the Southwest Groundwater Remediation and Treatment Project since 1999.

DESCRIPTION OF ALTERNATIVE

See the attached Drawing of Alternative I.2 for a visual representation of the alternative.

This alternative consists of a 9.4 mile long, 8-inch PVC pipeline and a 26.7 mile long 8-inch diameter PVC pipeline constructed from the Zone B Lost Use Reverse Osmosis (RO) Plant in West Jordan. Two pumps stations are required for the 8-inch pipeline; one at the pant. Three pump stations would be required for the GSL pipeline; one at the RO plant, the second at 7 to 8 miles from the plant, and the third at 15 to 16 miles from the plant.

SCALING CONCERNS

The RO by-product contains a high concentration of salts, consisting mostly of calcium sulfate (gypsum) and calcium carbonate (calcite IE Timpanogos Cave). The solutions are super-saturated and on the verge of precipitating. This means that if the fluid were to stop moving a scale would start to form on the interior of the pipelines. In the RO plant an antiscalant chemical prevents scale formation; however, the chemical does not last for more than approximately 24 hours.

The formation of scale or precipitation of salts is the same process that occurs in the Great Salt Lake as the tributaries to the lake bring in salts into the lake. In this case the salts are concentrated due to evaporation until the point that saturation is reached and the salts form particles (precipitation) and settle to the bottom. In order to prevent this type of scaling from occurring, the pipelines need to be kept in continuous operation or drained.

PIPELINE MATERIAL

Polyvinyl chloride (PVC) was selected as material of choice after considering ductile

iron, steel, high density polypropylene (HDPE), and PVC. This took into account the actual internal diameter of the various types of pipeline, the working pressure of the pipelines, the hydraulic characteristics of the pipeline materials (friction factor) and the construction cost. Each pipeline material option was evaluated in a large spreadsheet. A copy of this spreadsheet is attached to this memo. The limitations of the pipeline material options considered affected the number and cost of pump stations required, the pressure loss required to be overcome by a pump, pipeline construction cost, and pump station operating cost.

PIPELINE DIAMETER

Six-inch, 8-inch, 10-inch, and 12-inch diameter pipelines were evaluated in the spreadsheet identified above. The size of the pipeline options evaluated affected the pressure loss (smaller pipe = higher pressure loss), the detention time in the pipeline (larger pipe = longer time in transit), pipeline construction cost, and pump station operating cost.

PIPELINE ALIGNMENT

Multiple alignments were considered for this alternative. First, an alignment extending westward, then northward was considered. Second a northern then westward alignment was evaluated. The two alignments were of comparable length. Due to the topography the first alignment required additional pumping to move the fluid uphill, then downhill towards Great Salt Lake. Both alignments utilized property owned by Kennecott Utah Copper Corporation (KUCC) along the east and north sides of its tailings impoundment in the northwest section of Salt Lake County.

SELECTION OF PREFERRED PIPELINE OPTION

Selection of the preferred pipeline option took into account the concerns with scaling and the effects of pipeline material, diameter, and alignment on the capital and operating cost.

The alignment selected for this alternative utilizes public right-of-way and private property, most of which is owned by KUCC. The tailings pipeline follows 7800 South. The other pipeline generally follows an elevation contour line to the north along 1300 West and then to the west along 1300 South to the KUCC tailings impoundment. The alignment then extends to the north and west until reaching Great Salt Lake. This alignment allows for utilizing existing right–of-way corridors. This alignment stays at almost the same elevation along its length. The alignment also avoids increasing in elevation, thereby avoiding additional pumping cost and making it easier to drain the pipeline with a backup pump in the event of a power failure.

Selection of a 8-inch and a 6-inch diameter PVC pipeline with four pump stations allows for the concerns expressed in this memo to be met will obtaining the lowest capital and net present value cost.

REQUIRED FACILITIES

- 9.4 mile long, 8-inch diameter PVC pipeline
- 26.7 mile long, 6-inch diameter PVC pipeline
- 4 pump stations

LEGALITY

The legality of this alternative was considered. The Zone B RO by-product will meet the limitation of KUCC's existing permit to GSL. A review of existing information indicated that a permit for discharge of Lost Use RO by-product to GSL could be issued which would be protective of Great Salt Lake.

The water quality of the RO by-product was compared against standards for the Jordan River. All of the water quality parameters of the by-product were below the Jordan River standards, with the exception of total dissolved solids (TDS) and selenium. Comparing the TDS of the by-product (8,300) to Great Salt Lake (100,000 plus) it was apparent that TDS in the by-product would not be a concern. In order to understand if the selenium concentration in the by-product would be a concern I researched the files of the Utah State Division of Water Quality. Although selenium is an essential trace element, it has the potential to cause harm to humans or wildlife at very high concentrations. There is an existing permit for a discharge from KUCC to Great Salt Lake with a 54 µg/L (ppb) selenium limitation. The files of the Division contained substantial documentation of the methods used to derive this limitation. The limit required by the Division was based on limiting selenium absorption by algae in Great Salt Lake, which algae are consumed by brine shrimp, which shrimp are then consumed by waterfowl. By limiting selenium accumulation in Great Salt Lake algae the Division of Water Quality is able to prevent reproductive failure in waterfowl that consume Great Salt Lake brine shrimp.

The files also contained concerns expressed by others regarding the permit limitations and responses to these concerns. The issue of selenium has been well researched and a permit limit was already established. The conclusion of my research was that a selenium permit limit for discharge into Great Salt Lake on a firm basis was already established. Comparing the RO by-product selenium concentration of 32-47 µg/L against an existing permit limitation of 54 µg/L indicates that Zone B and Lost Use RO by-product will meet a limit for discharge to Great Salt Lake.

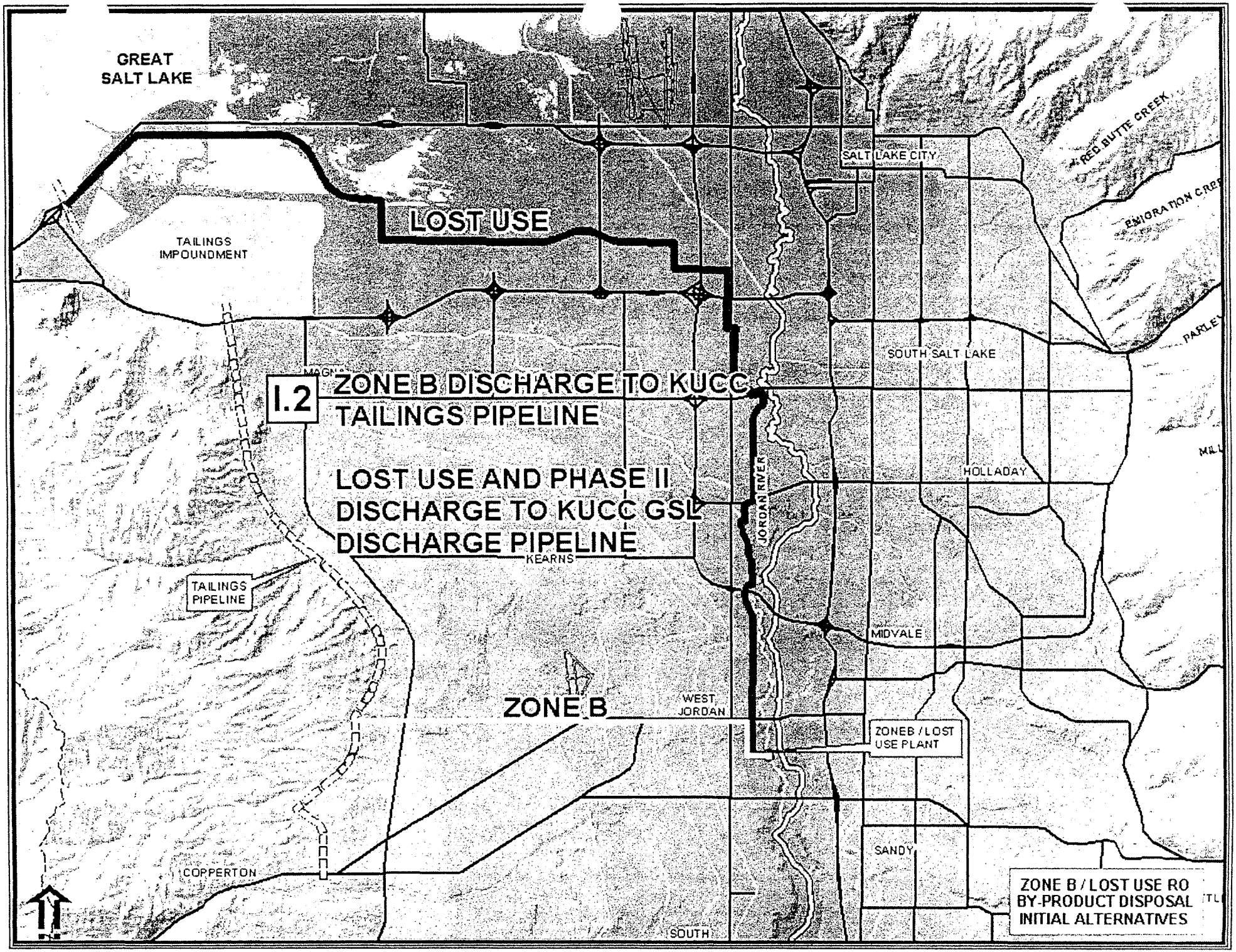
ASSUMPTIONS

- Pump Efficiency: 85%
- Motor Efficiency: 90%
- Pump Station Capital Cost: $500,000 each
- NPV interest rate: 4%
- 25 feet wide easement cost: $14.35/ foot ($50,000/acre)
- Pipeline in roadways installation cost: $$39.90/ft (8-inch), $35.21/ft (6-inch)
- Pipeline in open areas installation cost: $18.65/ft (8-inch), $16.09/ft (6-inch)
- Pipeline costs from two contractors and MWH Engineers
- RO plant operates 330 days per year
- Power Cost $0.055/kW hr

COST ESTIMATE

The cost estimate for this alternative took into account the size of the pipeline, number of pump stations, pumping costs, length of pipeline, length of pipeline in roadways, length of pipeline in open areas, easement acquisition costs, dewatering costs, and engineering costs. The net present value cost for disposal of Zone B and Lost Use RO by-product is $13.6 million. This includes a capital cost of $12.0 million and an operation cost of $81,000 per year.

See the attached spreadsheet for details and calculations of the cost estimate.


GREAT SALT LAKE
LOST USE
TAILINGS IMPOUNDMENT
I.2
ZONE B DISCHARGE TO KUCC TAILINGS PIPELINE
LOST USE AND PHASE II DISCHARGE TO KUCC GSL DISCHARGE PIPELINE
TAILINGS PIPELINE
ZONE B
SALT LAKE CITY
RED BUTTE CREEK
SOUTH SALT LAKE
HOLLADAY
JORDAN RIVER
KEARNS
MIDVALE
WEST JORDAN
ZONEB / LOST USE PLANT
SANDY
COPPERTON
SOUTH
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL INITIAL ALTERNATIVES

SOUTHWEST GROUNDWATER
REVERSE OSMOSIS BY-PRODUCT DISPOSAL OPTIONS

Alternative I.2
Zone B Discharge to Tailings Pipeline
Lost Use Discharge to KUCC GSL Outfall

Alt. No.	Disposal Alternative	Project Yield (AF/yr)	Pipeline Material	Pipeline Actual Inside Diameter (Inches)	Zone A Yield (AF/yr)	Zone B Yield (AF/yr)	Zone B Production Rate (cfs)	Lost Use Yield (AF/yr)	Lost Use Production Rate (cfs)	Future Shallow Wells Yield (AF/yr)	Future Shallow Wells Production Rate (cfs)
I.2 ZB	Zone B to Tailings Pipeline Lost Use to KUCC GSL	3500	PVC C-909	8.29	0	3500	5.35	0	0	0	0
I.2 LU	Lost Use & Totals	9300	PVC C-909	6.3	3500	0	0	2300	3.51	0	0

By-product Flow Rate (cfs)	Number of Pipelines (#)	Pressure Rating (psi)	Pipeline Hazen Williams C-factor	Pipeline in Roadways Length (ft)	Roadway Pipeline Unit Cost ($/ft)	Pipeline In Open Field Length (ft)	Open Pipeline Unit Cost ($/ft)	Total Pipeline Length (ft)	Total Pipeline Length (miles)	Dewatering Length (ft)	Dewatering Unit Cost ($/ft)
1.23	1	200	120	38,544	39.90	10,850	18.65	49,394	9.35	1,850	2.00
0.51	1	200	120	90,290	35.21	50,690	16.09	140,980	26.70	58,610	2.00

Pipeline Boring & Additional Costs ($)	Easement Length Required (ft)	Easement Cost ($)	Total Pipeline Cost ($mill)	Velocity (ft/sec)	Detention Time OK? (hrs)	Max Head Loss between Pump Stations (ft)	Max Distance between Pump Stations (ft)	Max Distance between Pump Stations (miles)	Calculated Number of Pump Stations (ft)	Actual Number of Pump Stations (ft)	Total Pump Station Cost ($mill)
134,750	0	0	1.879	3.29	4.2	416	69,018	13.1	0.7	2	1.000
0	1,850	26,548	4.139	2.35	16.7	416	93,354	17.7	1.5	2	1.000

Total Const Cost ($mill)	Eng Cost ($mill)	20% Contingency ($mill)	**Total Capital Cost ($mill)**	Discharge Hydraulic Gradeline (ft)	Static Pump Lift (ft)	Head Loss (ft)	Total Pump Lift (ft)	Pump Size (HP)	**Annual Pumping Cost ($)**	**NPV of Pumping Costs ($mill)**	**Total NPV Cost ($mill)**
2.879	0.432	0.993	**4.304**	5,385	903	298	1,201	220	**71,929**	**1.424**	**5.727**
5.139	0.771	1.773	**11.986**	4,215	-267	628	361	27	**80,846**	**1.600**	**13.586**

N.14 Zone B to Tailings Pipeline, Lost Use Distillation

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No: 14

SUBJECT: Cost Estimate for Disposal of Reverse Osmosis By-product
Alternative I.3 -
Zone B Discharge to KUCC Tailings Pipeline
Lost Use Distillation

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Mark Atencio

DATE: April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of pumping the Zone B RO by-product to the KUCC tailings pipeline in a 9.4 mile long, 8-inch diameter pipeline using two pump stations. The Lost Use RO by-product would be distilled at the RO treatment plant. The new present value cost for disposal of Zone B and Lost Use RO by-product is $37.7 million. This includes a capital cost of $14.5 million and an operation cost of $1,172,000 per year.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe the methods used to estimate the cost of disposing of Zone B RO by-product to the KUCC tailings pipeline and Lost Use RO by-product distilled in a distillation plant adjacent to the Zone B Lost Use Treatment Plant in West Jordan.

AUTHOR'S CREDENTIALS

I am a registered professional engineer specializing in the area of water resources. I have completed Bachelor and Master of Science degrees in civil engineering. Following graduation I have been working at Jordan Valley Water Conservancy District as a civil engineer. My current title is senior engineer, in which I fill project management and

supervisory roles. I have been studying and investigating various membrane and TDS reduction treatments for eight years. I have completed a number of well drilling and construction projects. I have completed three years of pilot testing using various membrane and reverse osmosis processes. I have been filling the role of a technical engineer for the District on the Southwest Groundwater Remediation and Treatment Project since 1999.

DESCRIPTION OF ALTERNATIVE

See the attached Drawing of Alternative I.3 for a visual representation of the alternative.

This alternative consists of a 9.4 mile long, 8-inch diameter PVC pipeline constructed from the Zone B Lost Use Reverse Osmosis (RO) Plant in West Jordan to the tailings pipeline. Two pump stations would be required; one at the plant.

SCALING CONCERNS

The RO by-product contains a high concentration of salts, consisting mostly of calcium sulfate (gypsum) and calcium carbonate (calcite IE Timpanogos Cave). The solutions are super-saturated and on the verge of precipitating. This means that if the fluid were to stop moving a scale would start to form on the interior of the pipeline. In the RO plant an antiscalant chemical prevents scale formation; however, the chemical does not last for more than approximately 24 hours.

The formation of scale or precipitation of salts is the same process that occurs in the Great Salt Lake as the tributaries to the lake bring in salts into the lake. In this case the salts are concentrated due to evaporation until the point that saturation is reached and the salts form particles (precipitation) and settle to the bottom. In order to prevent this type of scaling from occurring, the pipeline needs to be kept in continuous operation or drained.

Of necessity, this pipeline would need to be drained into the Jordan River in the event of a power failure.

PIPELINE MATERIAL

Polyvinyl chloride (PVC) was selected as material of choice after considering ductile iron, steel, high density polypropylene (HDPE), and PVC. This took into account the actual internal diameter of the various types of pipeline, the working pressure of the pipelines, the hydraulic characteristics of the pipeline materials (friction factor) and the construction cost. Each pipeline material option was evaluated in a large spreadsheet. A copy of this spreadsheet is attached to this memo. The limitations of the pipeline material options considered affected the number and cost of pump stations required, the

pressure loss required to be overcome by a pump, pipeline construction cost, and pump station operating cost.

PIPELINE DIAMETER

Six-inch, 8-inch, 10-inch, and 12-inch diameter pipelines were evaluated in the spreadsheet identified above. The size of the pipeline options evaluated affected the pressure loss (smaller pipe = higher pressure loss), the detention time in the pipeline (larger pipe = longer time in transit), pipeline construction cost, and pump station operating cost.

PIPELINE ALIGNMENT

7800 South was the most direct and only pipeline alignment considered.

SELECTION OF PREFERRED PIPELINE OPTION

Selection of the preferred pipeline option took into account the concerns with scaling and the effects of pipeline material, diameter, and alignment on the capital and operating cost.

The alignment selected for this alternative utilizes public right-of-way and private property, most of which is owned by KUCC. The alignment generally follows an elevation contour line to the north along 1300 West and then to the west along 1300 South to the KUCC tailings impoundment. The alignment then extends to the north and west until reaching Great Salt Lake. This alignment allows for utilizing existing right–of-way corridors. This alignment stays at almost the same elevation along its length. The alignment also avoids increasing in elevation, thereby avoiding additional pumping cost and making it easier to drain the pipeline with a backup pump in the event of a power failure.

Selection of the a 8-inch diameter PVC pipeline with two pump stations and a distillation plant allows for the concerns expressed in this memo to be met will obtaining the lowest capital and net present value cost.

DISTILLATION PLANT

Memorandum number six describes the details and cost estimate of a distillation plant.

REQUIRED FACILITIES

- 9.4 mile long, 8-inch diameter PVC pipeline

- 2 pump stations
- distillation plant

LEGALITY

The legality of this alternative was considered. The Zone B RO by-product meets the limitations of the existing KUCC GSL discharge pipeline.

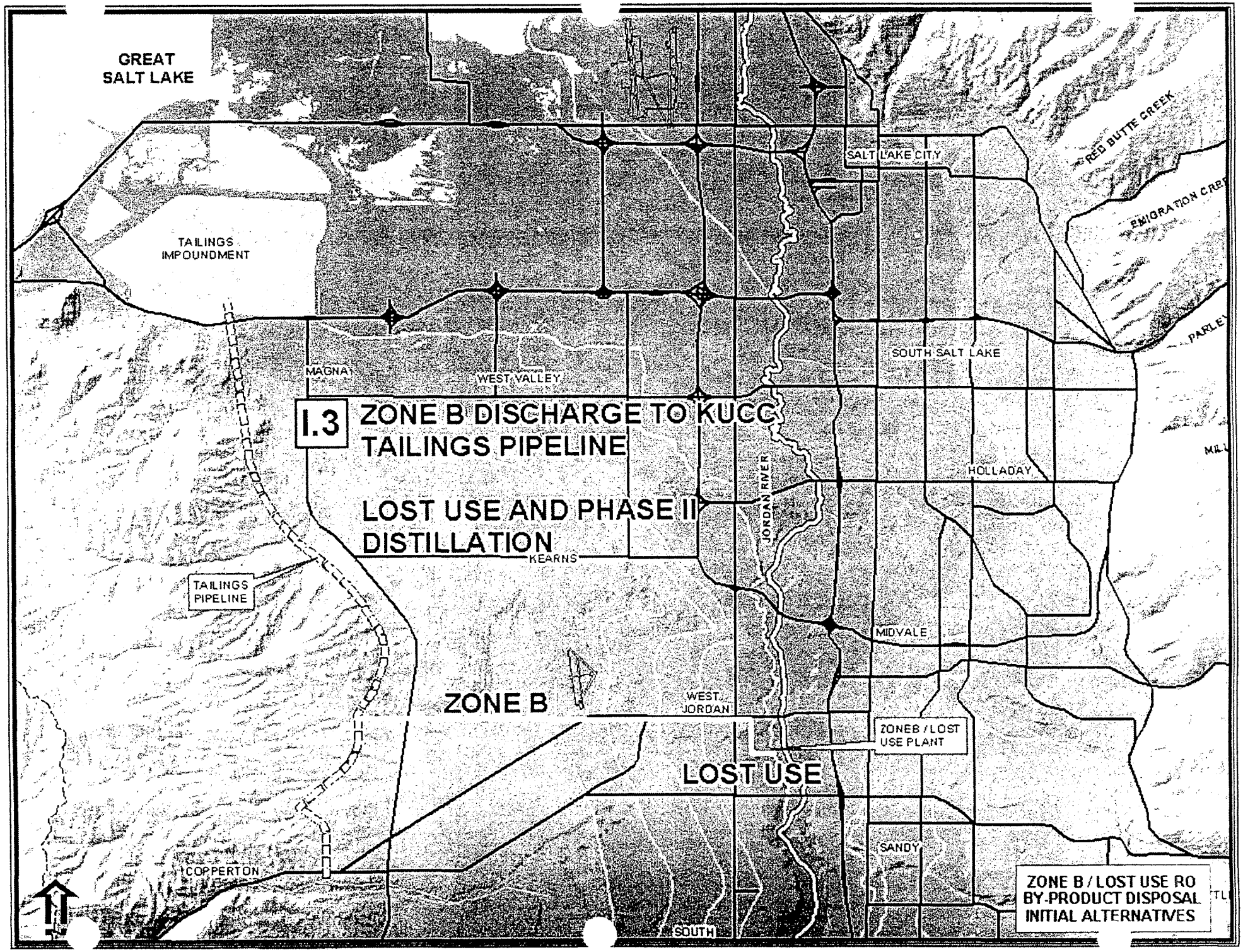
ASSUMPTIONS

- Pump Efficiency: 85%
- Motor Efficiency: 90%
- Pump Station Capital Cost: $500,000 each
- NPV interest rate: 4%
- 25 feet wide easement cost: $14.35/ foot ($50,000/acre)
- Pipeline in roadways installation cost: $39.90/ft
- Pipeline in open areas installation cost: $18.65
- Pipeline costs from two contractors and MWH Engineers
- RO plant operates 330 days per year
- Power Cost $0.055/kW hr

COST ESTIMATE

The cost estimate for this alternative took into account the size of the pipeline, number of pump stations, pumping costs, length of pipeline, length of pipeline in roadways, length of pipeline in open areas, easement acquisition costs, dewatering costs, and engineering costs. The net present value cost for disposal of Zone B and Lost Use RO by-product is $37.7 million. This includes a capital cost of $14.5 million and an operation cost of $1,172,000 per year.

See the attached spreadsheets for details and calculations of the cost estimate.


GREAT SALT LAKE
TAILINGS IMPOUNDMENT
SALT LAKE CITY
RED BUTTE CREEK
EMIGRATION CREEK
SOUTH SALT LAKE
MAGNA
WEST VALLEY
I.3 ZONE B DISCHARGE TO KUCC TAILINGS PIPELINE
LOST USE AND PHASE II DISTILLATION
KEARNS
JORDAN RIVER
HOLLADAY
TAILINGS PIPELINE
MIDVALE
ZONE B
WEST JORDAN
ZONEB / LOST USE PLANT
LOST USE
SANDY
COPPERTON
SOUTH
ZONE B / LOST USE RO BY-PRODUCT DISPOSAL INITIAL ALTERNATIVES

SOUTHWEST GROUNDWATER
REVERSE OSMOSIS BY-PRODUCT DISPOSAL OPTIONS

Alternative I.3
Zone B Discharge to Tailings Pipeline
Lost Use Distillation

Alt. No.	Disposal Alternative	Project Yield (AF/yr)	Pipeline Material	Pipeline Actual Inside Diameter (Inches)	Zone A Yield (AF/yr)	Zone B Yield (AF/yr)	Zone B Production Rate (cfs)	Lost Use Yield (AF/yr)	Lost Use Production Rate (cfs)	Future Shallow Wells Yield (AF/yr)	Future Shallow Wells Production Rate (cfs)
I.3 ZB	Zone B to Tailings Pipeline Lost Use Distillation	3500	PVC C-909	8.29	0	3500	5.35	0	0	0	0
I.3 LU	Distillation & Totals	9300	PVC C-909	0	3500	0	0	2300	3.51	0	0

By-product Flow Rate (cfs)	Number of Pipelines (#)	Pressure Rating (psi)	Pipeline Hazen Williams C-factor	Pipeline in Roadways Length (ft)	Roadway Pipeline Unit Cost ($/ft)	Pipeline In Open Field Length (ft)	Open Pipeline Unit Cost ($/ft)	Total Pipeline Length (ft)	Total Pipeline Length (miles)	Dewatering Length (ft)	Dewatering Unit Cost ($/ft)
1.23	1	200	120	38,544	39.90	10,850	18.65	49,394	9.35	1,850	2.00
0.51	1	200	0	0	0.00	0	0.00	0	0.00	0	2.00

Pipeline Boring & Additional Costs ($)	Easement Length Required (ft)	Easement Cost ($)	Total Pipeline Cost ($mill)	Velocity (ft/sec)	Detention Time OK? (hrs)	Max Head Loss between Pump Stations (ft)	Max Distance between Pump Stations (ft)	Max Distance between Pump Stations (miles)	Calculated Number of Pump Stations (ft)	Actual Number of Pump Stations (ft)	Total Pump Station Cost ($mill)
0.000	0.000	0.000	1.744	3.29	4.2	416	69,018	13.1	0.7	2	1.000
0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	415.80	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!

Total Const Cost ($mill)	Eng Cost ($mill)	20% Contingency ($mill)	**Total Capital Cost ($mill)**	Discharge Hydraulic Gradeline (ft)	Static Pump Lift (ft)	Head Loss (ft)	Total Pump Lift (ft)	Pump Size (HP)	**Annual Pumping Cost ($)**	**NPV of Pumping Costs ($mill)**	**Total NPV Cost ($mill)**
2.744	0.412	0.947	**4.102**	5,385	903	298	1,201	220	**71,929**	**1.424**	**5.526**
#DIV/0!	#DIV/0!	#DIV/0!	**14.502**	4,215	-267	#DIV/0!	#DIV/0!	#DIV/0!	**1,171,929**	**23.196**	**37.698**

N.15 Water Cost Methodologies

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

MEMO No.:	15
SUBJECT:	**Project Costs and Impact to JVWCD Water Rates-** Zone B Lost Use Reverse Osmosis By-Product Disposal Alternatives Southwest Jordan Valley Groundwater Remediation Project Stakeholders Forum
TO:	Mark Atencio and Stakeholder Forum Members
COPIES:	David Ovard, JVWCD Paula Doughty, KUCC Douglas Bacon, UDEQ
FROM:	Richard Bay, JVWCD
DATE:	April 13, 2004

EXECUTIVE SUMMARY

The cost of service basis for JVWCD setting its wholesale water rates are explained in this memo. JVWCD is a public agency, and no profit is involved in recovering its costs through water rates. Important criteria for determining additional JVWCD funding participation in by-product disposal alternatives include:

- Maintain a reasonable annual unit cost of treated water
- Avoid adversely impacting JVWCD's ten-year financial plan
- Avoid displacing the discounted price for Zone A delivered water

As a result, guidelines for JVWCD include additional capital contributions not exceeding $3.3 million, and the overall unit cost of treated water not exceeding $210/AF.

BACKGROUND:

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

Component	**Flow Rate**	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,240**	**38 - 47**

PURPOSE

This technical memo provides information on revenues requirements and water rates of JVWCD. It also provides analysis for JVWCD cost participation in the Southwest Groundwater Treatment/remediation Project and impacts to the JVWCD rate structure for various levels of cost participation.

CREDENTIALS, EXPERTISE AND EXPERIENCE OF AUTHOR

I am a registered professional engineer with in Utah. I have a BS degree in civil engineering from the University of Utah. I am employed at the JVWCD as Assistant General Manager and Chief Engineer.

I have been involved in pursuing a southwest groundwater extraction and treatment project since 1990, and co-authored the Joint Proposal submitted by JVWCD and KUCC to the State NRD Trustee. I participate in rate setting studies, presentations to the JVWCD Board of Trustees, and discussions with JVWCD member agencies, regarding water rates.

JVWCD WHOLESALE AND RETAIL WATER DELIVERIES

The Jordan Valley Water Conservancy District (JVWCD) is a public agency. It was created in 1951 under the enabling legislation known as the Utah Water Conservancy Act.

JVWCD delivers water on a wholesale basis to 19 member agencies. JVWCD also provides retail water deliveries in distribution systems to approximately 8,000 connections and accounts. JVWCD delivers approximately 85% of its deliveries to its wholesale member agencies, and 15% to its retail customers.

JVWCD REVENUES

JVWCD receives most of its revenues from wholesale and retail water rates. During the current JVWCD fiscal year July 01, 2003 through Jun 30, 2004, JVWCD revenues are projected to be:

Water Rates - 71%

Taxes – 23%

Other - 6%

JVWCD WHOLESALE WATER RATES

JVWCD delivers water to its whole member agencies under water purchase contracts. These contracts specify that the wholesale water rate for each agency will be established under the conceptual framework known as the American Water Works Association Base – Extra Capacity method. In this method, base costs for water supply and deliveries are shared prorata by all member agencies. Extra capacity cost components are calculated for peak day demand patterns and flow rates, peak hour demand patterns and flow rates, pumping charges, and flat meter charges. Therefore, each member agency has a different water rate, based upon its demand patterns and its pumping pressure zone.

For its fiscal year 2003 – 2004, the JVWCD Board of Trustees established a seasonal water conservation rate component to its wholesale water rates. In this conservation rate, summer period and winter period water rates are offset by 25%, with the summer period water rates being at the higher cost. This is to encourage water conservation efforts in outdoor water uses.

JVWCD retail water rates are calculated on the same basis as wholesale water rates. Specific distribution costs for storage, piping, and other costs, are then allocated to the retail water rate.

For its fiscal year 2003 – 2004, the weighted average JVWCD wholesale (non pumped) water rate is $315.55 per acre foot (AF).

JVWCD maintains a ten-year rolling financial plan. This financial plan anticipates future capital expenditures, operation and maintenance costs, growth in water demands, and cost changes in other cost components. As a result, the current ten-year financial plan anticipates gradual water rate increases of 5% annually during the first five years, and 6% annual increases thereafter.

JVWCD WATER RATE COMPONENTS

Since JVWCD is a public agency, there is no profit involved in JVWCD water rates. Many cost components make up the total revenues to recover JVWCD costs of operation.

These include operation and maintenance expenses, personnel and administrative expenses, compliance and water conservation efforts, debt service and capital improvement funds.

A study of JVWCD costs and water rates during 2003 identified the "unbundled components" of the JVWCD water rates. The unbundled components are as follows:

- Water Supply
- Water Treatment
- Transmission
- Distribution
- Storage
- Capital
- Conservation
- Other

The cost components that correspond to water produced through the southwest groundwater remediation and treatment project are water supply and water treatment. The cost component for water supply and treatment in the JVWCD 2003 – 2004 fiscal year are as follows:

Groundwater and streams -	$63.22 per AF
Treated surface water -	$178.29 per AF
Weighted average -	$149.55 per AF

JVWCD COST PARTICIPATION IN THE SOUTHWEST GROUNDWATER TREATMENT PROJECT

JVWCD views its participation in the southwest groundwater treatment project as a means of providing a public water supply to its member agencies. It also considers its participation as a service to its member agencies in facilitating the containment and remediation of extensive groundwater contamination that could otherwise impact its member agencies' wells.

The Joint Proposal provides for project funding by JVWCD and Kennecott Utah Copper Corporation (KUCC), in addition to the Trust Fund. The following table shows the proposed net present value funding, expressed in September 2003 dollars.

Project Funding [a] (Millions)

Project Components	ILC(b)	Lost Use	KUCC	JVWCD	TOTALS
Zone A	$24.05	$0	$14.80	$5.90	$44.75
Zone B	$24.05	$0	$4.50	$11.10	$39.65
Lost Use	$0	13.2[c]	$0	$6.30	20.0
TOTALS	$48.1	$13.2	$19.3	$23.3	$103.9

(a) In October 2002 dollars. Includes both construction and O,M&R cost NPV for 40 years.
(b) Irrevocable letter of credit (September 2003 value).
(c) $0.7 million to UDEQ for Trustee expenses.

As shown above, the proposed JVWCD project funding has a net present value of $23.3 million. The JVWCD cost participation involves both capital funds and operation, maintenance and replacement (O,M&R) funds over the 40-year project life.

Table 9.0 in the Joint Proposal provides details on the capital and O,M&R costs of JVWCD, KUCC and the Trust Fund. The estimated breakdown of JVWCD capital cost participation is:

- Capital $7.9 million
- O,M&R (40 years) – $15.4 million
- **Total** **$23.3 million**

JVWCD calculated its overall costs of participation in the Joint Proposal project in 2003. Its overall cost was calculated as $175 per AF, expressed in September 2003 dollars. The Joint Proposal provides for JVWCD to discount the water rate it will charge for Zone A water to provide the full "subsidy" offered by the Trust Fund.

The portion of project capital of which is currently under consideration by the Stakeholder Forum is the discharge or disposal of reverse osmosis (RO) by-product water. In the Joint Proposal, the net present value of costs to JVWCD for RO by-product disposal is $6.7 million. Of this amount, $6.4 million is the capital cost.

FACTORS IMPORTANT IN DETERMINING JVWCD'S LEVEL OF FUNDING BY-PRODUCT ALTERNATIVE

1. It is important that JVWCD maintain a unit cost for delivered municipal water under the project within a reasonable proximity to its current cost components for water supply and treatment. Many public and private officials have submitted comments that JVWCD should not shoulder the burden of groundwater cleanup, since it is not a responsible party. Instead, the mission of JVWCD, as a public agency, is to provide the public with municipal quality water.

2. Additional capital requirements for a by-product disposal alternative must not adversely impact JVWCD's ten-year financial plan.

3. Additional capital requirements should not displace the discount for Zone A water to the Affected Municipalities.

GUIDELINES FOR JVWCD FUNDING

Factor 1 Unit Cost of Water Is Reasonable

The maximum unit cost that I am prepared to recommend to the JVWCD Board of Trustees is $210 per AF. This exceeds other pertinent thresholds by the following amounts:

a.	Joint Proposal Unit Cost ($178/AF) -	20%
b.	Average water supply and treatment unit cost (178.29/AF) _	17%
c.	Average finished water unit cost (149.55/AF)	40%

This maximum unit cost for the overall JVWCD participation in the southwest groundwater treatment project corresponds to a maximum net present value cost for RO by-product disposal/discharge of $8.3 million.

Factor 2 Additional capital does not adversely impact 10 year financial plan.

In considering this factor, the additional capital requirement of any alternative which exceeds the original program capital of $6.4 million will be examined. The important issue is to determine whether the generation of capital funds during the first ten years will adversely impact the District's 10 year financial plan.

In performing this evaluation, the following assumptions are made:

- The capital can be spread relatively evenly over ten years, during construction and through the blending of generated capital reserves with bond issues.
- One third of the additional capital will be funded through capital reserves generated from water rates during the first ten years.
- For the other two thirds of capital, assume that capital will result from bond issues with repayment at 5% interest over 20 years.
- 80,000 AF per year of total JVWCD deliveries are made
- The average JVWCD wholesale water rate is $315 .55 per AF.

For the above assumptions, each $1.0 million of excess capital will have an impact of $1.15 per AF. This will create a 0.36% increase each year to the wholesale water rate.

I am not prepared to recommend greater than a 1.0% increase in impact to wholesale water rates over the first ten years, since this would be in addition to the 5% - 6% annual increases projected in the District's ten year financial plan. This limit would correspond to an additional capital contribution by JVWCD of $3 million.

Factor 3 Additional Capital Does Not Displace the Zone A Rate Discount

The Joint Proposal includes a formula for discounting the wholesale water rate for Zone A treated water delivered to the four Affected Municipalities. Table 11.0.B in the Joint Proposal sets forth this discount formula. The formula removes average raw water supply and treatment components from JVWCD's water rate methodology, and replaces them with amortized capital contributions from JVWCD in the actual project.

An application of the Zone A price discount formula results in a 2004 wholesale rate of $288.10 per AF. This is for water delivered in Pressure Zone D. The comparable wholesale water rates for the current fiscal year to West Jordan City, South Jordan City and Herriman City, with an additional pump lift (assumed as $20.00 per AF) added to reflect Pressure Zone D deliveries, are shown below:

Herriman City	$355.46/AF
South Jordan City	$331.05/AF
West Jordan City	$359.68/AF
Average	**$348.73/AF**

The formula for discounting the Zone B wholesale price in 2004 would result in a discount of $60.63/AF, or a 17.4% discount. Additional capital contributions required from JVWCD would have the effect of decreasing the discounted price. Each $1.0 million additional capital contribution would result in an increase of $9.38/AF during fiscal year 2003 – 2004. Expressed a different way, an additional capital requirement of $6.5 million would totally eliminate the Zone A price discount.

As a result of the above analysis, I would not recommend additional capital requirements substantially approaching $6.5 million. This is because of the reliance the four Affected Municipalities have made on the discounted price for Zone A water.

N.16 Discharge of Zone B By-product to KUC Facilities Perpetually

Kennecott
Utah Copper

Memorandum

SUBJECT: Evaluation of Alternatives for Disposal of Zone B Reverse Osmosis Byproduct to KUCC Facilities

TO: Mark Atencio and Stakeholders' Forum Members

COPIES: Richard Bay, JVWCD
Douglas Bacon, UDEQ

FROM: Paula Doughty, KUCC
Director, Environmental Affairs

DATE: April 13, 2004

BACKGROUND

Mining and other activities in the southwestern Salt Lake Valley have created groundwater contamination with elevated sulfate concentrations. Under the federal Superfund Law, the State of Utah, through a designated Trustee, brought an action against Kennecott Utah Copper Corporation (KUCC) for injuries to groundwater in the area. The Trustee's claims were resolved in a 1995 Consent Decree approved by the Federal District Court for Utah. The Consent Decree established a Trust Fund to be used to restore, replace or acquire the equivalent of the injured groundwater.

In accordance with the terms of the Consent Decree, the Jordan Valley Water Conservancy District (JVWCD) and KUCC have submitted a Joint Proposal to develop and construct a groundwater extraction and treatment project with groundwater remedial functions that will provide treated, municipal quality water to the public in the southwestern Jordan Valley. KUCC and JVWCD are asking the Trustee to fund a portion of the Joint Proposal from the Trust Fund established under the Consent Decree. The Joint Proposal involves one reverse osmosis (RO) treatment plant constructed, owned and operated by KUCC to treat mining contaminated Zone A deep groundwater (the Zone A Plant), and one RO plant constructed, owned and operated by JVWCD to treat mining contaminated Zone B deep groundwater (the Zone B Facilities) and shallow agricultural contaminated groundwater (the Lost Use Facilities). The Trustee held a public information and public comment period on the Joint Proposal during September through November 2003.

As a result of comments, JVWCD withdrew its Zone B/Lost Use RO byproduct water discharge permit to the Jordan River and renewed efforts to find an alternative disposal location for byproduct waters to be produced from its treatment process. The Trustee established a Stakeholders' Forum for groundwater remediation issues in early 2004. JVWCD is seeking input from the Stakeholders' Forum as it considers various alternatives for disposal of Zone B/Lost Use RO byproduct water.

Zone B/Lost Use byproduct water is projected to have the following characteristics among others:

	Flow Rate	TDS Concentration	Selenium Concentration
	(cfs)	(mg/L)	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	1.75		
Weighted Average		8,270	32

PURPOSE

JVWCD has asked KUCC to provide information regarding the following three evaluation criteria established by the Stakeholders' Forum to facilitate review of the Zone B/Lost Use byproduct disposal alternatives that involve KUCC facilities:

- Allow Organizations to Meet Objectives
- Allow for Perpetual Water Treatment
- Environmentally Sound

In response to that request, this Technical Memorandum reviews each of the stated criteria for each of three alternatives that involve utilization of some aspect of KUCC operational facilities. This Technical Memorandum is based on information that is presently available to KUCC.

EXECUTIVE SUMMARY

As described in the Joint Proposal, if JVWCD elects to deliver to KUCC the byproduct stream from the Zone B Facilities, KUCC has committed to accept such byproduct stream into its water management system for the forty-year operational period described in the Consent Decree. The byproduct from the Zone B Facilities will be chemically similar to the byproduct from the Zone A Plant that will be owned and operated by KUCC.

Contaminants in the shallow groundwater aquifer (Lost Use water source) are not related to historic mining operations. Additionally, at JVWCD's request KUCC has evaluated the chemistry of the Lost Use byproduct. The byproduct stream from the treatment of water pumped from the shallow aquifer is different from the deep groundwater that will be treated in the Zone A and Zone B facilities. Test work indicates that even in very small quantities organics similar to those found in the Lost Use byproduct stream could adversely affect KUCC operations. Under the Joint Proposal, JVWCD is responsible for the Lost Use byproduct stream.

Each alternative presents operational and other issues and uncertainties for KUCC, some of which KUCC will undertake with appropriate safeguards or limitations. As stated in the Joint Proposal, KUCC will undertake many of the issues and uncertainties associated with disposal of Zone B byproduct streams for the forty-year operational period. It is not possible to take the Lost Use byproduct stream into KUCC's water management system. However, assuming appropriate safeguards and following management review and approval, KUCC may be willing to undertake the issues and uncertainties associated with JVWCD's disposal of Lost Use byproduct streams under a separate UPDES permit that utilizes KUCC's Outfall Pipeline for the forty-year operational period. The issues and uncertainties with commitments associated with byproduct disposal extending beyond forty years cannot be undertaken at this time.

KUCC'S WATER MANAGEMENT SYSTEM

KUCC operates a slurry pipeline for transporting tailings (Tailings Slurry Pipeline) from the Copperton Concentrator to a tailings disposal impoundment (Tailings Impoundment) located adjacent to the Great Salt Lake. Water is recycled from the Tailings Impoundment back to the Copperton Concentrator. Any excess water that accumulates seasonally at the Tailings Impoundment is discharged, under a UPDES permit, to the Great Salt Lake via KUCC's pipeline (Outfall Pipeline).

ALTERNATIVES FOR RECEIVING ZONE B BYPRODUCTS

In the discussions by the Stakeholders' Forum, several options are being evaluated for discharge of Zone B byproduct stream into KUCC's water management system. Possible discharge points include:

1) The Tailings Slurry Pipeline at approximately 7800 South,
2) The Tailings Impoundment near 2100 South, or
3) Directly into KUCC's Outfall Pipeline to the Great Salt Lake (bypassing the Tailings Impoundment and process water recycling circuit).

Under the first two alternatives, the Zone B byproducts are handled within KUCC's system. The management of RO byproduct in the Tailings Impoundment was specifically contemplated during development of KUCC's UPDES permit and the South End Groundwater Record of Decision (ROD) issued by EPA, and is believed by KUCC to be covered by the terms and conditions in the existing UPDES permit. The Division of Water Quality (DWQ) is specifically reviewing this assessment. These two alternatives, which entail Zone B byproduct reporting to the Tailings Impoundment at different locations, are addressed collectively below.

Under the third alternative, KUCC would retain its UPDES permit, and JVWCD would obtain a separate UPDES permit for both Zone B and Lost Use byproduct waters. Both permits would discharge from KUCC's Outfall Pipeline.

DISCHARGES REPORTING TO THE TAILINGS IMPOUNDMENT

1. Impact on KUCC's Operational Objectives:

Preliminary assessments indicate that the Zone B byproduct can be handled in KUCC's Tailings Slurry Pipeline and Tailings Impoundment. As a result, and assuming appropriate safeguards, KUCC has indicated it will bear the additional cost of managing the Zone B byproducts and handle those byproducts within its system for the forty-year operational period.

Following mine closure, it is anticipated that the Tailings Slurry Pipeline and Tailings Impoundment would continue to operate for a period of time to address KUCC's ongoing water management needs. However, following closure, the Tailings Impoundment would not be available for disposal of JVWCD treatment byproduct. As described in the Joint Proposal, KUCC and JVWCD anticipate that after impoundment closure, the Zone A byproducts and Zone B byproducts (if delivered to KUCC) would be discharged to the Great Salt Lake (as contemplated by the ROD) or into an alternative system, either of which may utilize all or part of the existing Tailings Slurry Pipeline.

2. Environmental Soundness:

KUCC has discussed the impact of introducing the Zone B byproducts into its water management system with the DWQ to assure that the impact will not adversely affect KUCC's UPDES permit. KUCC believes that the Zone B byproducts will have minimal adverse affect on the material delivered to the Tailings Impoundment or the limits established by the UPDES permit. Since the KUCC permit was drafted anticipating disposal of treatment byproduct into the Tailings Impoundment, KUCC does not expect the discharge of the Zone B byproducts to the impoundment to impact KUCC's discharge of excess water to the Great Salt Lake under its existing UPDES permit.

3. Perpetual Water Treatment:

The Consent Decree outlines the terms under which KUCC and others may utilize the Trust Fund for projects such as the one KUCC and JVWCD have proposed. One requirement is that the municipal quality water to be delivered must be a sustainable water supply of 40 years or more. As a result of this provision, the Joint Proposal outlines a forty-year project. KUCC and JVWCD have used the costs associated with a forty-year project to assess the feasibility of the project and obtain management approval. The terms and conditions for the period after the forty years would need to be negotiated in the future.

It is projected that the vast majority of the Zone B mining contaminated groundwater will be remediated within the forty-year operational period for the Zone B Facilities. The uncertainties (costs, permits, operations) associated with perpetual management of JVWCD treatment byproducts are beyond the scope of the NRD project and cannot be undertaken at this time. For this reason, KUCC requires that the terms of an arrangement after the initial forty years be left open for future negotiation.

DISCHARGE AT THE OUTFALL PIPELINE COMMINGLED WITH KUCC DISCHARGE TO THE GSL

1. Impact on KUCC's Operational Objectives:

This alternative introduces Zone B and Lost Use byproduct into KUCC's water management system at the last point in the system before KUCC discharges into the Great Salt Lake under its UPDES permit. Due to the location in the system and the separate permit JVWCD proposes to obtain, at this time little adverse impact on KUCC's operations is anticipated. KUCC's discharge in the Outfall Pipeline will be discontinued from time to time, and will change over time as mining operations cease.

KUCC's assessment is based on the condition that JVWCD's discharge is limited to the byproducts generated by the Zone B Facilities and Lost Use Facilities outlined in the Joint Proposal. Expansion plans that JVWCD has for its RO plant present uncertainties that are difficult to assess at this time.

2. Environmental Soundness:

Under this alternative, JVWCD would obtain a separate UPDES discharge permit for the Zone B and/or Lost Use byproducts. KUCC will maintain its current permit to discharge to the GSL during mining operations and undertake permitting for the post-mining operation. Each entity would conduct compliance sampling upstream of the co-mingling point. Uncertainties in the permitting environment exist over the forty-year period, and as such, KUCC must assure that its operations and use of the Outfall Pipeline are not adversely affected if JVWCD discharges at this point.

3. Perpetual Water Treatment:

See discussion under Discharges Reporting to the Tailings Impoundment above. KUCC's operation of the Outfall Pipeline beyond the forty-year remediation project is uncertain; however, the possibility of continued use or operation by JVWCD could be negotiated at a future time.

N.18 Selenium Removal Treatment

carollo engineers

TECHNICAL MEMORANDUM

MEMO No: 18

SUBJECT: Evaluation of Disposal of Reverse Osmosis By-product
Biological Treatment for Selenium Removal

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Bryant Bench

DATE: April 13, 2004

EXECUTIVE SUMMARY

The concentrated selenium in the reverse osmosis (RO) by-product water might effectively be removed utilizing biological treatment technologies. However, given the unique characteristics of the by-product water, there are significant concerns and challenges which must be investigated to determine if the biological process is truly viable, cost effective, and reliable. Additional treatability studies, pilot investigations, and preliminary engineering evaluations are necessary to assess biological treatment process performance, reactor contact time, flushing frequency, biomass recovery time, flushing water treatment and sludge disposal methods, and scaling potential within the bioreactors. Potential for scaling is of greatest interest as it could adversely impact the cultured biomass and selenium removals.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund, which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one RO treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe selenium treatment of the RO by-product water using a metal specific biological treatment technology and to present the potential benefits and challenges of implementing this new and emerging technology.

AUTHOR'S CREDENTIALS

Bryant Bench is a registered Professional Engineer specializing in the area of water treatment process selection and facility design. Mr. Bench holds a Bachelors degree in Civil Engineering and a Masters degree in Environmental Engineering. For the past 25 years, Mr. Bench has been working as a consulting engineer for public and private water utilities involved in the planning, design, and construction of public water

treatment plants. He has provided engineering services for most of the major water treatment plants located in the Salt Lake Valley and along the Wasatch front. Mr. Bench has engineered advanced treatment technologies for water treatment including high-rate conventional treatment, managed filtration, ozonation, ultraviolet light (UV) disinfection, and reverse osmosis and other membrane separation processes.

BIOLOGICAL SELENIUM REMOVAL

Common practices for removing selenium from contaminated ground or surface waters have typically consisted of conventional chemical addition for precipitation or adsorption of the selenium followed by separation through gravity or other clarification means. Biological treatment for metals removal is an emerging technology for treating mine waste and similar waste discharges in Utah and other locations across the country. One such biological process is called the ABMet™ Water Treatment System as developed by Applied Biosciences Corporation located right here in Salt Lake City. This process utilizes microbes, cultured in bioreactor beds that create a ion-reducing environment for selenium removal. The bioreactors are typically sized to provide 2 to 12 hours of detention time depending on specific treatment requirements. The bioreactors are filled with granular activated carbon (GAC) which provides an abundant surface area for the biomass to flourish and grow. The microbes are kept alive and happy by feeding them a biodegradable nutrient blend, which contains molasses. The unique features of GAC is that this material contains significant cracks and crevices within its sphere for biological activity to occur. As the biomass develops, the beds become covered with a biofilm. The effect of the biomass and the microbial conditions within the bed create a reduced environment, which converts the selenate or selenite ions into its more elementary selenium form. In this state, the metal precipitates as a solid and is enmeshed and attached to the biofilm within the reactor. Over time, usually weeks or months, the reactors are flushed to remove the captured waste material. This waste stream is then treated by dewatering the solids and disposing of the high-concentration, selenium sludge.

This biological process has been pilot studied on mine drainage wastes at the Kenecott mine. Full-scale plants have recently been installed out of state. In most applications, the ABMet™ Water Treatment System has demonstrated selenium removals to below 2 micrograms per liter or parts per billion (µg/L). Current application for this biological metal removal is for treating acid mine drainage, surface mine waste streams, and industrial wastewaters.

APPLICATION POSSIBILITIES AND CONCERNS

Discussions with Applied Biosciences representatives about the application of the ABMet™ Water Treatment System for removing selenium from the RO by-product water yielded a number of potential advantages for this type of process:

1. Could potentially remove selenium to below 2 µg/L.

2. Process uses a biodegradable nutrient to maintain biomass. Other conventional processes require use of iron-based chemicals.

3. The biological process produces less sludge than the conventional chemical precipitation processes.

4. The biological process facility and operations costs could potentially be less than other selenium treatment technologies.

As discussed above, most applications for biological selenium removal have been implemented for acid mine drainage and other metal-laden waste streams. Although similar in concept, the RO by-product water has different chemical and physical characteristics than typical mine drainage. Potential concerns and challenges were also identified in applying this process for treating the by-product water. These concerns include the following:

1. There is a significant mineral scaling potential of the concentrated by-product water which could adversely impact biomass growth and performance within the reactors.

2. Biological processes are by nature tempermental. The biomass must be properly cultured and controlled.

3. Bioreactor tanks or chambers must be sized to provide 2 to 12 hours of contact time. The process might work in the two-hour time range, but this would have to be demonstrated.

4. Waste, flushed from the reactor, contains very high concentrations of selenium. As such, the waste has limited options for ultimate disposal. In addition, water used for flushing must be separated from the sludge. That requires properly designed dewatering equipment.

5. Once the reactors are flushed, there is a recovery time before the biomass returns to equilibrium and maximum selenium removal. This recovery time would need to be tested and evaluated as a result of each flushing sequence.

One significant challenge listed is that of mineral scale formation. As described previously in another Stakeholder Forum memo, the by-product water has tremendous scaling potential due high concentrations of calcium sulfate and carbonate ions. Upon scaling, the precipitate attaches itself or "plates-out" on a material surface. In the case of a concentrate pipeline, the surface is the pipewall located around the internal circumference of the pipe. In the case of the bioreactor, the available scaling or plating surface is the GAC material, which offers a tremendous area for scale to form. The GAC

surface not only promotes biofilms growth, but is also an excellent environment for scale to occur. It is not known how effective the scale inhibitor, utilized as part of the RO process, would be in preventing scale under these untested conditions. It is also unknown what impacts scaling would exhibit upon biomass production and performance in reducing selenium. Scaling of the reactor and GAC media could cause the biological selenium treatment process to fail.

ADDITIONAL STUDIES

Biological removal of selenium from the RO by-product water using the ABMet™ Water Treatment System appears to be a potential treatment approach. However, additional studies must be conducted to demonstrate the viability of such treatment and to answer the concerns described in this memorandum. Pilot and engineering studies would need to be conducted investigating the following parameters specific to the unique water quality characteristics of the RO by-product stream:

- Selenium removal capability.
- Mineral scale potential and methods for controlling scaling within the bioreactor.
- Determine contact time within the bioreactor.
- Determine the frequency for bioreactor flushing and the microbial recovery time.
- Acceptable sludge dewatering and selenium disposal methods
- Develop preliminary capital and operating costs for implementing the biological treatment system.

N.19 Deep Aquifer Hydrogeology

Jordan Valley Water Conservancy District

TECHNICAL MEMORANDUM

SUBJECT: Deep Aquifer Hydrogeologic Issues
Alternative C - Deep Well Injection

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
Paula Doughty, KUCC
Douglas Bacon, UDEQ

FROM: Bruce N. Kaliser

DATE: April 13, 2004

BACKGROUND

Mining activities in southwestern Salt lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

AUTHOR'S CREDENTIALS

Mr. Kaliser is a registered professional geologist and has practiced hydrogeology since 1964, including 22 years as a senior geologist with the State of Utah, Geological Survey.

DEEP AQUIFER HYDROGEOLOGIC ISSUES

(1) Unknown deep geologic and hydrogeologic environment. Only one single boring has penetrated the Salt Lake Valley to the depth of 5,000. No other borings come even close to reaching this depth.

(2) Twelve months of investigation for determining the hydrogeology of the Oquirrh Formation, a Paleozoic bedrock aquifer, has led to our comprehension of the Principal Aquifer and its upward hydraulic gradient throughout the Valley. Fluid injected at depth will sooner or later migrate to shallower depths to discharge naturally or through wells.

(3) The complexity of faulting is significant. In addition to the border faults of the Wasatch, Oquirrh and Traverse Mountain systems, there is the Great Salt Lake, mid-valley and southern extension to Point of the Mountain, which affords higher transmissivity and hydraulic conductivity of deeper occurrences groundwater.

(4) The potential is clearly possible for transverse, east-west, faulting in the Valley. This fact further serves to complicate the hydrogeologic scenario.

(5) The distribution, profile and conformity of Tertiary through Palezoic formations is far from understood in the geologic section below the Quatermary Valley Fill sediments.

(6) Water Quality within each formation is anything but uniform. Drinking water quality can extend to great depth.

(7) Induced seismicity cannot be ruled out as a consequence of deep well injection.

(8) Introduction of an antiscaling solution will be required to prevent casing scaling. The byproduct, $CaSO_4$ would be precipitated interstitially in the deep aquifer.

(9) The geothermal gradient varies significantly from place to place in the Valley. This becomes important when injecting fluid at 5,000 foot depths.

(10) Cost required to adequately explore the deeper hydrogeologic environment would likely be prohibitive. Without such exploration, the risks would far exceed what is prudent. With present demands for such knowledge, the resources of the federal, state and local governments has been no where near adequate to explore even one of the above listed phenomena.