Oquirrh Mountains Mining and the Environment

Eva J. Hoffman
U. S. Environmental Protection Agency, Region 8
999 18th Street #300
Denver, CO 80202

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SCIENCE AND HISTORY

The Environmental Protection Agency is not particularly well-known for its efforts in historical research. With the advent of dating and aging technologies, such as C-14 dating, historians have begun to rely on scientists to unravel historical mysteries. The reverse is also true. Chemists might find an unexpected deposit of minerals and local historians can often explain what was going on at a location over time. This interface between science and history does occasionally become important, benefitting both disciplines in unexpected ways.

Such is the case with the Kennecott Sites environmental cleanups. When the Environmental Protection Agency and the State of Utah discovered that mining wastes had washed all the way from the nearby mountains down into the Jordan River Valley floodplain, it became obvious that the wastes had been there for a long period of time. What was formerly ranchlands were now suburbs. What had been remote at the time of early mining was up close and personal today. By necessity, environmental scientists from EPA, UDEQ, and Kennecott became amateur historians.

In addition to simple intellectual curiosity, the governmental agencies became interested in the history of the site for two major reasons. The first reason is that the Superfund statute allows the government to recover its cleanup costs from any party that released hazardous substances into the environment. This means that EPA and UDEQ needed to know who was doing mining in the mountains when the wastes were dumped into the creeks. In short, EPA needed to know who to negotiate with to get the cleanups done, or who to sue if the government paid for the cleanups. The term used for this activity is called Potentially Responsible Party (PRP) Searches. The PRP Searches determine which companies were doing what, do the companies exist today, and do they have the resources to help defray the costs of cleanup. The theory is rather simple - those who made a profit from the activity should also pay for the costs of cleaning up the messes they made in the process.

The second reason that EPA scientists become history enthusiasts is that a knowledge of where the historic facilities were, what processes they used, and what they did with their wastes could give sampling crews an idea of where to look for hazardous substances, which hazardous substances are likely to be found at each site and whether or not the wastes might have migrated (through air and water erosion) from their original location. With a knowledge of history, the scientists can pinpoint their investigations rather than look for a needle in a haystack. This can save significant financial resources in sampling and analysis costs.

KENNECOTT SITE BACKGROUND

Mineral deposits were discovered in Bingham Canyon as early as 1862, launching a history of mining in the area now spanning 130 years. Mining operations continue today with a scale not even imagined by early day miners. The operations at first were conducted by a number of small companies which operated mines and erected small mills and smelters for processing. Waste management practices were not high on the list of miner priorities. Now the Kennecott Corporation owns most of the land in the area, and has launched into a program of modernization and automation. Waste handling practices have been greatly improved.

EPA became involved at the site from it beginning as an agency in 1971. The early environmental dispute involved stack emissions at the smelter. EPA believed that Kennecott could reduce its emissions and Kennecott responded that the solution was a taller smokestack. Magna citizens also began to express concerns about the dust storms on the tailings pond. The disputes were loud and the angry words were covered by the local newspapers. The next area of interest of EPA was the treatment of smelter wastewater which was loaded with arsenic. Kennecott, state and EPA scientists formed a working group to examine different treatment technologies and strategies. The state and EPA (and some citizens) at this time (early 1980s) also expressed concern about potential groundwater contamination near the mine. Kennecott's initial response to this was denial that there was a groundwater problem.

Correspondence indicated a growing frustration - the dialogue continued but was not productive. In 1986, the State of Utah sued Kennecott alleging damages to natural resources of the state, namely, the groundwater near the mine. At the same time, EPA began collecting preliminary information to be used in listing the Kennecott properties on Superfund's National Priority List. Upon the discovery of high levels of lead in the yards of suburbs near Bingham Creek, the EPA Superfund forces were unleashed. In 1990, cleanups began using federal Superfund funding and serious negotiations began about the overall environmental cleanups needed.

From the beginning, Kennecott executives were not fond of the fact that Kennecott could become a full blown Superfund Site. Superfund responses came with unfortunate impacts to the industry and to the surrounding communities. They lobbied with their elected officials to avoid Superfund status, preferring instead to conduct the appropriate cleanups outside this process. EPA agreed to examine this idea. After all, cleanup of the site was the most important thing, not the particular process or statute used. Negotiations began in 1991 and fell apart in 1993. The main problems were that none of the parties knew exactly what was out there, what would have to be done to solve the problem, or how much it would cost. Upon the failure of the negotiations, in 1994, EPA proposed the Kennecott lands to be listed on the National Priorities List.

Yet Utah elected officials, Senator Orrin Hatch in particular, did not give up on this approach. The parties had come very close to agreement and the approach of cleanups without listing deserved another try. This time, in 1995, EPA officials and Kennecott executives agreed to try a non-binding informal agreement, avoiding the courts. The idea was that if ever the parties came to a severe disagreement, then the full power of the federal Superfund statute could be used. Otherwise, the cleanups would proceed based on negotiations after the problems were known and the alternatives evaluated. Only at the end would EPA, Utah, and Kennecott document their decisions for the court. The strategy was entirely different than was used by EPA at the time. The idea was a success. Cleanups continued. Citizen participation was incorporated. Communication was open and productive. Cleanups considered future land use. Now, this approach has received national recognition and is a regular option which can be used at other sites.

Other than a few demolition projects and the long term actions needed to address groundwater problems, in 2005, the cleanup work at the Kennecott Site has been completed, although all parties recognize that unexpected findings may be discovered in the future.

THIS DOCUMENT

Initially, the main purpose of this study was to document what we knew about the various facilities on Kennecott property to serve as an aid in designing sampling plans in each area. This information was then used in official site documents, some written by Kennecott and others by EPA. Later, it came to be used as a summary of the actions taken at the various locations so that future scientists and historians would understand what was done and why.

The compilation of this document began in 1993 and was updated as additional historic information was located. When the site was located and investigated, the findings were also added. Finally, the cleanup information was added as the final reports were received.

Please note that portions of the information presented in descriptions of these facilities are derived from secondary sources and have not been confirmed with the original source material. Sometimes even different primary sources contain conflicting information, but little effort was made to resolve the discrepancies unless critical to cleanup decisions. There is no reference list, but the original documents are available at the Superfund Records Center at the U. S. Environmental Protection Agency in Denver, Colorado.

Special thanks go to Kennecott's unofficial historian, Brian Vinton (of North American Mine Services), and the various Kennecott staffers and contractors who served as project managers for the cleanups. These include Preston Chiaro, Bart Van Dyken, Jon Callender, Fred Fox, Charlie Masson, Tom Nannini, Jon Cherry, Elaine Dorward King, Bill Adams, Kelly Payne, and Paula Doughty.

CHAPTER 2
MINING AND MILLING ON BINGHAM CREEK, THE ENVIRONMENTAL LEGACY

BINGHAM CREEK HISTORY (facility 110)

In 1848, one of the first settlers in West Jordan, the Bennions, established a farm and irrigated it with water from Bingham Creek "a clear flowing stream from the west mountains." [History of Jordan Area, Holt, 1989]. Bingham Canyon was originally wooded as evidenced by early settlers using Bingham Canyon wood for fencing and bark for tanning [Holt, 1989].

Bingham Creek flowed freely out of the Oquirrh Mountains until mining operations, beginning around 1863, dammed or diverted it for mineral extraction processes. As the town of Bingham grew around the mining camp, the creek was channeled and flumed. Many bridges and homes were erected over its course, along with mills/concentrators and mine waste dumps. It essentially became a seven mile long sewer, with outhouses perched on frames built immediately over the stream. The spring runoff supposedly flushed it out and the residents were said to rake it out yearly, but the drinking water of the town of Bingham was condemned regularly by the sanitation officers of Salt Lake County.

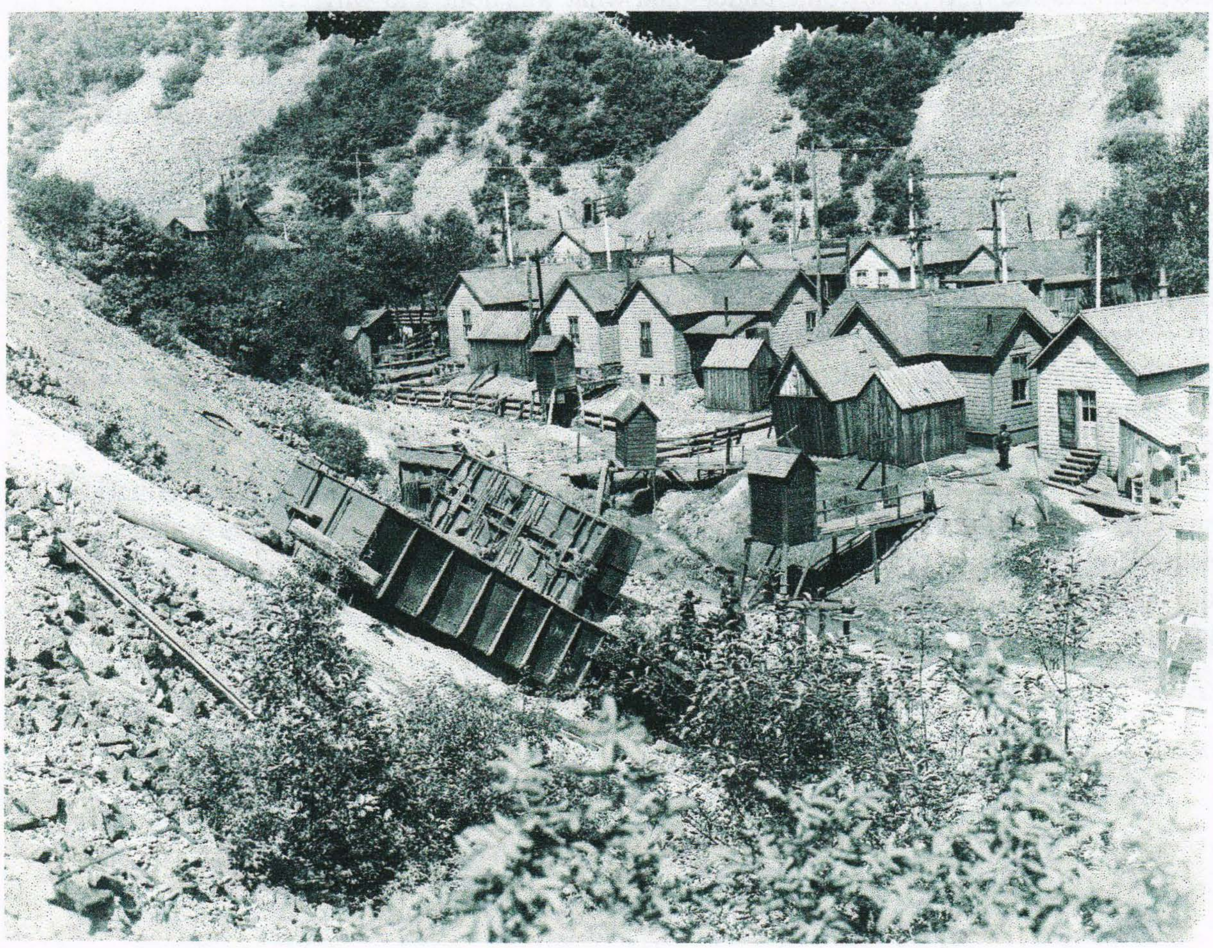

Figure 1: Outhouses perched over Bingham Creek in the settlements up Bingham Canyon

"Probably the only thing which saved Bingham from a series of epidemics of typhoid was the fact that the water of the creek was contaminated with mine water and mill waste which are usually highly acid and therefore antiseptic [Addy, 1949]. Another historian of the times (Jensen, LDS, 1899) said "...Formerly, its water was pure and good but since the opening of the mines, where the stream is monopolized for cleaning and other purposes, it has become filthy and poisonous." The garbage raked out of the creek by the early residents was hauled down the canyon to about a mile below the town of Bingham. In 1904, the health commission forbad any person from dumping in the creek. "It was to be used for sewerage and liquid wastes only" [Addy, 1949].

The 1885 Census reported "Below the place where the copper belt crosses the canyon, the water which runs or percolates along the bedrock contains a small percentage of blue and green vitriol in solution resulting from the oxidation of copper and iron pyrites. In placer mining fragments and nuggets of copper are found, especially in alluvial soil and among partially decayed twigs and roots where organic matter has precipitated it. So strongly is the water impregnated with this metal that picks and shovels immersed in it instantly become reddened from the deposit. No attempt has been made to save the very considerable quantity of copper daily running down the canyon."

The flow of Bingham Creek in 1909 was 7.4 MGD (with flow from the West Mountain Shaft which was used by the Utah Copper mill) down to 2.2 MGD without the additional flow from the shaft [Earl, 1929].

The stream flowed east, out of Bingham Canyon and into the Salt Lake Valley, terminating at the Jordan River, approximately 10 miles distant. At various points, it was diverted for irrigation purposes. Around 1900, copper leaching and precipitation operations began in the canyon. Full scale copper leaching and precipitation operations were started around 1923 by the Utah Copper Company. Water not used or recycled by the precipitation process continued to flow down the canyon.

A 1929 internal Utah Copper memo summarized what was known about water usage of the creek waters and pollution. He reported remembrance of old timers which stated that water from Bingham Creek was drinkable until 1904, but some waters especially in Muddy Gulch and Carr Fork were highly acid and not drinkable. In 1927, Utah Copper sampled the creed and found the Utah Delaware drainage was unsafe, and also Highland Boy. They expressed doubts that they would ever be able to catch all the copper running into the creek from their dumps.

Prior to 1936, the entire runoff from the Bingham Canyon watershed was discharged into the natural Bingham Creek drainage. Earlier floods had carried mine wastes out into farm fields, impairing or destroying their capacity for agriculture. They may have resulted in the purchase of the lands by the Utah Copper Company.

In 1936, the Utah Copper Company built evaporation ponds roughly six miles east of the mouth of Bingham Canyon at approximately 40th West and 110 South. A diversion structure was placed across the stream to divert flows to a canal for conveyance to the evaporation ponds. The evaporation ponds were built to handle the annual spring runoff and other flood events. The ponds were unlined, resulting in percolation of the wastewater and contamination of the local groundwater. After the placement of the diversion structure, stream flows below it occurred only occasionally.

The town of West Jordan was incorporated in 1941 and the first town election was held in 1949.

In 1965, Kennecott Copper Corporation constructed the Bingham Reservoir to impound water for the heap leaching process used at the Bingham Canyon Mines' vast waste dumps. Since that time, Bingham Creek has essentially ceased to flow with all of its waters being used in the copper mining processes of the Kennecott Copper Corporation and its successors. After the completion of the reservoir, the stream below it only flowed when the capacity of the reservoir was exceeded.

Sometime in the 1970s, land surrounding the Bingham Creek Channel in the City of West Jordan was subdivided and developed for residential use. In some cases, the natural drainage channel was altered to conform with subdivision planning and flood control. [SAIC, 1991]

Based on a study in 1990, Kennecott estimated that the channel of the creek contained about 3 million tons of tailings which exceed 500 ppm lead. [Kennecott, 1991],

BINGHAM CREEK CLEANUPS

During a preliminary investigation in 1990, the State of Utah (with funding from EPA) discovered that Bingham Creek was loaded with tailings and that these tailings had been transported down the creek all the way to the Jordan River. In addition, the tailings could be found all along the floodplain of the creek. Unfortunately, entire subdivisions of West Jordan had been built on the floodplain and now the yards, parks, playgrounds were all contaminated with mining wastes, mainly tailings. The particular health concern was the high lead and arsenic content of the tailings. The State of Utah invited the EPA Emergency Response Program to launch an immediate cleanup action. Characterization began in late 1990 and cleanup of the highest concentrations in the residential neighborhoods was completed by 1991. Kennecott Utah Copper, although denying that they had any responsibility for the contamination in the creek (saying "we've always mined copper, not lead"), agreed to build a repository on their land and to haul the contaminated soils and tailings excavated by EPA. An Administrative Order on Consent (AOC) documented the agreement. The cleanup involved excavation of at least 18 inches of the contaminated surface, replacement of the surface soils, and replacement of sod and landscaping. Residents were allowed to design their own landscaping.

After the very contaminated soils had been removed from the residential neighborhoods (mainly Jordan View Estates), EPA then focused its attention on the creek itself. Historic documents had led EPA to believe that there were two entities which operated in the Bingham Canyon at one time that still existed and should therefore participate in the cleanup of the creek. Negotiations began with these two parties, Kennecott Utah Copper (a successor to Utah Copper and Boston Consolidated) and ARCO (a successor to Anaconda and Utah Apex). Neither of these two parties agreed to cleanup the creek voluntarily, so EPA issued Unilateral Orders (UAOs) to them in 1993. When Kennecott and ARCO could not agree on the appropriate division of the work, EPA divided the creek into segments with Kennecott responsible for cleaning up half the segments and ARCO responsible for the other half. The order called for removal of the top 3 feet of contamination, or complete removal of the tailings, replacement with clean soils, and re-establishment of the channel and vegetation. The action level was about 2000 ppm lead, to reflect the industrial and open space land use.

Kennecott and ARCO completed sections of the Channel in residential areas of West Jordan and South Jordan in 1993. ARCO began working in the Channel on Kennecott property in 1994, while Kennecott worked on the Bingham Flats. Approximately 1,020,723 cubic yards

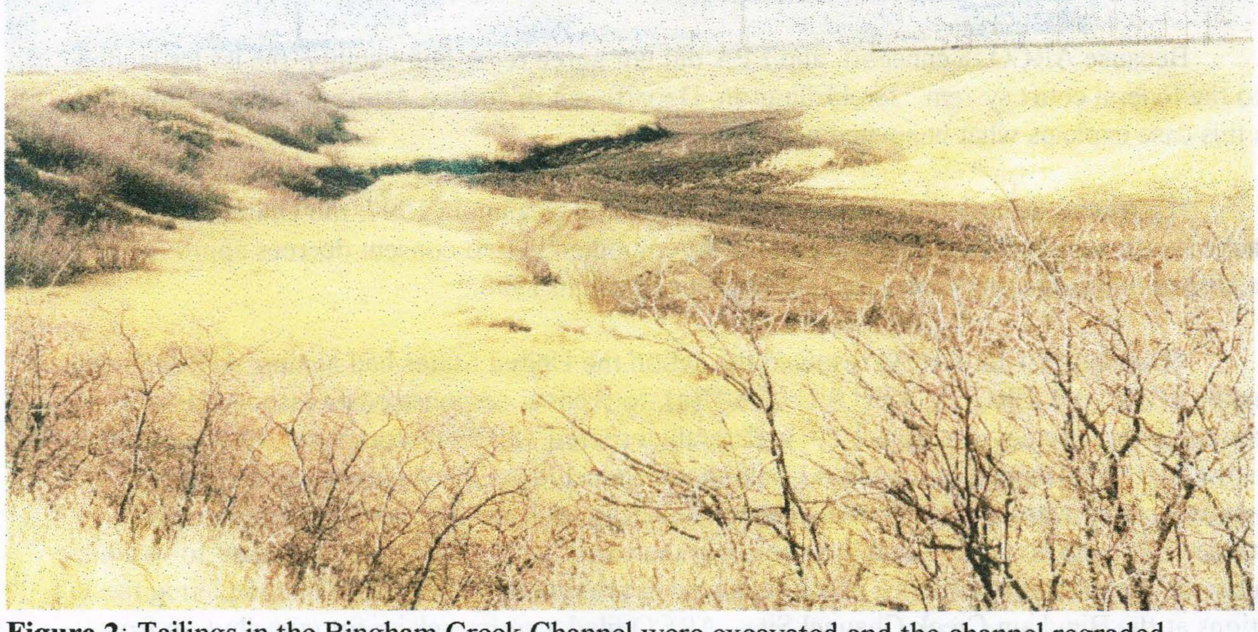

Figure 2: Tailings in the Bingham Creek Channel were excavated and the channel regraded.

of tailings/soil were removed. Steve Way is the OSC. The UAOs required either total removal of tailings from the channel or removal of the top 3 feet with capping back to grade. In general, Kennecott decided to remove all the tailings to avoid future maintenance costs, and ARCO removed the top 3 feet. Occasionally, maintenance was required to keep the remaining wastes covered.

While the channel work was ongoing, EPA began an Endangerment Assessment to determine what the final action level should be in the residential neighborhoods adjacent to the creek. In order to determine if the lead in the soils could be digested by children who put dirty hands into their mouths, EPA dosed Bingham Creek soils to juvenile swine as part of a national study of lead bioavailability. Luckily, Bingham Creek soils were relatively inert in comparison to other lead sites across the nation. In addition, gardeners along Bingham Creek donated vegetables from their gardens so that EPA could determine if home-grown vegetables were a significant source of lead exposure to the residents. This proved to be an insignificant exposure route. Finally, a local farmer provided wheat samples to EPA so that EPA could determine if it was safe to continue to use the farmland around the creek. Again, the wheat did not take up the lead to any health significance. After all the calculations were completed, EPA determined that the safe level for lead in Bingham Creek residential areas was 1100 - 1500 ppm lead. A workgroup of citizens preferred that the 1100 ppm lead level be used for the final cleanup. (The emergency cleanup had removed all the soils higher than 2500 ppm lead.) Since Kennecott had previously participated in the initial residential cleanups in 1991, EPA issued an Unilateral Administrative Order (UAO) to ARCO to complete the cleanup in the neighborhoods. Although indicating that they didn't believe they were liable for the contamination, ARCO nonetheless complied with the order. This final cleanup began in 1995 and was completed in 1997.

Because ARCO, Kennecott, and EPA did not agree regarding liability, the issues landed into the federal court system. Jerel Ellington, Department of Justice Attorney representing EPA on this case explains what happened next.

"Following completion of the Phase 3 residential cleanup in 1997, the United States reached settlements with ARCO and Kennecott embodied in two consent decrees approved by the United States District Court for the District of Utah in 1998.

"The decree with ARCO resolved the action the United States had against ARCO under Section 107(a) of CERCLA, 42 U.S.C. §9607(a), to recover response costs associated with overseeing three removal actions EPA unilaterally ordered ARCO to complete. EPA's claim against ARCO totals approximately $3 million which includes EPA's unreimbursed response costs associated with EPA's initial residential soil removal action completed cooperatively between EPA and Kennecott and in overseeing the work ARCO performed pursuant to various unilateral administrative orders. ARCO incurred approximately $17 million in completing the actions at the Bingham Creek Channel Site. ARCO filed a counterclaim for contribution from the United States as an allegedly liable party. ARCO also administratively petitioned EPA pursuant to Section 106(b) of CERCLA, 42 U. S. C. § 9606(b), for reimbursement of its costs of complying with one of EPA's three unilateral administrative orders on the basis that ARCO is not, under corporate successor liability rules, liable for historic mining contamination, and that EPA's selection of a residential soil lead clean up standard of 1,100 ppm was arbitrary and capricious based upon site-specific human blood lead data (no risk to human health). As a result of the settlement ARCO and the United States each agreed not to pursue their respective cost recovery claims against each other.

"The decree with Kennecott resolves claims by the United States against Kennecott, as well as Kennecott's claims against the United States (similar to ARCO's claims/defenses). Kennecott incurred approximately $18.5 million in implementing numerous removal actions EPA selected as part of the Bingham Creek Channel and other related Operable Units of the "Kennecott South Zone" proposed NPL-site. EPA incurred approximately $274,000 of unreimbursed costs of overseeing Kennecott's work. Under the terms of the settlement, Kennecott paid the United States $265,000.

"ARCO and Kennecott each received statutory contribution protection for claims the parties had against one another for matters addressed in the two consent decrees."

Occasionally, the channel and floodplain remediation was disturbed during later development. When this is discovered, EPA requires that the cap be replaced. This is supervised by the City of West Jordan through its building permit program. A Five-Year Review conducted by EPA in 2003 revealed that very little of the contamination had been left on the surface after these redevelopment projects supervised by the city.

Figure 3: The channel revegetation 10 years after cleanup.

Figure 4: Redevelopment along Bingham Creek, an apartment complex across the street from Jordan View Estates.

Figure 5: Redevelopment along Bingham Creek, industry across the street from Jordan View Estates.

CHAPTER 3
ORE MILLS IN BINGHAM CANYON

What were the facilities up Bingham Canyon whose wastes led to the unpleasant discoveries downstream? The purpose of ore mills is to grind the ore and then try to separate out the economic minerals from the host rock. The ground-up host rock (along with some of the economic minerals which were not recovered) was simply dumped close by. The method of separation of the economic minerals from the host rock varied from mill to mill. Most of the historic mills used gravity separation using shaking tables (sort of like panning on a large scale). Others used leaching techniques. Here is a compilation of facilities found by EPA and Kennecott as listed in historic documents from the Utah State Historical Society Library and in company archives.

LEAD MINE MILL (facility #1)

The Lead Mine Mill was built by the Omaha Smelting Company sometime before 1883 to serve several early lead/silver producing mines in the Copper Gulch area of Butterfield Canyon. Ore was transported by mule-powered tramway to the mill located on the south side of Bingham Canyon, alongside the Bingham branch of the Denver and Rio Grande Railroad system, near the present site of Kennecott Utah Copper's Precipitation Plant. The products from the mill were shipped via the Bingham Canyon Railroad to the Hanauer (Morgan) Smelter in the Salt Lake valley. The 1890 Sanborn-Perris fire map details the mill facilities and indicates that it was being operated day and night, with a capacity of 50 tons of ore per day. Earlier sources list production at 100 tons of ore per day. The Sanborn map also shows a flume on the downstream side of the mill, heading in the general direction of the Anaconda Tailings. The period of operation of this facility appears to have been from 1883 to sometime in the 1890s. The US Census report [1885] reported that in 1880, the Lead Mine was shipping first class ore, containing 50% Pb, and the second class ore (not defined) was being dumped to await construction of the concentrating works. In 1923, the Utah Copper Company built is first precipitation plant in the approximate area of the mill. [SAIC, 1991].

Kennecott [1997] reports that the processes at the mill included grinding and crushing of lead, silver and gold ores. The mill burned in 1896. A pyritic smelter was then erected at the site which was operated from 1896 to 1901 [Kennecott, 1997]. The ruins were later used in 1905 to house people with small pox and other infectious diseases. USSRM [1937] reported that it granted Kennecott permission in 1937 to divert Bingham Creek to a new location crossing the portion of the Lead Mine Mill site owned by USSRM. Billings [1952] indicated this area was used as a shipping area for US Mine ores when the Bingham and Garfield RR was abandoned in 1947.

Kennecott reports that during the operation of this mill from 1882 - 1896, it milled 70,000 tons of Pb/Au/Ag ore leaving 46,667 tons of tailings, containing 1400 tons of Pb. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that this mill location has not yet subsumed by the Bingham Pit or dumps. The site is now buried beneath the current Kennecott precipitation plant facility. As this site is characterized during demolition of the precipitation plant in 2005, additional information about the Lead Mill Site may be located. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA purposes. The site was closed out in the Bingham Creek ROD of Sept. 1998.

UTAH COPPER COMPANY MILL (COPPERTON MILL) (facility #2)

Built as an experimental mill by the Utah Copper Company to prove the economic value of the large low-grade copper deposits in Bingham Canyon, the mill began operations in April of 1904. A lease was acquired in 1903 for surface rights on 20 acres for the mill site and for the right to dump tailings. (Another source [Utah Copper, 1939] indicates Utah Copper holdings in 1903 consisted of 200 acres of mining claims and 1000 acres in the mouth of Bingham Canyon to serve as the mill site and disposal of wastes.) Initial purposes of the mill were (1) to verify the accuracy of the mine sampling by actually treating substantial tonnages of ore; (2) to demonstrate on a reasonably large scale the percentage of copper in the ore that could be recovered; and (3) to permit the testing of various kinds of machines and devices for crushing and concentrating the ore so as to guide the engineers in designing the proposed 6000 ton milling plant at Garfield. Later the objectives were expanded to include (1) the training of workers for the Garfield mill; (2) enhancing the company's potential in view of rival claims by competitors; and (3) aiding in soliciting capital for development and expansion.

Most of the equipment for the mill came from the Sunnyside works of the US Reduction and Refining Co. in Colorado. Construction of the mill started in August 1903, and was completed and put into operation in April 1904.

Another source [Crump, 1978] indicates that the mill processed its first ore in August 1904 with a 300 ton/day mill located on a 20 acre site in lower Bingham Canyon at Dry Fork. It was called the Copperton Mill and the area around it became known as Copperton (Old Copperton). By the time the mill closed August 1, 1910, the mill's capacity was 1000 tons/day.

A history of Utah Copper mills [1939] reports that the building was 193 by 327 feet, framed of wood and sheathed in iron. A boiler house, 36 x 100 feet stood in the floor of the canyon and furnished steam power for operating the mill machinery. Water was supplied from a shaft 150 feet deep, dug in the early days by the West Mountain Placer Mining Company to develop a water supply for hydraulic mining. A Cornish pump lifted the water out of this shaft to a 20,000 gallon wooden tank from which it was relayed to two 10,000 gallon tanks above the mill [Utah Copper, 1939].

This method of water supply caused a legal dispute with a group of local farmers [Chandler v. Utah Copper, 1907, Utah Supreme Court]. Chandler was the owner of 2000 acres of land near the mouth of Bingham Canyon and had used the water from the West Mountain

Placer Mining Co. to irrigate 140 acres of alfalfa. Testimony in the case indicated that the West Mountain Placer Mining Co tunnel was originally built to dewater the placer deposits in the Bingham Creek channel. Utah Copper built a shaft and another tunnel upstream and adjacent to the tunnel used by Chandler. Utah Copper then obtained water rights to these tunnels and began pumping. The discharge in the tunnel used by Chandler ceased. Chandler sued. The lower court ruled in favor of Utah Copper, but the Utah Supreme Court overturned the decision in favor of Chandler. The Supreme Court found that the underground stream was a well-defined natural channel. [See also Bingham Creek underflow]. It also found that the State Engineer could not grant water rights from this channel when it would prejudice the rights of a prior owner. The court concluded that Chandler had the right to at least 225 gallons per minute. The decision was not unanimous.

In 1905, the water supply from the West Mountain Placer Mining Company proved

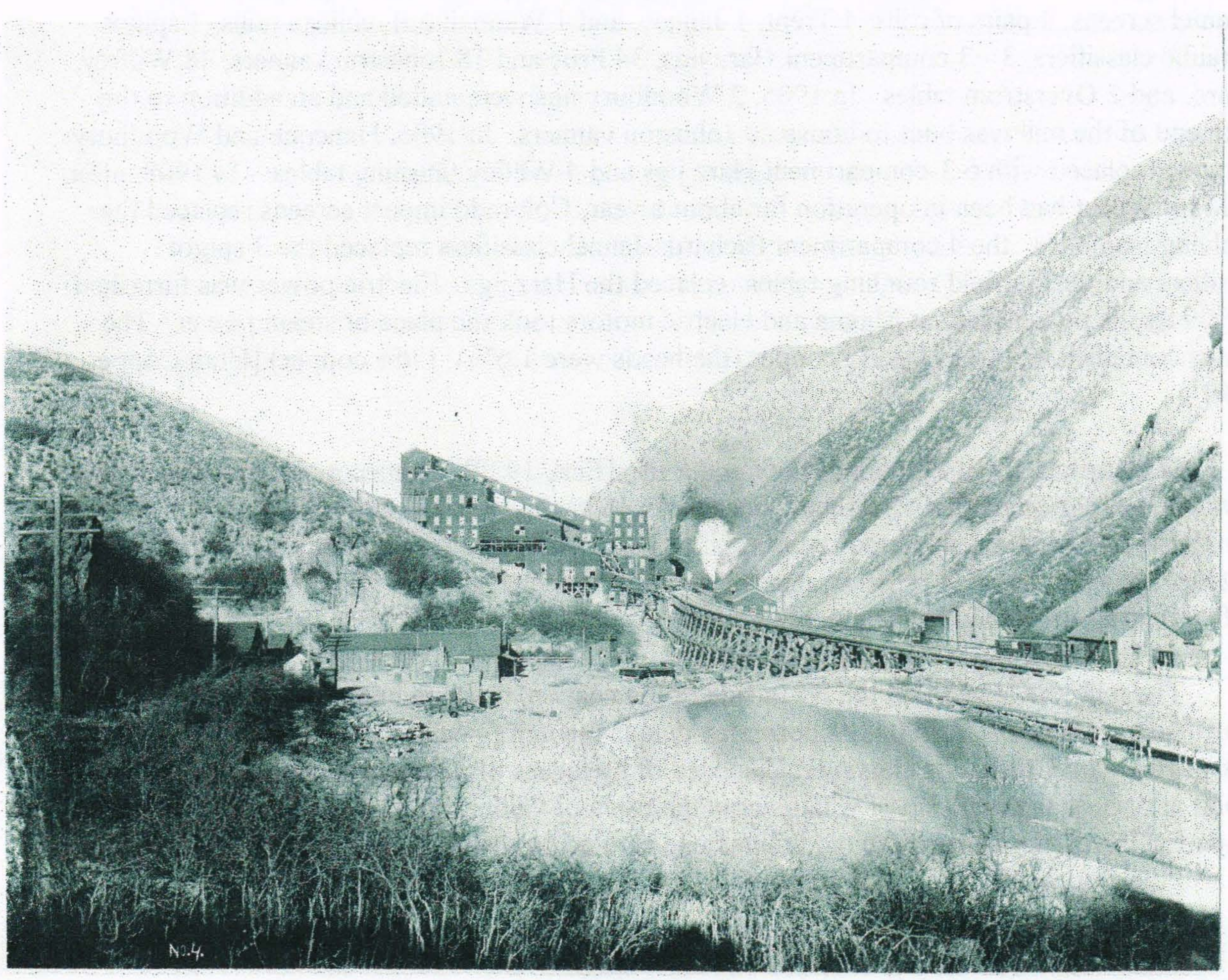

Figure 6: Utah Copper's Experimental Mill in Bingham Canyon. The tailings pond in the foreground may have been the settling reservoir used to remove tailings from upstream sources in Bingham Creek. This view is looking downstream.

inadequate, so a settling reservoir was built to impound water from Bingham Creek, which was then pumped to the mill. The equipment was powered by steam until 1906 when the company completed an electric plant at Magna.

The concentrates from Copperton were at first smelted at the Bingham Consolidated Plant at Midvale. After the construction of the Garfield smelter by ASARCO in 1906, all concentrates were shipped to Garfield.

Although it was the original intention to use the Copperton mill solely as a pilot mill on which to base the design of a larger mill at Magna, enlargements were made in the years following, embodying every known type of gravimetric concentrating apparatus. It was the largest mill ever operated in the canyon, with an initial capacity of 400 tons of ore per day that increased over the period of its operation to 1000 tons of ore per day at the time of its dismantling in 1910. [Arrington, 1963]. It was equipped originally with 2 gyratory crushers, 5 trommel screens, 4 pairs of rolls, 4 Trent, 1 Janney, and 1 Waddell 6 ft. chilean mills, 3 spigot hydraulic classifiers, 3 - 3 compartment Harz jigs, 34 Frue and 18 Johnston vanners, 48 Wilfrey, 2 Card, and 2 Overstrom tables. In 1905, 2 Woodbury jigs were added and an addition to the south end of the mill was built to house 20 Johnston vanners. In 1906, Hancock and Woodbury jigs were replaced with 6 3-compartment Harz jigs and 4 Wilfley finishing tables. In 1908, after the Magna plant had been in operation for about a year, Colorado impact screens replaced the revolving trommels; the 4 compartment Richards-Jannel classifiers replaced the 3 spigot classifiers and the Garfield roughing tables replaced the Harz jigs. Electric power was furnished in 1909 by the power plant at Magna and electric motors took the place of steam power. The tailings contained 0.59% to 0.82% copper (the heads were 1.6% - 1.9% copper).[Utah Copper, 1939]

In an article about Bingham Creek water use [Earl, 1929], Kennecott indicated that early flows in the creek were hard to estimate because in 1919 the Utah Copper Mill was taking water from the West Mountain shaft and returning it to the creek "in uneven quantities." Early water rights for the mill were #74 (creek water, all returned to the creek) and #240 (West Mountain Shaft water, also returned to the creek).

The mill was located on the north side of the canyon, near the intersection of Dry Fork with Bingham Canyon. A 1907 Sanborn map details the mill's facilities and its location on the bank of Bingham Creek. Tailings were disposed of by means of a flume running from the mill to a point at or near the east side of what is now the town of Copperton. A number of homes in Copperton have been built on the old tailings pile created by the mill's operation [SAIC, 1991]. See also the Copperton Dump description.

One serious handicap to the Copperton mill was the poor ore transportation service furnished by the Rio Grande Western Railway. Inadequate and irregular ore deliveries seriously affected operations at this plant. The railroad equipment was the principal source of trouble being entirely too limited to handle the tonnage needed for constant operation.

Some of the tailings from this operation washed down Bingham Creek all the way into the Jordan River, resulting in several damage claims in 1905 [ARCO, 104e, 1993]. An article in the Bingham Bulletin also reported that the tailings had reached the Jordan River [Kennecott, 1997]. A retention reservoir was planned to prevent tailings from going down the creek. No information was given by ARCO on the location of this pond. The pond was constructed and is thought to have been located in the general area where the Large Bingham Reservoir is today. The Bingham Bulletin reported that a large dam had been built in July, 1905. Kennecott [1997] indicates that several tailings ponds were constructed, one of which was in the vicinity of the Bingham Reservoir. Complaints continued at least until 1907 about the damages due to tailings.

The mill was demolished in 1911. The equipment was moved to the Arthur Mill. Only the foundations remain (cribbing for the foundations can be seen on the north bank of Bingham Canyon. Portions of the foundations are still intact along with cement cribbing adjacent to the paved road. The foundations are located on a hillside which supports the Dry Fork shops, road, and various utilities. The hillside and cribbing are stable. No present or future construction is planned for this site. The site will be buried by the Bingham Canyon waste rock dump sometime between 2000-2003 [Kennecott, 1998].

Kennecott reports that during the period of operation of this mill between 1904 and 1910, 1,489,737 tons of Cu ore were milled producing 1,426,000 tons of tails. [Kennecott 104e, 1991] A 1994 Kennecott map indicates that the site of this mill has not been subsumed by the Bingham Pit or dumps. Kennecott[1997] reports that a portion of the site has now been buried by waste rock. This site was closed out in the Bingham Creek ROD of Sept. 1998.

WINNAMUCK MILL (facility #3)

The mill was erected at the site of the Winnamuck Smelter, one of the first smelters in Bingham Canyon. The mill first opened in 1877 to experiment with stamps, jigs, and shaking tables. Leaching was also tried in 1878 with both raw ore and ore after chloridizing roasting. An old slag dump was leased and much value was recovered. [Census, 1885]. The Census commented "The results from this, as from most other old slag dumps, were not flattering to early smelters."

One source indicates that it was operating in the 1870s and 1880s milling lead/silver ores. The mill was probably treating the lead/silver ores from the Winnamuck Mine. It was located approximately 100 feet south of Bingham Creek near the intersection of Freeman Gulch with the main canyon. Billings [1952] reported that Ohio Copper either leased or purchased the Winnamuck Mill in 1903, and operated it from 1904 to 1907, using it as an experimental mill to work out operational details for the Ohio Copper Company Mill whose construction began in 1907 at Lark. In 1903, the capacity was 125 tons/day of second class ore. First class ores was sent directly to the smelter in Midvale. The mill was described as opposite the Denver and Rio Grande depot in lower Bingham [Billings, 1952]. The Ute Copper Company acquired the property in 1907 and appears to have continued its operation. The mill had a capacity of 200 tons of ore per day by 1911, and was treating ores from the Utah Consolidated Mining Company and the Bingham Mines Company. The Sanborn maps of 1898, 1902, 1907 and 1913 detail the increasing size of the mill's waste dump to a point where it is held back by an 18 foot cribbing wall in 1907. In 1913, the mill was leased to Wener Ziegler. The mill appears to have been operated from sometime before 1880 to after 1913. It is not shown in the 1929 Sanborn maps. [SAIC, 1991]. Another source indicates that the mill burned in June, 1919 [Moore, 1992].

Kennecott [1997] reports a similar, but different, history of this mill. It was located at the same site at the Winnamuck Smelter, approximately 1/4 mile east of Kennecott's former North Ore Shute headframe and on the south margin of Bingham Canyon. The smelter property was bought by the Amsterdam Company in 1876, and renovated into the Winnamuck Mill in 1877 to process lead and silver ores. In 1882, the mill was modified to work oxidized gold ore and later added cyanide plants. In 1904, the mill was remodeled to work porphyry copper ore. The Winnamuck Mill was intermittently operated between 1877 and 1912. The mill was also referred to as the Ohio Mill after it was bought by Ohio Copper Company in 1905. It was dismantled and the machinery was sold in 1917 and 1918. The building was destroyed by fire in 1919. [Kennecott, 1997]

Kennecott [1997] also indicates that in 1896, a second mill, owned by S. B. Milner, was moved across the gulch to the Winnamuck property. The name of this mill is not known. It started as a gold extracting plant and was later converted to a concentrating mill. The mill was moved to the Winnamuck Mill site to process low grade ore from the Winnamuck Mine. The mill could concentrate 50 - 125 tons per day.

Kennecott reports that during the operation of this mill from 1877 - 1913, 140,000 tons of Pb/Au/Ag ore was milled producing 122,500 tons of tails containing 1841 tons of lead. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill has not been subsumed by the Bingham Pit or dumps. The site is now in the Bingham Canyon railroad corridor and a portion of the site is buried under waste rock dumps. [Kennecott, 1997]. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. This site was closed out by the Bingham Creek ROD of Sept. 1998.

MARKHAM MILL (RED WING MILL) (facility #4)

This mill was built by the Markham Gulch Milling Company at the site of the old Red Wing Mill, which had been operating sometime before 1900. Earl [1929] indicates that the Red Wing Mill was operating in 1898 and used 100-150 gpm of water from Bingham Creek. Later in 1903, the Markham mill also used waters from the Campbell and Heaston drain tunnel [Earl, 1929]. Water used upstream by the Dewey Mill between 1898 - 1904 made water scarce. All the water, except that used for boiler purposes, was returned to the creek [Earl, 1929]. (The old Red

Wing Mill was a 21 ton concentrating mill, dates of operation unknown.) This company was jointly owned by the New Red Wing Mining Company and the Utah Development Company, both Utah-Apex related companies. The Markham Mill was completed in May of 1907 and began treating ores from the Utah-Apex Mine. In 1908, the North Utah Mining Company of Bingham absorbed the Utah Development Company and the lands of the New Red Wing Mining Company. In 1913, the Mineral Lands Company acquired the properties of the North Utah Mining Company. Sometime around 1916, the mill and related claims were acquired by Bingham Coalition Mines Company. The mill was located at the intersection of Markham Gulch with the main canyon, immediately south of Bingham Creek. The 1907 Sanborn maps indicate that cribbing on the waste dump had reached 12 feet in height. Bingham Creek also appears to have been relocated into a culvert. The period of operation for mills at this location appears to have been from sometime before 1900 to 1911. There may have been later operations. [SAIC, 1991]

Kennecott [1997] amplifies this information indicating that the mill changed ownership on a number of occasions. It was built by Higdon and Stein in 1893 who operated it until 1897. It was originally used to process lead, gold and silver ores. Some testing was done in 1895 on copper porphyry ores too. It was sold to Giant Chief in 1897-1898. The Red Wing Extension Mining Company bought the mill in 1898 who operated it until 1905. Massasoit Consolidated Mining Co (the new name of the Red Wing Company) operated the mill between 1905 and 1906 and changed the name to Massasoit Mill. In 1906, the mill was bought by Markham Gulch Mining Co who owned it until 1916. [Kennecott (1997)reports that the Markham Gulch Mining Co. was controlled by Utah Apex.] By 1907 the mill was reportedly a 200 ton concentrator. The land was bought (the mill was not operating) in 1916 by Bingham Coalition Mines Co who owned the land until 1930. The mill was dismantled in the 1930s.

A history of Utah Copper mills [1939] indicates that under the direction of Wall, Utah Copper did a test run at the Markham mill about 1895. The concentrate produced from 2% copper ore varied from 28 - 33% copper and recoveries were 60-62%.

Spendlove [1937] reports that the property was bought by Utah Copper in 1926 for a dumping ground. By 1937, the canyon was filled with waste dumps.

Kennecott reports that during the operation of this mill from 1893 - 1917, 95,000 tons of Pb ore were milled producing 76,000 tons of tails, containing 1520 tons of lead. [Kennecott 104e, 1991]. Kennecott suggests that this was also the site of the Massasoit Mill. A 1994 Kennecott Map indicates that this site has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. This site was closed out by the Bingham Creek ROD of Sept. 1998.

WALL'S MILL (DEWEY MILL) (facility #5)

Boutwell [1905] reported that in 1900 the Dewey Mill was equipped with 5 stamps of 650 lbs. each, 2 revolving screens, 3 jigs, 2 Wilfrey tables, and a hydraulic sizer. It treated both lead and copper ores. In 1900, 5500 tons were concentrated. The capacity was 20-25 tons/8 hours, but varied with ore hardness. Kennecott [1997] indicates the mill was originally built over Bingham Creek prior to 1874.

Earl [1929] reports that the Dewey mill used Bingham Creek water between 1898 and 1904 and this water usage deprived the Markham Mill of most of its water. Kennecott [1997] reports that the mill was located 400 feet south of the Markham mill. Earl [1929] indicates that the water intake for the mill was 800 feet upstream of the Markham mill.

The mill was purchased sometime after 1900 by Enos Wall, one of the original stockholders of Utah Copper. The Dewey Mill was operated either by Wall or lessees as a side business to his Utah Copper concerns. The facility was located approximately 400 feet south of the Markham Mill and appears to have been built directly over Bingham Creek. One source indicates that the Boston Consolidated Mining Company was using the mill just before it was destroyed by fire in 1900. Sources indicate that Enos Wall rebuilt the mill in 1905 to have a capacity of 300 tons of ore per day. The mill was destroyed by a derailment of the Copper Belt Railroad in April 1908. In 1909, it was treating ores from the Starless Group of mines. A 1909 publication of the Bingham Commercial Club indicated that at the time the mill was being enlarged so that the Starless mines and the mill could operate at full capacity. The mill was rebuilt to a 125 ton capacity in 1910, and ceased operations in September of 1911. In 1926, Utah Copper Company acquired the property. [SAIC, 1991]

Kennecott[1997] reports that previous owners included AH and George Bemis (1874-1898), Bemis and Swan (1898-1899), JT Hudson and R. Bemis (1899-1900), the Bemis Brothers (1900), Dewey Consolidated Mining and Milling Co. (1900 - 1904) and Colonel Enos Wall (1904 - 1920).

ARCO reports that the Wall mill dumped its tailings into Bingham Creek, and the tailings contained 3000 ppm Pb. Kennecott [1997] indicates that the mill was decommissioned in 1920. The equipment was bought by the Salt Lake Engineering Company and the lumber was sold locally.

Kennecott reports that during the operation of this mill from 1874 - 1911, 200,000 tons of Pb/Au/Ag was milled producing 116,667 tons of tailings, containing 3,500 tons of lead. [Kennecott 104e, 1991]. Kennecott suggests that this was also the site of the Bemis Mill. A 1994 Kennecott map indicates this site has been subsumed by the Bingham Pit and dumps. The mill site lies underneath waste rock which serves as a foundation for Kennecott's truck shop [Kennecott, 1997]. Because the site is currently non-existent of inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept. 1998.

SHAWMUT MILL (facility #6)

The mill was erected in 1900 by the Shawmut Mining and Milling Company and had a capacity of 100 tons of ore per day. The mill appears in the 1902 and 1907 Sanborn maps and was located in Carr Fork, only a few feet from the Carr Fork branch of Bingham Creek, approximately 600 feet southwest (upgradient) of the intersection of Carr Fork with the Main canyon. Historic photographs of the mill show substantial waste dumps surrounding the mill site. Another source indicates the tailings were dumped into the creek [ARCO, 1993]. The period of operation for the mill appears to be from 1900 to sometime before 1908. The Utah Copper Company acquired the property in 1910. [SAIC, 1991] Utah Copper bought the land to use as a railroad corridor and dumping ground [Kennecott, 1997].

Boutwell [1905] indicates that the mill was located on the north slope of Carr Fork just above its mouth. It was equipped with 1 Gates rock breaker, 2 pairs smooth Davis rolls, 7 Hartz jigs, 1 chilean mill, 4 sets of cylindrical screens and 4 Wilfrey tables. Capacity was 100 tons/8 hours, but was typically operated at 30 tons/day. Kennecott [1997] indicates that a drought in 1900 created a water shortage at the mill site and 600 feet of boxes were laid to divert water from Carr Fork Creek to the mill.

Kennecott [1997] reports that the mill actually operated only between 1900 - 1902 and 1906 - 1907. Operations ceased between these period because of litigation difficulties.

Kennecott reports that during the operation of this mill from 1900 -1901, it milled 10,000 tons of Pb/Au/Ag ore producing 8,333 tons of tails, containing 125 tons of lead [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill was subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

UTAH-APEX MILL (PHOENIX MILL) (facility #7)

The mill was built in 1908 by the Phoenix Mining Company. The Utah-Apex Company acquired the mill in 1908 and remodeled it in 1910. The ores processed were primarily lead/silver. A 1909 publication of the Bingham Commercial Club indicated that the Phoenix mill had a 200 ton concentrator operated with electric power and in 1909 was treating Apex ore. According to Yeatman and Berry [1917], the original capacity was 170 tons/day. In 1913-1914, the plant was expanded to 300 tons/day. In 1915, oil flotation was installed. Ore processing involved a combination of wet concentration and oil flotation. The flow chart indicates that the tailings were discharged to the creek. [Yeatman and Berry, 1917]. The facility was located in Carr Fork, approximately one and one quarter miles from the intersection of Carr Fork with the main canyon. By 1926, the mill had a capacity of 750 tons of ore per day. The mill appears in the 1913 and 1929 Sanborn maps, which show extensive waste dumps and indicate that the water was supplied from one of the branches of Bingham Creek. Historic photographs of the mill show the waste dumps in close proximity to the creek. The mill had one of the longest operating histories in Bingham Canyon, finally ceasing operation on July 15, 1930. The period of operation was from 1908 to 1930. [SAIC, 1991]. The Utah Apex Mining operations became locally famous when suspected murderer, Raphael Lopez, took refuge in the mine in 1913. He was never found, alive or dead [Bailey, 1990].

From 1907 to 1914, the tailings were not captured and went into Carr Fork and Bingham Creek. Between 1914 and 1930, the tailings were impounded [Randolph, 1991]. Kennecott [1997] indicates that in 1914, Utah Apex began placing the tailings via various flumes along the south margin of Bingham Creek to an area now known as ARCO tails. Yeatman and Berry [1917] described the creation of the tailings pond: "In order to dispose of the tailings discharged by the mill and to provide against the contamination of the water in the creek, and to avoid lawsuits being brought by the farmers using the water of the creek for irrigation purposes, a tailings disposal plant of about 95 acres was procured about 4 ½ miles distant from the mill. This is owned jointly by the Bingham-New Haven and the Utah Apex, the former owning 1/4 interest and the latter company 3/4 interest [Yeatman and Berry, 1917].

Earl [1929] reported that Utah Apex had water rights for Bingham Creek water, 2 sec ft, of which 1.9 sec ft was to go back to the Creek. The water was used to transport tailings to their tailings pond. The water right application 2127 certificate was issued in 1913. Earl [1929] also indicated that one year Utah Apex dumped water out on Utah Copper's Cottonwood Gulch dumps. About 1.5 million gallons came out carrying 30 lbs copper/1000 gallons. "This water mixing with Bingham Creek contaminated the entire stream so that it was unfit for irrigation purposes." The practice was stopped. [Earl, 1929].

Kennecott reports that during the operation of this mill from 1907 - 1939, 1,895,458 tons of Pb/Zn ore was milled, producing 1,421,381 tons of tails, containing 23,413 tons of lead. [Kennecott, 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Kennecott [1997] reports that Kennecott demolished the foundations of this mill in 1992 due to expansion of the pit. Because the site is currently non existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

This mill was the primary source of the tailings deposited at the ARCO Tails, and contributed to contamination found in the Bingham Creek Watershed. See also ARCO tails, Bingham Creek, Bastian Sink, Bastian Ditch, and South Jordan Evaporation Ponds.

ROGER'S MILL (facility #8)

Roger's Mill was first located in Highland Gulch (a.k.a. Galena Gulch) below the Spanish

Mine. It was constructed in 1891 by J. B. Rogers to concentrate Pb/Au/Ag ore and tailings. In 1895, the mill was moved approximately one mile down Bingham Canyon. The move was brought about by a shortage of suitable water released by upgradient mills. It operated intermittently from 1891 to 1900.

When mentioned in 1900, Roger's Mill was a small 5-stamp mill that treated both copper and lead ore. It was located in a gulch just below the Columbia Mine and had a capacity of 25 to 30 tons of ore per day. The site of the mill is marked by a plaque commemorating its operation by Daniel C. Jackling, one of the founding fathers of Utah Copper. [SAIC, 1991; Arrington, 1963] Roger's Mill worked tailings from the Spanish mine in Highland Gulch and dumped its spent tailings down the slope to the creek. It had 5 stamps, 2 Wilfrey Tables and a vanner. [Rice, 1906]

Kennecott [1997] cites a Salt Lake Tribune article (Jan. 1, 1895) which indicates that in 1894 the tailings were run into two tanks of puddlers. The concentrates were collected from the tanks while permitting slime to pass down the canyon.

A history of Utah Copper mills [1939] indicates that D. C. Jackling performed extensive concentration tests in 1898 - 1899. At that time this mill was described as a "small abandoned stamp mill". Jackling repaired the mill for more thorough tests. The vanner was seldom used in these tests because of its poor condition. E. A. Wall bought the mill in 1901 [Kennecott, 1997].

Kennecott reports that during the operation of this mill from 1891 - 1903 it milled 25,000 tons of Pb/Au ore and 22,500 tons of Cu/Ag ore producing 21,000 tons of Pb/Au tails and 21,000 tons of Cu/Ag tails, containing 8180 tons of Pb. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of 1998.

BOSTON CONSOLIDATED MILL (facility #9)

Various oblique references are made to Boston Consolidated Mining Company's 200 acre millsite in Bingham Canyon, and Kennecott personnel identified a site near the Roger's Mill. It is possible that what is being referenced is the Stewart No. 2 mill. There is a reference to Boston Consolidated doing some experimental concentrating at the Dewey Mill (Wall's Mill) until it was destroyed by fire in 1900. [SAIC, 1991]. By 1909, Boston Consolidated was sending its sulfide ores to the Garfield Smelter and its porphyry ores to the Boston Consolidated mill in Magna. [Bingham Commercial Club, 1909].

Kennecott [1997] indicates that this mill operated from 1906 to 1910 to test methods for porphyry copper ores prior to the construction of the Arthur mill.

Kennecott reports that during the operation of this mill in 1906, 52,000 tons of Cu ore were milled, producing 49,739 tons of tails. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

STEWART NO. 2 MILL (BEVAN MINING AND MILLING COMPANY MILL) (facility #10)

The Stewart No. 2 Mill was a ten-stamp mill erected in 1882 at the Stewart No. 2 mine. [One source says the Bevan Mining Co. owned a 10 stamp gold mill serving the gold mines around Stewart #2 in 1879, Census, 1885. It ran in intervals in 1879 crushing 1500 tons. According to the 1885 Census report, the Bevan Mill was located 3/4 mile from the Stewart #2 Mine on Carr Fork]. According to Kennecott [1997] the mill concentrated siliceous gold ores by amalgamation and cyanidizing. Tailings were probably dumped into Carr Fork. The mill is reported to have burned in 1894. The property was acquired by the Boston Consolidated Mining Company in 1897. According to Boutwell [1905] the mill was rebuilt in 1898 by Bevan and was operated by Bevan until July 1898. Sanborn maps indicate that the mill was being operated by the Bevan Mining and Milling Company in 1898. The mill was located on the east bank of Bingham Creek in Carr Fork, approximately one and one half miles southwest of the intersection of Carr Fork with the main canyon. Its period of operation would appear to be from1882 to sometime after 1898. The Stewart No. 2 Mill does not appear in the 1902 Sanborn maps for the area. [SAIC, 1991]

Boutwell [1905] indicates that the Stewart No. 2 was processing 25 ton/day with a 10 stamp mill between 1879 and 1894. An attempt to recover oxidized old ore using amalgamation and then cyanidization was made. The two processes were not combined. Boutwell [1905] also indicated that the mill burned in 1894. When Boston Consolidated bought the property, Boutwell suggests they tried amalgamation and cyanide together.

Kennecott reports that during the operation of this mill from 1879 - 1893, 50,000 tons of Au ore was processed producing 41,667 tons of tails, containing 833 tons of lead. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "no action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

HIGHLAND BOY MILL (facility #11)

The Highland Boy Mill was a stamp mill and cyanide plant erected at the Highland Boy Gold Mine around 1895. The Utah Consolidated Mining Company purchased the operation in

1896. In 1905, the old stamp mill and cyaniding tanks were dismantled and sold. A new facility for milling copper ores was built with a capacity of 500 tons of ore per day. The facility was located at the Highland Boy Mine in Carr Fork, approximately two miles southwest from the intersection of Carr Fork with the main canyon. Its period of operation would appear to be from around 1895 to sometime after 1905. [SAIC, 1991]. The property was described in a 1909 publication of the Bingham Commercial Club. At that time the ore was shipped to Garfield under consignment, but they were planning to use the new International Smelter and transport the ore to the smelter by aerial tram. A mill was not listed on the grounds in 1909. One source indicates the cyanide plant was operated only a few months. The high Cu content required much more cyanide for gold recovery than anticipated. [Rickard, 1919].

Boutwell [1905] reported that in 1900 the plant consisted of a stamp and cyanide mill, assay office, workshops, and a tramway to the railroad. The company's smelter was in Sandy. Boutwell [1905] also indicates that extra cyanide had to be added for gold recovery due to the presence of copper. Cyanidization could be used at a profit only with ore south of Niagara mill.

Kennecott reports that during the operation of this mill from 1895 - 1898, 22,000 tons of Cu/Au ore were milled producing 20900 tons of tails, containing 314 tons of lead. [Kennecott 104e, 1991]. Kennecott suggests that the Utah Consolidated Mill operated at this location also. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent of inaccessible to resident, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

BINGHAM-NEW HAVEN COPPER AND GOLD MINING COMPANY MILL (UTAH METALS MILL) (facility #12)

Built in 1909 by Utah Metals Mining Co, it had a capacity of 100 tons of ore per day in 1911. The Bingham-New Haven Company was purchased by the Utah Metal and Tunnel Company in 1914. The mill is shown as operating in the 1913 Sanborn maps, and was located in Carr Fork, two and one quarter miles from the intersection of Carr Fork with the main canyon. The period of operation would appear to be from 1909 to sometime after 1918. [SAIC, 1991]. A 1909 publication of the Bingham Commercial Club indicates that there was a concentrating mill operating on the site at that time.

Kennecott [1997] reports that the mill operated from 1909 - 1918 and then intermittently to 1923. In 1916, a flotation plant (Callow flotation) was added to the mill to treat tailings and low grade copper-iron ores. Kennecott also indicated that new flumes were constructed in 1914 to dispose of tailings. Kennecott does not know where the flume went. Yeatman and Berry [1917] indicates that the mill owned 1/4 interest in the Utah Apex Tailings Pond at the mouth of the canyon. [see ARCO Tailings Pond].

USSRM [1936] reports they leased Utah Metal and Tunnel land for 20 years. The lease was canceled in 1943 by USSRM when Kennecott wanted to lease it for dumping purposes.

Kennecott reports that during the operation of this mill from 1909 - 1925, 75,000 tons of Pb/Zn ore was milled, producing 45,000 tons of tails, containing 675 tons of lead.

There is a reference to a mill called "Excelsior Placer No. 1773 Mill" in Kennecott's 104e request. One of the owners was the Bingham-New Haven Copper and Gold Company. This may be the same facility. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

COLUMBIA COPPER COMPANY MILL (facility #13)

The Columbia Copper Company Mill was built around 1902 below the Columbia mine by Frank B. Cook and associates (Kennecott, 1997, reports the date of construction at 1901). The Columbia operations were purchased by Ohio Copper Company in 1903. In 1904, the operation consisted of a five-stamp mill and a 20-ton concentrator. Sometime before 1905, the mill was re-equipped to give it the capacity of 120 tons of ore per day. This mill does not appear as such in the Sanborn map series for Bingham Canyon, but was apparently located at the mine in the main canyon, near the intersection with Copper Center Gulch. The period of operation would appear to be from around 1901 to 1904. In 1937, Ohio Copper sold the property to the Utah Copper Company. [SAIC, 1991]. Kennecott suggests that this site was also the location of the Rogers Mill #1 (1891 - 1895), and the Jackson and Bennett Mill (1877). If so, a 1994 Kennecott map indicates that the site has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

LAST CHANCE MILL (NORTH LAST CHANCE MINING COMPANY MILL) (facility #14)

The Last Chance Mill was located in the upper end of Muddy Gulch two miles from the confluence of Carr Fork and Bingham Canyon. The mill was built prior to 1882 and known as the North Last Chance Mill, and was also known as Wald's Mill. Operations in the mill began prior to 1882 by the North Last Chance Company and was operated intermittently from 1882 - 1913 processing Pb/Zn/Ag ore. In 1889, the company was reorganized and renamed the West Mountain Group. In 1897, the mill burned and was rebuilt in 1898. Nevada-Utah Mines and Smelter Corporation acquired the property in 1904 and it was later conveyed to the Nevada-Utah Mining Company in 1906. After milling operations ceased in 1913, the property was acquired by

United States Mining Company and then later conveyed to Kennecott [Kennecott, 1997].

The 1898 Sanborn maps show a small operation, probably a stamp mill, being operated by the North Last Chance Company. By 1905, the mill had a capacity of 100 tons. The Nevada-Utah Mines and Smelter Corporation appears to have acquired the property in 1904 and rebuilt the mill in 1906. By 1907, the milling capacity had been increased to 125 tons of ore per day. Sanborn maps show the property as operating in 1898 and 1902. The mill was located in the upper end of the main canyon, two miles from its intersection with Carr Fork. Photographs indicate the mine and mill were surrounded by steep mountainsides and waste piles. The period of operations appears to have been from sometime before 1898 to October 1907. [SAIC, 1991]. A 1909 publication of the Bingham Commercial Club indicates that the mill was in operation in 1909 with 125 tons/day capacity.

Boutwell [1905] mentions that the Last Chance Mine was located on the southern slope of the head of Muddy Fork. The mill was located at the British Tunnel, the lowest of the mine.

Kennecott reports that during the operation of this mill from 1882 - 1910, 40,000 tons of Pb/Zn/Ag ore were milled producing 36,000 tons of tails, containing 720 tons of lead. [Kennecott 104e, 1991]. Kennecott suggests that the mill was also called the West Mountain Mill. A 1994 Kennecott map indicates that this site has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

NEW ENGLAND GOLD AND COPPER COMPANY MILL (facility #15)

The New England Gold and Copper Company was acquired before 1905 by the New England Company. The 50-ton lead concentrator was remodeled in 1907. The mill was built after 1901 by the New England Gold and Copper Mining Company to process Pb/Ag/Au ore. It was operated intermittently from 1904 to sometime after 1913 [Kennecott, 1997].

A 1909 publication of the Bingham Commercial Club indicates that the concentrating mill was equipped with a crusher, rolls, Huntington mill, jigs, tables, etc. At that time, the capacity of the mill was 50 tons/day and produced gold, silver, lead, and copper. The property was located between Highland Boy and Boston Consolidated. Mill operations appear to have ceased in 1913.

The property was acquired by the Utah Boston Development Company in 1920 and operations resumed. The property was purchased in 1925 by the Bingham Metals Company. After Bingham Metals purchased the mill in 1925, the mill is referred to as the Bingham-New England Mill. However there is no reference to milling after 1925 [Kennecott, 1997].

In 1936, the United States Smelting, Refining and Mining Company (USSRM) began working the Bingham Metals properties under a 10 year lease; presumably the ores were then shipped to the USSRM mill at Midvale.

The New England Gold and Copper Company Mill is shown in the 1907 and 1913 Sanborn maps. The mill was located close to the Last Chance Mine in the upper end of the main canyon, two and one quarter miles south of its intersection with Carr Fork. (Kennecott, 1997, says the location of the mill was one and three quarters miles south of the confluence). It appears that the mill was operated periodically from around 1900 to 1936 [SAIC, 1991]. Kennecott suggests that this was also the site of the Stewart Mill (1878 - 1895), the Bingham New England mill (1904-1913) and was also known as the Bingham M & M mill. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

JORDAN MILL (OLD JORDAN MILL; GALENA MINING COMPANY MILL; SOUTH GALENA MILL) (facility # 16)

Originally a ten-stamp mill erected in 1880 at the mine, the Jordan Mill had a capacity of 50 tons of ore per day in 1882. It was a steam gold mill with 500 lb stamps, amalgamated copper plate riffles, two pans, one settler, one Ball amalgamator and tie boxes for the concentration of lead ores. In its first year, it processed 1500 tons of ore [Census, 1885].

Kennecott [1997] reports that in 1893 complaints were made in the Old Jordan Mill of the rapid destruction of iron pipes due to the presence of sulfuric acid in the mine waters (Eng. And Mining J, 1893). Kennecott [1997] indicates a cyanide plant was built in 1898 to process auriferous ores.

The Sanborn maps show the mill as operating in 1890 and 1898. The 1898 maps indicates that the waste dump had grown to a height where it required a 20-foot log retaining wall on its south side. The facility was located in Bingham (also known as Galena) Gulch, approximately two and three quarters miles southwest of the intersection of Carr Fork and the main canyon. The Jordan mill processed lead as well as gold ores. Ores from the Galena mine had smelter returns of 20% lead per ton from silver/lead ores. The period of operation was apparently from 1880 to sometime after 1898.[SAIC, 1991]

The two stamp mills in operation in 1882 (10 stamp and 60 stamp) and the cyanide plant were sold and dismantled sometime prior to 1900 [Boutwell, 1905]. Note: the 60 stamp mill was not loçated in Bingham Canyon; it was located in Sandy.

Kennecott reports that during the operation of this mill from 1879 - 1900, the mill processed 75,000 tons of Pb/Ag/Au ore producing 61,364 tons of tails, containing 1841 tons of lead. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

STEWART MILL (facility #17)

The Stewart Mill started in 1878 when the Eagan and Bates 10 stamp mill was removed from Bingham Canyon and erected at the Stewart mine. Ten additional stamps were added in 1879 bringing capacity to 50 tons of ore per day. The mill is reported to have treated over 10,000 tons of ore in 1880. Its original equipment included a Blake plaster crusher, 20 stamps, screens, self-feeders, and aprons. Mercury was added every 30 - 60 minutes. Reportedly, mercury losses were about 1/20 lb per ton. The mill operated for 17 months. [Census 1885]. This would calculate to be a loss of about 750 pounds of mercury during these 17 months of operation.

Sanborn maps for the area, starting in 1890 do not show the facility. The mill was located in Mud Gulch (also known as Muddy Fork) in the upper end of Bingham Canyon, approximately one and one half miles up the main canyon from its intersection with Carr Fork. (Kennecott, 1997, places the site one and three quarters miles from the confluence.)

Boutwell [1905] gives slightly different dates. He indicates that the 20 stamp mill was erected in 1882 with a capacity of 50 tons/day. Boutwell also suggests that this process was a failure due to loss of gold in tailings through imperfect amalgamation.

Kennecott [1997] reported that cyanide treatment was added in 1893, but abandoned later in 1893. The mill burned in 1895.

Kennecott reports that during the operation of this mill from 1878 to 1895, the mill processed 80,000 tons of Pb/Zn/Au ore producing 68,571 tons of tails, 2,734 tons of which have lead concentrations in excess of 500 ppm lead. [Kennecott 104e, 1991] Kennecott suggests that this was also known as the Bingham M&M mill and the New England Gold and Copper Mill and was also the site of the Bingham New England Mill (1904-1913). A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

SPANISH MILL (NIAGARA MILL) (facility #18)

A mill was installed on the Niagara property in 1874 with 4 jigs. A water wheel and steam engine were installed in 1876 to run the jigs. A five-stamp mill was reported to be associated with the property in 1884. The operation was acquired by the United States Mining Company in 1899. The mill appears in the Sanborn maps for 1890, 1898, and 1902. The mill was located in Bingham Gulch, two and one half miles southwest from the intersection of Carr Fork with the main canyon. Both the cyanide mill and concentrator were operating in 1890. Its period of operation appears to be from before 1890 to sometime after 1902. [SAIC, 1991].

Kennecott [1997] indicates that jigs were erected by the Niagara Mining and Smelting Company in 1874. The Niagara company later built two concentrators on the site. The Spanish Mill was erected in 1890 to process Pb/Zn ore until 1901. The Niagara concentrator was built in 1891 to process Au/Ag ore until 1902. The mills used crushers, jigs, and a cyanide plant to process the ores.

USSRM records [1906] indicate purchase of substantial shares of Niagara mining operations in 1906. After then, the ores were sent to Midvale for processing. The mill does not appear in the 1907 Sanborn maps for the area. Waste pile locations are shown in old photographs of the mill. [SAIC, 1991]

Kennecott lists the Spanish Mill and Niagara Mill separately. The Spanish Mill was in operation between 1874 - 1901 and milled 95,000 tons of Pb/Zn ore producing 63,333 tons of tails, 2533 tons of which contained lead exceeding 500 ppm. The Niagara Mill was in operation from 1891 - 1902 and milled 30,000 tons of Au/Ag ore producing 25,000 tons of tails, containing 1000 tons of lead. [Kennecott 104e, 1991]

A 1994 Kennecott map indicates the period of operation of the Spanish mill at 1890-1892. This map also indicates that the site of the mill has been subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to resident, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

TELEGRAPH MILL (U. S. MINING COMPANY MILL) (facility #19)

The Telegraph Mill was probably built in 1876 or 1878 at the Telegraph Mine by L. E. Holden. It originally consisted of one 5-stamp and 2 10-stamp batteries and associated equipment. During the course of operations at the Telegraph Mill, two types of processing were incorporated to extract the metals, leaching and concentrating. The standard method of concentrating was used from the beginning and in 1877 a leaching circuit was added. The original equipment came from the Utah Mill site [Kennecott, 1997].

In 1884, the mine was being leased by Hazelgrove and Mullett and a five-stamp mill was being operated. The original stamp mill was dismantled and sold sometime prior to 1905. In 1910 a 50-ton cyanide plant was built by the Utah Leasing Company. The 1913 Sanborn maps indicated that the facility was being operated night and day by the Utah Leasing Company. It probably processed lead/silver ores as well as gold ores [SAIC, 1991]. The mill was leased by several entities over time with the latest person being J. C. Dick, who erected a mill to process ores including reprocessing the tailings on site. His leases were for three years beginning in 1909 from the United States Smelting Company [Kennecott, 1997].

Photographs show a nearby waste dump. The period of operation was apparently from 1878 to sometime after 1913. The mill does not appear in the 1929 Sanborn maps for the area. [SAIC, 1991]

Remnants of the tailings pond can be observed on the southeast side of the Bingham Pit. The area will soon be mined away. [There is a current photograph in Kennecott, 1997.] The portion of mill tailings still present is located in a bench at the 6970 ft elevation. The pit rim elevation is approximately 7500 ft. As the pit is expanded the tailings will be mined away. If any erosion does occur the tailings will end up on the bench immediately below. Each bench is 40-50 ft high. Therefore, the tailings can only end up contained either in the pit, in the waste rock dumps, or in ore that will be processed [Kennecott, 1998].

Kennecott reports that this mill operated from 1876 - 1914 and processed 152,000 tons of Pb/Ag/Au ore producing 91,200 tons of tails, containing 3,648 tons of lead. [Kennecott 104e, 1991]. A 1994 Kennecott map indicates the period of operation between 1876 and 1883, with a leaching works in operation between 1878 and 1880. This map indicates that the mill site has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

BEMIS MILL (facility #20)

The location of this facility has not yet been determined. It was built in 1898 and treated custom ores through 1905. It had a capacity of 120 tons of ore per day by 1900 and during that year, 14,000 tons of ore were treated. The Bemis Mill may have been the Bingham Mining and Milling Company Mill. [SAIC, 1991] Kennecott suggests it might have been the Wall Mill. A 1994 Kennecott map indicates that the Wall mill site has been subsumed by the Bingham Pit and dumps.

Boutwell [1905] indicates that the mill was located in Bingham Canyon. The mill was doing much of the custom work in the district in 1900. It was equipped with one Blake crusher, one smooth faced roll, 4 jigs, 2 Wilfrey tables and a sizer. The capacity was 5 tons/hr. It was originally designed for treating low grade copper ores. Boutwell [1905] mentions the Dewey (Wall) mill as a separate mill.

The site is currently underneath the 6190 truck shop [Kennecott, 1997]. Because the site is currently non-existent or inaccessible to residents, workers and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

WEST MOUNTAIN MINING COMPANY CONCENTRATOR (facility #21)

This facility only appears in the Sanborn map for 1890. This map indicates that it was not in operation at the time. Its location is unclear. It may have been about one half mile up Muddy Fork (Mud Gulch) from the Stewart No. 2 Mill. The West Mountain Mining Company Placer claim, located almost three miles down the canyon (near the Copperton Mill), was purchased by Utah Copper in 1903. [SAIC, 1991]. The headframe for the tunnel itself still exists in the creek channel next to the Utah Copper Mill site.

Kennecott [1997] indicates that the West Mountain Placer Mining Co did exist during this period, but did not own a concentrator. Alternatively, Kennecott points out that the West Mountain Mining Group was formed when the Last Chance company reorganized in 1889 (SLT, Jan.1, 1890). This concentrator, therefore, may be a later name used for the Last Chance Mill.

If this was another name for the Last Chance Mill, according to a 1994 Kennecott map, the site of the mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

SILVER SHIELD MILL (facility #22)

The Silver Shield Mill appears to have been built around 1909-1910 by the Silver Shield Mining Company. The Silver Shield Company had planned to build a mill at its tunnel mouth as early as 1906, but had a dispute with Utah Copper over water rights (Deseret News, 1906). The mill was located close to the mouth of the Silver Shield tunnel with a planned capacity of 100 tons of ore per day. The mill was located in a draw to the south of Galena or Bingham Gulch, approximately two miles from the main canyon and Carr Fork intersection. Its period of operation is unknown. [SAIC, 1991]

Kennecott [1997] indicates the location according to Boutwell was 1000 feet NE of the Old Jordan. Kennecott also suggests that the capacity was 60 tons/day and the period of operation 1890 - 1913.

A 1909 publication of the Bingham Commercial Club indicates that the foundation of the plant had been laid and the mill would be completed by the end of 1909. A 1994 Kennecott map indicates the period of operation was 1910 - 1913. The map also indicates that the site of the mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

BINGHAM MINING AND MILLING COMPANY MILL (facility #23)

The 1890 Sanborn maps states that the Bingham Mining and Milling Co. mill had a capacity of 100 tons of ore per day. Its location is unclear. It may have been about a quarter mile up Muddy Fork (Mud Gulch) from the Stewart No. 2 Mill. Its period of operation was apparently from 1898 to sometime before 1900. The Bingham Mining and Milling Company Mill may have been the Bemis Mill [SAIC, 1991]. Kennecott suggests this was another name for the Stewart Mill (1878 - 1895) and later the New England Gold and Copper Co. Mill. A 1994 Kennecott map indicates that the site of the mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of 1998.

UTAH CONSOLIDATED GOLD MINE MILL (facility #24)

Utah Consolidated Gold Mines Ltd. began to construct a cyanide mill in 1897, but may not have operated it due to a shift to copper interest. [Hansen, 1963]. Kennecott indicates the location of this mill was at the Highland Boy Mill.

Kennecott [1997] indicates the mill was located one and a half miles upgradient of the confluence of Carr Fork and Bingham canyons in upper Carr Fork Canyon. The mill was built to crush and cyanide leach oxidized gold-silver ores at the rate of 100 - 125 tons per day. Initially pregnant gold bearing cyanide solution was shipped to the Consolidated Kansas City Smelting and Refining Company's smelter in Salt Lake City. Later the cyanide was stripped of gold at the mill site and refined. In addition to extracting gold and silver, the mill concentrated up to 40 tons of copper ore daily. In 1905, the old stamp mill and cyanide tanks were dismantled and sold [Kennecott, 1997].

A 1994 Kennecott map indicates the site of this mill has been subsumed by the Bingham Pit and dumps. Kennecott also indicates this mill was at the site of the Highland Boy mill. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

BINGHAM GOLD MINING COMPANY (COMMERCIAL MINE) (facility # 25)

In 1895, the Bingham Gold Mining Company sought to extract and treat the oxidized gold ore by a cyanide process, but these efforts were unsuccessful, and the property remained idle for several years. The mines were reopened in 1898 and the company built a smelter in Midvale. [Hansen, 1963]. Kennecott suggests that this may also have been called Brooks Mill (1900) or Hicks Jig (1896). A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dump. Boutwell [1905] contains the same operational information.

Kennecott [1997] indicates the mill was located at the Commercial Mine in upper Copper Center Gulch approximately ½ mile above its confluence with Bingham Creek. In 1898, the property came under the ownership of the Bingham Copper and Gold Mining Company, and later in 1906 it was owned by Bingham Consolidated Mining and Smelting Co. Kennecott [1997] could find no production numbers for this operation. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

UTAH CONCENTRATOR (facility #26)

A map provided by Kennecott lists a facility called the "Utah Concentrator" in an area between the Niagara Mill and the Jordan Mill. Kennecott [1997] indicates that this was also called the Utah Mill operating from 1874 - 1876. It was at the site of the Utah Smelter. The mill was erected in 1874 by the Utah Silver Mining Company, and it processed lead-silver ores. The concentrator was erected by John Longmaid on the Utah Mine and demolished in 1876. The mill was moved to the Telegraph site, according the US Census, 1885 report. Kennecott [1997] indicates that the zinc content from the Utah Mine made treating the ore unprofitable and precipitated the closure. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham pit and dumps. Kennecott [1997] indicates that this operation milled 1000 tons of lead-silver-gold ores producing 600 tons of tails containing 30 tons of lead. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

HEASTON CONCENTRATOR JIGS (facility #27)

The Heaston Concentrator Jigs is shown on a map in the Bingham Creek 104e request. It was located close to the Red Wing Mill. According to Kennecott, the mill operated between 1896 and 1910, during which time it milled 5000 tons of Pb/Ag/Au ore and produced 4,127 tons of tails. Another Kennecott map indicates the period of operation as 1896 - 1900. This map [1994] indicates that the site of this mill has been subsumed by the Bingham Pit and dumps.

Kennecott [1997] indicates that the Heaston Concentrator Jigs were located adjacent to the Markham Mill (Red Wing Mill) at the junction of Markham Gulch and Bingham Creek

Canyon. The tailings were probably dumped into Bingham Creek. In 1904, the jig was sold to E. A. Wall and was used in the reduction of Kempton Mine ores [Mining and Scientific Press, Aug 6, 1904). Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

MASSASOIT MILL (facility #28)

The Massasoit Mill is shown on a map in the Bingham Creek 104e request. It was located just to the west of the Winnamuck Mill. Kennecott suggests this was another name for the Markham Mill (1893 - 1911). The name change occurred in 1905. A 1994 Kennecott map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps.

According to Kennecott [1997], the mill was built and operated in 1893. In 1899, the mill was purchased by the Red Wing Company. The Red Wing Extension Mining Company at Bingham was changed to Massasoit Mining and Milling Company. It owned and operated a 200 ton concentrator on the site of the old Red Wing Mill. The Markham Gulch Mining and Milling Co. was controlled through 50% ownership by the New Red Wing Mining Co., and was under the same general management as the Utah Apex and Utah Development companies. The New Red Wing Mining Co. was disincorporated in 1908 and merged with North Utah Mining Co. The mill operated until Sept. 1911, reopened and operated until 1917. In 1916, Massasoit sold the property to Bingham Coalition Mines Company. The mill was dismantled in the 1930s. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

UTAH MILL (facility #30)

The Utah Mill appears in a table of tailings producers in Kennecott's 104e request. The Utah mill operated in 1874 milling 1000 tons of Pb/Ag/Au ore producing 600 tons of tails, containing 30 tons of lead. According to a 1994 Kennecott map this may have been another name for the Utah Concentrator. If so, the map indicates that the site of this mill has been subsumed by the Bingham Pit and dumps. See description of the Utah Concentrator for further details. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out in the Bingham Creek ROD of Sept 1998.

BROOKS MILL (facility #31)

The Brooks Mill appears in a table of tailings producers in Kennecott's 104e request. The

Brooks mill operated between 1899 - 1900, and milled 5000 tons of Pb/Ag/Au ore producing 4167 tons of tails, containing 83 tons of lead. Kennecott originally suggested that this was another name for the Hicks Jig and the Bingham Gold Mill. Later, Kennecott [1997] indicates that the Brooks Mill must have been a separate facility because this mill processed lead-bearing ores not gold ores. The mill was located adjacent to the Niagara dumps in upper Bingham Creek Canyon. The owners of the mill apparently leased the dumps from the United States Mining Company until increased smelter charges cut into profits. The site has been subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

DURRANT MILL (facility #32)

The Durrant Mill was built in 1877 to concentrate low grade lead but was changed to a gold/copper mill in 1879. It had a 10 stamp mill, 2 jigs and revolving screen. One reference reports that it had amalgamation facilities. Between 1877 - 1880, it reportedly ran for only a few weeks and was otherwise idle. [Census, 1885]. It ceased operations in 1879. The Durrant Mill appears in a table of tailings producers in Kennecott's 104e request. The Durrant Mill operated between 1877-1879 milling 5000 tons of Pb/Ag/Au ore producing 4167 tons of tails, containing 125 tons of lead. Kennecott [1994] indicates this was located somewhere in Carr Fork, exact location unknown. According to Kennecott [1997] it processed ore from the Gipsey and Morning Star Mines. Because the site is currently non-existent or inaccessible to residents, workers and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

EAGAN and BATES MILL (facility #33)

The Eagan and Bates mill was on main Bingham Canyon. It was a 10 stamp mill which was dismantled in 1878 and moved to the Stewart mine. It may have had amalgamation facilities [Census, 1885]. It originally processed lead-silver ores from the Old Telegraph and Jordan mines (SLT, 1878) and had a capacity of 100 tons/day [Kennecott, 1997]. The Eagan and Bates Mill appears in a table of tailings producers in Kennecott's 104e request. The mill operated between 1877-1879 during which time it milled 20,000 tons of Pb/Ag/Au ore producing 16,667 tons of tails containing 333 tons of lead. According to Kennecott [1994], this was also the site of the Hazelgrove and Mullett mill (1879 - 1886) and the Clarks Mill 1884. A 1994 Kennecott map indicates the site of this mill has been subsumed by the Bingham Pit and dumps. Because the site is currently non-existent or inaccessible to residents, workers and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

BINGHAM - NEW ENGLAND MILL (facility #34)

The Bingham-New England Mill appears in a table of tailings producers in Kennecott's 104e request. The mill operated between 1905 - 1913 during which time it milled 60,000 tons of Pb/Ag/Au ore producing 48,000 tons of tails, containing 1440 tons of lead. [Kennecott 104e, 1991]. This may have been the New England Gold and Copper Mill, at the same site as the Stewart Mill, but the details are somewhat different.

Kennecott [1997] gave further information about the various names of this mill. In 1878, the Egan and Bates 10 stamp mill was removed from the main Bingham Canyon and erected at the Stewart Mine. The mill was converted to mill lead-zinc ores. The mill burned in 1895. In 1901, the New England Gold and Copper Mining Company constructed another mill at the Stewart Mine which operated until 1913 to process lead-silver-gold ore. It operated intermittently from 1904 to sometime after 1913. Mining of the "old" New England Mine continued until after 1925. After Bingham Metals Company purchased the mill in 1925, the mill is referred to as the Bingham-New England mill. However, there is no reference to milling after 1925. The site has been subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

WHAT CHEER MILL (facility #37)

The What Cheer Mill was a 4 stamp mill erected in 1874, and was associated with the What Cheer mine. It reportedly did not concentrate the ore much. The product was 20% lead, and the ore was 10 - 12% lead [Census, 1885]. Kennecott [1997] reports that a claim map indicates that the What Cheer Claim was located northeast of the confluence of Copper Center Gulch and upper Bingham Canyon. The site has probably been subsumed by the Bingham pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

MURPHY MILL (facility #38)

The Murphy Mine was reported to have a jig mill by the Census of 1885. The jigs failed to concentrate the ore. Kennecott [1997] could not find either the location of the mine or mill. They assume that it was built at the same time as the What Cheer Mine. No references were found in later documents indicating that the mill was short-lived. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

C. W. WATSON'S's JIG (facility #40.14)

The C. W. Watson's Jig was located in the vicinity of the current KUC Precipitation Plant. The jig was used to collect placer gold in Bingham Creek Canyon in the early 1890s. The water and probable feed used by the jig was flumed from a tunnel (Watson) located 2000 feet up gradient in Bingham Creek Canyon (SLT, Jan 1, 1895) [Kennecott, 1997]. In 1903, Utah Copper leased the land for tailings storage and the Copperton Mill was constructed. In 1897, the Watson Company merged with the West Mountain Placer Company whose property was leased at the same time for the Copperton Mill. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

DARRENUGUE JIG (facility # 40.15)

The Darrenugue Jig was used to "placer mine" areas along Bingham Creek. It was operational in 1906. No other information is available [Kennecott, 1997] From an interview for the Jack Haymond Oral History Project, the operation was described as a single jig owned by a man named Darrenugue. He would simply move this jig up and down the creek recovering copper and gold from the Winnamuck Mill tailings or other tailings along Bingham Creek. No facility was ever constructed to require demolition. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The area of operations was closed out by the Bingham Creek ROD of Sept 1998.

VERONA URANIUM PLANT (aka Verona Copper and Uranium Recovery Pilot Plant) (facility # 40.16)

Kennecott constructed and operated a uranium recovery pilot plant during the 1969-1973 period. The facility included a copper precipitation cone, an ion exchange-solvent extraction uranium recovery plant, and the requisite piping and pumping capacity to collect effluent solutions and return the barren solutions to the dump. It was located 2 miles upstream from Copperton near the creek downgradient of the Verona Waste Rock Dump.

It was designed for a maximum throughput of 2000 gpm. After copper recovery, the solution was fed to a vertical vessel (45' high, 12' diameter) containing ion exchange resin. After passing through the resin, the barren waters were returned to the dump. (The designs also included an "emergency bypass to Bingham Creek".) The resin with the uranium was then transferred to a smaller vessel where it was eluted with 15% sulfuric acid solution. The sulfuric acid solution containing the uranium was further purified by solvent extraction using a tertiary amine in kerosene as the solvent and ammonium carbonate as the strip solution. The uranium was precipitated from the strip solution by steam distillation. The precipitate was filtered and calcined to produce a 98% pure U3O8 product. The capacity was about 150 lbs/day. Recovery efficiency for this process was thought to be about 80%. Overflows went to Bingham Creek.

The plant was closed in 1973. In 1982, the Nuclear Regulatory Commission approved decommissioning and the plant was demolished in 1982-1983. The site is partially buried beneath waste rock from the Bingham Pit with total burial anticipated by 2000. [Kennecott, 1997]. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD in Sept 1998.

NEW YORK AND UTAH MILL (facility #40.17)

The New York and Utah Mill was described in the Census Report [1885]: " The works of the New York and Utah Milling Company are located at Revere Switch, at the mouth of Bingham Canyon, 5 ½ miles below [east of] Bingham. They were built in the summer of 1878 as leaching works for raw ore. About 400 tons of ore, principally from the Lucky Boy Mine, assaying from 20 to 25 ounces, were leached and yielded from 8 to 10 ounces [gold] per ton. The present company was organized in March, 1880. The works are intended to treat the "rebellious" silver and gold ores of Bingham, or sulphurets of iron, zinc, etc. (Lead excepted); and at the time of the writer's visit were almost completed. They have cost to date about $30,000. The intended process is to roast and leach both gold and silver. The company owns 5 acres of land and water rights, and have erected buildings containing a 40 horse-power engine, rotary drier, Howland crusher, one pulverizer, one Libsey single-stamp battery, one Brewster roasting furnace, and leaching vats. The Libsey stamp is an eastern invention (Patented June 3, 1880). It consists of one 900 pound stamp, speed 120 drops per minute, and drop 5 inches; a pulley also gives it seventy-five revolutions per minute. The shoe and die are 15 inches in diameter, the feed being through the opening in the boss..." Kennecott [1997] suspects that this site, east of Hwy 111 along Bingham Creek was cleaned up by ARCO in Bingham Creek Phase II removal UAO (1994-5). (See also Revere Smelter #43). This site was closed out by the Bingham Creek ROD of Sept 1998.

YELLOW CAKE PLANT (aka Energy Fuels Nuclear IX Plant)(facility #83)

There was a uranium recovery facility just upstream from Copperton. It was apparently installed as a secondary uranium recovery plant in the early 1960s by Westinghouse Electric. It was later sold to Wyoming Minerals. The license has since been transferred to Energy Fuels Nuclear of Denver, owned by Oren Benton. Energy Fuels bought the property in 1987 and recovered 200,000 pounds of uranium oxides over the next two years. About 10 million gallons of precipitation plant waste water was used. The facility treated effluent from Kennecott's copper precipitation plant with an ion-exchange circuit, and recovered the uranium in a slurry which was sent to various locations for further refining. Apparently Kennecott retained only a royalty on any uranium recovered. This facility operated only intermittently, perhaps 8 years out of the 30.

The plant was closed in 1989 and there was an application to UDEQ for decommissioning and decontaminating this facility in 1991. Kennecott instructed the operator to remove everything from the property including the buildings and associated pipelines to and from the precipitation plant.

According to Kennecott [1997] chemicals used at the site included kerosene and di-2-ethylhexyl phosphoric acid. "All materials, tanks, pumps, tools and equipment from the operation which held commercial value or could be used at other industrial facilities were released for unrestricted use and shipped to EFNI storage in Fredonia, Arizona. All building material was released for unrestricted use; steel went to Utah Metals and Atlas Steel. Concentrate and wood debris were disposed of in a private commercial landfill operated by NNC near Magna, Utah. Radioactive contaminated material was sent to U. S. Ecology in Richland, Washington. Contaminated soil from the calciner floor was excavated and shipped to Hanford, Washington."

The cleanup standard was 30 pCi/g. The cleanup, conducted by Energy Fuels Nuclear, Inc. was supervised by UDEQ's Division of Radiation Control and observed by Kennecott, who owns the land.

On Jan 12, 1995, the Denver Post announced that the site has been cleaned up by "removing tons of radioactive waste materials". The article did not say where the wastes were placed. The report indicated that the state had released the site for unrestricted use. Additional data submitted to EPA by Kennecott indicates than any elevated heavy metals at the site were removed along with the radioactivity cleanup. The land is suitable for unrestricted land use.

CHAPTER 4
SMELTERS IN BINGHAM CANYON

There were a few smelters in Bingham Canyon. The purpose of smelters is to take the concentrates produced by the mills (the economic fraction of the ores) and drive off the sulfur using heat. The molten mixture separated into layers with the top fraction composed of iron compounds and the bottom containing the other metals. The top fraction (called slag) was skimmed off and dumped. The rest (matte) was poured into ingot molds or plates and shipped off-site for further refining or purification. The following compilation describes the various smelters located in or near Bingham Canyon.

UTAH SMELTER (facility #41)

The first smelter in the canyon was built in 1871 by Buel and Bateman. This smelter processed lead ore during 1871 to 1873. It had a large furnace of the combined Piltz-Raschetter pattern, with a capacity of 45 tons per day. It is thought to have been located in the mouth of Bingham Canyon. [Moore, 1992].

Boutwell [1905] indicated that the first smelter in the canyon was erected in 1871 at the Utah mine. By 1873, it was declared a failure. (The profit was $5.52/ton.)

Another reference says that the Utah Silver Mining Co. smelter was built by James Murphy in 1871, and had two blast furnaces, one of 15 tons/day capacity and the other of 30 ton/day capacity. The operation failed in 1873. The operation was reorganized under superintendent John Longmaid. He extended the workings, erected a concentrator and tore down the smelter. [Bailey, 1988]. The concentrator, built in 1874, was the first concentrating works in Utah. It was a stamp mill and jigging plant. It was reportedly dismantled in 1876 and moved to the Telegraph mine [Census, 1885].

Another source reported by Kennecott [1997] indicates the smelter was located in upper Bingham Canyon at the Utah Silver-Lead Company's mines (Leichter and Adamson, 1941, U of U thesis). It was built and operated by Buel and Bateman in 1871 and sold to an English company also in 1871 (Census, 1885). It was equipped with two hexagonal blast furnaces, one having a capacity of 20 tons and the other 50 tons of ore per 24 hours. According to Leichter and Adamson [1941], the plant seemed to handled more like a stock promotion scheme than a smelting venture and closed in 1873. Another indicates it was a failure when pyrites were struck in 1873.

According to a 1994 Kennecott map, the site of this smelter has been subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD in Sept 1998.

WINNAMUCK SMELTER (BRISTOL AND DAGGET SMELTER; BINGHAM CANYON SMELTER) (facility #42)

This smelter operated during the years 1871-1875 and was located in the mouth of Bingham Canyon. It had two furnaces, a cupola and blast, with a 30 ton capacity per day. It is thought that the smelter was located near the Winnamuck Mine. [Moore, 1992]. Another source [Billings, 1952], indicated that this smelter was built in the late 1860s and included an important development in smelter construction: the application of the water jacket.

The Census Report [1885] indicated that the smelter and mine was bought by Bristol and Dagget in 1871, and smelting was started in 1871. It was later sold in 1872 to an English company who found the smelter was not profitable, and abandoned the facility in 1875. The report also indicates that Winnamuck's old slag dump was leased and produced 3 tons of "scrap bullion". "The results from this, as from most other old slag dumps, were not flattering to early smelters." [US Census, 1885].

Boutwell [1905] reported that in 1872 the Winamuck Smelter report that it recovered lead and silver more efficiently than most, losing 6.4% of the lead and 5.5% of the silver. The process did not work well with sulphide ores, but was profitable with carbonate ores. Boutwell [1905] indicates there were 6 tuyeres with 2 1/2" nozzles. The slag discharge was 10" below the tuyeres. The automatic siphon tap was employed. Blast was furnished by Root blowers. The Winamuck Smelter shut down in 1875 when the mines had passed through their carbonate zones into sulphide ores.

Another source indicates this smelter was built in 1872 (fire brick was purchased then). Just below the Winnamuck Mine, Bristol and Dagget erected a smelter consisting of two Piltz furnaces, fourteen feet in height from the tuyeres to the feed hole, three and half feet in diameter at the tuyeres, and eighteen inches in thickness of walls. [Bailey, 1988]

According to Kennecott [1997] the Winnamuck Smelter was located in Bingham Creek Canyon approximately 1/4 mile east of KUC's former North Ore Shoot head frame and on the south margin of Bingham Creek canyon. The 1885 Census report indicates it was constructed by Bristol and Dagget in 1871 to smelt lead-silver ores in circular Piltz furnaces. Leichter and Adamson, 1941, indicates that in later years, as ore grades became lower and less oxide ores were available, the Matte-roasting process was incorporated which subjected the lead-copper matte formed in the blast furnaces to further treatment. The high costs of smelting and the inherent inefficiencies forces closure of the smelter in 1875. Much of the slag generated at the smelter was hauled off and reprocessed (Engineering and Mining Journal, Oct 7, 1893).

Kennecott [1997] indicates that the Bristol and Dagget operation was sold to a British company in 1872, and then later to a German company in 1873 and the operation was abandoned in 1875. The smelter was bought in 1876 by an Amsterdam company but smelting never resumed. In 1877, the smelter was renovated into a mill (see Winnamuck Mill, #3). The mill burned in 1919.

Kennecott collected several samples of slag found at the site. The samples, containing slag, waste rock and soil, contained 255 - 403 ppm arsenic and 1090 - 10700 ppm lead. Four of five samples collected failed TCLP for lead.

Kennecott reports in its 104e request that the Winnamuck Smelter of Buel and Watson operated between 1867 and 1870. Perhaps this was an earlier works at the site. No other information was given. [Kennecott 104e, 1991]. In 1998, this site was buried by waste rock. Because the site is inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

REVERE SMELTER (WELBY SMELTER) (facility #43)

This smelter, built in 1880, was located near the mouth of the Bingham Canyon at the Revere Switch of the Bingham Canyon and Camp Floyd Railroad (now D&RGW). This is near where the railroad crosses Rt. 111 today. The smelter was owned by the New York and Utah Mining Company. A lien indicates that the reduction works were supplied with building materials including a smelting furnace, an assay furnace, and leaching tanks. The date of operation is circa 1881 [Moore, 1992].

Another source indicates the facility also included a leaching plant which was built in 1878. The process involved roasting and then leaching gold and silver raw ores. Located on 5 acres of land with water rights, it included a rotary drier, Howland crusher, one pulverizer, one Libsey single stamp battery, one Brewster roasting furnace and leaching vats. The Brewster furnace, a circular reverberatory roasting furnace, was 15 feet in diameter and 40" high with walls 30" thick and a hearth covered with fire brick. It was located at the mouth of the canyon 5.5 miles below Bingham City. [Census, 1885]

This smelter does not seem to be related in any way with the town of Welby which was founded around 1905. A history of Welby does not mention a smelter or smelter ruins [Stocking, n.d.].

Kennecott [1996] suggests that this is more accurately described as the NY and Utah mill. The site is believed to be 1/2 mile east of State Hwy 111 on the north shoulder of Bingham Creek channel where the channel takes a sharp bend to the south. Kennecott[1996] reports signs of a possible mineral processing operation during the Bingham Creek Channel removal action. The facility produced gold and silver concentrates. The tailings and slag were probably deposited in the Bingham Flats area of the channel. If so, the site was cleaned up by Kennecott as part of the Bingham Creek channel removal action. The site was closed by the Bingham Creek ROD in

Sept 1998.

YAMPA SMELTER (facility #44)

This smelter was operated between 1904 to 1910, and was located on the Broad Gauge, M Gibbons Place, and Charles Brink Placer mining claims in the Bingham Canyon. [Moore, 1992]

Another source indicates that the Yampa Smelter operated in Bingham Canyon from 1903 - 1909. Bingham Consolidated sent its ore to the Yampa Smelter during 1907 - 1908 after closing its own smelter following the smelter-farmer damage suits [Hansen, 1963]. Billings [1952] also indicates the Yampa smelter was constructed in 1904. In the early days, the smelter produced copper matte which was shipped to one of the Salt Lake Valley smelters for converting into slab copper [Billings, 1952].

Boutwell [1905] stated that the smelter began in 1903 with one furnace with an initial capacity of 250 tons/day, but with power, bins, and stack to double this capacity. Billings [1952] reported that in the early days of operation, the product was copper matte which was then shipped to Salt Lake Valley smelters for conversion into slab copper. The original design (hearth roasting) was abandoned and the plant rebuilt with a capacity of 600 tons/day. In 1907, the company had decided to produce its own blister copper, and by 1908 the converter plant was installed [Leichter and Adamson, 1941]. The smokestack was 287 feet tall [Boutwell, 1905].

The Yampa Smelter reportedly processed copper ore at the rate of 1000 tons/day. Ore from the Yampa Mine was transported to the smelter by means of a 12,300 ft aerial tram. Most of the ore originated at the Yampa Mine with some custom ore from the Commercial Mine. According to one source [Spendlove, 1937], the smelter was erected in 1899 and handled 800 tons daily from its own mine, as well as 200 tons daily of custom ores from various leasers and small mines. USSRM records [1906] indicate that they too used the Yampa Smelter under the terms of a 3 year contract. In 1909 the converter furnace was shut down and copper matte was shipped to the Garfield smelter for further purification. The Yampa Smelter continued to operate until 1910 when it was taken over by the International Smelting Company [Spendlove, 1937]. In 1910, the company realized that it would be more cost effective to smelt their ores at the Garfield smelter and consequently, Yampa, the last operative smelter in the Bingham district, was shut down [Leichter and Adamson, 1941].

An article appearing in the 10-15-09 edition of the Salt Lake Mining Review described the smelting process and plant facilities. It reported that the smelter had a daily capacity of from 1000 - 1200 tons per day of ore and flux, operating with 3 blast and 3 reverberatory furnaces. It was located near the mouth of Bingham Canyon on a steep hillside. Although the topography was not advantageous, the 1909 article said; "it has the advantage of being in a barren region where there can be no damage done to stock or vegetation."

A 1909 publication of the Bingham Commercial Club confirms the facts given above. It stated that the Yampa Smelter included calcining furnaces, reverberatory furnaces and flowers. Steam power was generated using the waste heat from the blast furnaces. The Yampa Mine sent 250,000 tons/year to the smelter in 1909.

The ore was transported to the smelter by means of an 1 1/2 mile long aerial tram. After sorting by size, the ore was either crushed with a Blake crusher or milled with a set of Cornish rolls. The ore was then hauled in cars to the roaster building which contained 9 - 18ft. MacDougall roasting furnaces. The roasters drove off the sulfur reducing the sulfur content from 20% to 5%. The 1909 article mentioned that the roasters were started using coal, but once started, "the sulphur burns off itself." The roasted ore (called calcine) was sent by cars to the reverberatory building. The building contained 3 reverberatory furnaces, one with capacity 150 tons at 17 x 45 ft, and two with capacity of 175 tons at 17 x 55 ft. Matte was withdrawn out the bottom into molds (9 x 20 x 48 inches). "The slag is run through iron launders to the slag cars, which are hauled to the dump by electric locomotives and the slag wasted."

The 1909 article goes on to describe how the superintendent decides how much ore and flux is needed in the blast furnaces. He uses "chemical arithmetic". At Yampa, a typical mixture would be crude ore 4000 lbs, lime 1400 lbs, reverberatory matte 300 lbs, coke 600 lbs, and slag. The blast furnace building contained 3 furnaces: one 44 x 180 inches, one 42 x 168 inches, and one 44 x 186 inches. Dusts were recycled. The converter building (which was added in 1908) contained two converters (Leghorn type, Allis-Chalmers make). The molten matte from the blast furnaces was dipped with a ladle (using an electric crane) into the converters. Slag on the edges (edges were made with ore + wet clay binder), was recycled. The product was called blister copper and was 98 - 99% pure. It was cast into 300 lb ingots.

Kennecott [1997] reports that the Yampa Smelter was located near the former KUC safety office in Bingham Creek Canyon where the railroad passes over the paved road leading to the pit. The smelter was on the north side of the canyon. Slag and limited foundations can still be seen at the smelter site.

Kennecott [1997] collected 5 slag samples and one soil sample from underneath the smelter foundations. The slag had concentrations ranging from 128 to 1200 ppm arsenic and 124 - 1930 ppm lead. The soil underneath the smelter foundation contained 662 ppm arsenic and 689 ppm lead. A portion of the slag dump is visible as a black bluff on the north side of Bingham Canyon Road. The rest of the slag was buried by an electric power substation.

In 1994, the site of this smelter had not yet been subsumed by the Bingham Pit and dumps. The site was buried by waste rock when Bingham Canyon was filled in 2000. Because the site will soon be inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD in Sept 1998.

CHAPTER 5
PRECIPITATION PLANTS IN BINGHAM CANYON

Early miners observed that waters loaded with copper trickled out of the various waste dumps, and mine portals in Bingham Canyon. This was such common knowledge that downstream ranchers could recover copper from Bingham Creek. The creek had so much acid and copper in it that the water was undrinkable, but it did kill disease causing bacteria. Miners attempted to recover the copper in the various mine waters and from the creek itself by erecting precipitation plants. The first ones were not much more than a barrel or a tub (sometimes called "launders") placed near the mine portals or dumps. The chemistry of recovery was simple. The metallic iron added to the tub went into solution and the copper in solution precipitated out as metallic copper. Later precipitation plants used exactly the same chemistry, but at a larger scale.

HISTORIC MINE DRAINAGE (facility #110.01)

Earl [1929], using historic records, attempted to reconstruct the flows into and out of mines, mills, and sumps into Bingham Creek and groundwater. Earl indicated that the water flowed on the surface for only a short distance before it either evaporated or " disappears into stream gravels".

In 1929, the flows from the various mines entering Bingham Creek were:

Highland Boy Tunnels	47,300 gpd
Utah Apex Mines	580,000 gpd
Utah Metals Tunnel	200,000 gpd
Shawmut Tunnel	36,000 gpd
Tunnels in Markham	111,520 gpd
Niagara Tunnel	430,000 gpd*
Montana-Bingham Tunnels	78,000 gpd

*later diverted out the Mascotte Tunnel

In addition, the mine waste dumps worked as reservoirs and tended to release water during dry periods. Flows from the dumps in 1929 were measured as follows:

Dixon Gulch	14,797 gpd
Carr Fork Tunnel	108,000 gpd
Copper Center Tunnel	27,500 gpd
Cottonwood	101,400 gpd
Ingersoll	2,585 gpd
J. Guld	2,400 gpd
McGuires	19,000 gpd
Tiewaukee	10,857 gpd

TOTAL 286,539 gpd

Flows prior to placement of the dumps were estimated at 35,210 gpd.

Bingham Creek also received diversions from Middle Canyon at 216,670 gpd, and Barneys Canyon at 13,000 gpd.

Earl [1929] referred to some water analyses of various water sources:

Utah Delaware - unsafe for irrigation
Highland Boy Tunnel - unsafe for irrigation
Utah Apex - unsafe for irrigation
Utah Copper dumps - unsafe for irrigation
Cottonwood Gulch - unsafe for irrigation (this was diverted from Bingham Creek in 1927)

Earl concluded that in 1929, 60% of the total flow in the creek came from various precipitating plants which were removing copper from the mine drainages.

PRECIPITATION PLANTS IN COPPERTON (facility #81)

In 1923, Utah Copper began experimenting once more in an attempt to recover copper in the accumulating mine dumps. It had been noticed that rain and snow percolating down through the dumps emerged greenish-blue. Investigation indicated that some of the copper exposed in the waste rock had been oxidized into a form soluble in water. Company engineers and scientists soon found a cheap and effective way of extracting this copper by placing metallic iron in the solution and allowing the copper to trade places with the iron. The copper would precipitate out in the form of copper mud, while the iron went into solution. By this process, the company hoped to recover one billion pounds of copper from the otherwise worthless dumps. To make this possible, Utah Copper set up a test plant at the bottom of the pit in 1923. An improved precipitation plant was erected in 1924, followed by still another which operated successfully until the plant was built in 1929 at Copperton.

Kennecott[1997] indicates that in June 1929 the Copper Company constructed a dam across the lower end of Stringham Gulch to impound the tailwaters from its precipitating plants. Previous to that time, the tailwaters from all plants had been returned to Bingham Creek. After that date all the tailwaters from the precipitating plants were kept separate and none returned to the creek [internal Utah Copper memo, 1937]

Earl [1929] stated "On May 28, 1929 the tail waters from the Lead Mine precipitating plant were turned through the settling pond where they seeped away and none of the reached Bingham Creek." On May 13, 1929, 60% of the total water of Bingham Creek was tail water from the various precipitation plants on the creek.

According to a 1937 memo the original construction costs between 1928-1930 was $563K. The memo indicated that in the first year, tail waters from the precipitation plant were returned to Bingham Creek. In June 1929, Utah Copper built a dam across Stringham Gulch to impound the tailwaters from all the precipitating plants. In 1920 Utah Copper built the Bingham Magna ditch to carry the tailwaters from the precipitating plant to the tailings pond at Magna.

In 1930, the Copper Company constructed the Bingham-Magna ditch to carry tailwaters from the precipitating plant to the tailings pond in Magna. On Dec 22, 1933, Bingham Creek was diverted to the Lead Mine precipitating plant as provided for under Application No 11383. This diversion was for experimental purposes as the creek did not carry sufficient copper to pay for the cost of precipitation. The test continued for about three months [internal Utah Copper memo, 1937].

The plant in 1963 was 960 feet long and used detinned scrap from tin can factories to precipitate the copper in huge concrete tanks (launders) into which run the copper-bearing waters.

Pictures of the p-plant launders available in Kennescope [May, 1956 and Nov, 1958] show extensive use of concrete troughs [launders] and long settling tanks. The 1958 article said the launders were 4 feet deep, 4 feet wide, and 960 feet long. An attached shed for storing scrap iron and unloading rail cars carrying the scrap iron was 550 feet long. The product, copper mud, was 75% - 90% copper. The better grade concentrates were sold directly to paint pigment and powder metallurgists, the remainder was shipped to the smelter for further refining.

The 1962 production of this leaching plant was approximately 20 million pounds of copper which is almost 5% of the total 1962 production. [1963 source]. Kennecott (1996) reports that the concrete launders were demolished in 1965. Copper precipitate was removed and processed prior to demolition. The area where the concrete launders were located was sampled in 1995. The maximum As was 167 ppm, and the maximum Pb was 10200 ppm. Copper was as high as 211,000 ppm, and Selenium 202 ppm. According to Kennecott, this part of the area has been partially reclaimed, although no details were given. Further reclamation was considered, but the report suggested that soil removal in the contaminated area was not possible since 90% of the area to be reclaimed was covered with rubblized concrete and rebar from the old launders along with a few miscellaneous piles of waste. The report suggested capping. According to Kennecott [1997], during demolition of the launders, 30,000 tons of thickener material was sent to the leach dumps. High metals soils were sent to the leach dumps also. Scrap metal was washed and sent to Atlas Steel for recycling, low metals soil was used for regrading and clean debris was sent to the Trans Jordan landfill [Kennecott, 1997].

In 1986, the production of copper from the leaching operations was estimated at 11% of the total [Kennecott, 1984]. The active facility consists of upright redwood tanks. See also

Precipitation launders for early history.

A 1905 reference indicates that Utah Copper installed a tailings impoundment in the area. The pond, located at the Shovell Placer Claim, was built to impound tailings from Utah Copper's experimental mill.

The early precipitation plants were noted by Earl [1929] to be a source of groundwater contamination. "On May 28, 1929, the tail waters from the Lead Mine precipitating Plant were turned through the settling pond where they seeped away and none of the reached Bingham Creek." The context was to indicate that very little of the p-plant water reached the Bastian ditch

In 1963, one resident at the west end of Copperton protested the M-2 (manufacturing) zoning given to the Lead Mine Precipitation Plant. He was concerned that Kennecott would continue to use a "particular fume-causing acid" at their plant. He stated that over 1.5 million pounds of the acid had been "dumped in just a few days the week before and that the fumes were almost unbearable". Kennecott agreed to set up some air quality monitoring stations and the zoning was approved [Crump, 1978].

The present p-plant is thought to occupy the former site of the Lead Mine mill. Local sources suggest that it was built on 20 feet or more of waste rock was used to level the site. Underneath the fill may be the former Lead Mine mill tailings pond.

In 1981, Kennecott reported that the precipitation plant consisted of "two cone modules, or structures, each housing 13 cone units. The modules are operated in parallel. Each of the 26 cones is designed to process copper bearing solutions through shredded scrap iron. The scrap iron is combined with the solution in the cones to react on a continuous basis to produce a solid copper precipitate. The copper precipitate slurry is discharged at pre-set intervals into a thickener. The thickened slurry is then pumped to a surge mixing tank. Precipitate slurry is pumped from that tank to filter presses for dewatering and drying. The precipitate material is then conveyed to a loading and storage building where weighing, sampling and loading for smelter delivery takes place. Tailing solution from the cones passes in parallel through two 140 foot diameter settling basins. The overflow goes to the sump of the central pump station where it is recirculated throughout the leaching system."

On August 5, 1995, a power failure due to a lightning strike at the p-plant caused a release of barren leach water from a pump station. (Barren leach water is leach water from the dumps from which the copper has been removed at the p-plant. This water was typically recycled back to the dumps for re-use in leaching.) With the computer system out, about 120,000 gallons of barren leach water overflowed the West One Pump Station Sump. The water ran down the Bingham Canyon Road initially to a drain to the Small Bingham Reservoir and later to a Bingham Creek drain leading to the Large Reservoir. The road was washed and stained soils were later excavated.

On Oct 3, 1996, a front-end loader broke a buried 36 inch pipeline which carried leach water from the Eastside Reservoir to the p-plant. About 250,000 gallons spilled (225,000 gallons were recovered and returned to the leach circuit - about 25,000 gallons soaked into the ground - the area was behind the cut-off wall and leach collection system.

Another spill of leach water occurred on Sept 22, 1997 when a valve near the p-plant leached about 25,000 gallons. About 8,000 gallons were recovered in a nearby concrete basin (the debris basin just upstream of the Large Bingham Reservoir). The rest infiltrated into the ground. The spot was about 100 yards upstream of the Bingham Canyon cut-off wall.

The precipitation plant was closed in 2000 with the cessation of active dump leaching. The facility is scheduled for demolition and cleanup in 2005. The site was covered in the North End ROD of Sept 2002.

Figure 7: Precipitation Plant near Copperton, slated for demolition in 2005.

UTAH METAL AND TUNNEL (facility #39)

In 1910, the Utah Metal and Tunnel Co. started a tunnel under West Mountain, Its purpose was to drain mines and aid in the development of ore bodies. The tunnel was completed in 1913, and was 11,494 feet long. Its water flow was reportedly 750,000 gals per day. See the Water Supply Tunnel Dump (#67) for a description of the dump at the western portal. See the Water Supply Tunnel (#134) for the water quality information. The Bingham Canyon side of the site was closed out by the Bingham Creek ROD of Sept 1998. The Middle Canyon side of the site was closed out by the North End ROD of Sept 2002.

ROBBE CELLS (facility #35)

The Robbe Cells were constructed in 1922 and used to recover copper from runoff water from the waste dumps in McGuire Gulch under a lease arrangement. The operation was continuing in 1936 when Robbe got a 10 year license from Utah Copper. Water was diverted into the cells, the copper was precipitated out, and the water was discharged into one of the tailwater ditches. The cells were located north of Bingham Creek Channel and one quarter mile west of Highway 111. The Robbe Cells were concrete containment cells approximately 600 feet long and 12 feet wide. Steel and wood gates were used to separate the concrete structure into cells. There are smaller test cells of similar construction just west of the main precipitation cells. According to Kennecott [1994], operations ceased in 1958. (Another report [Kennecott Fact Sheet, 1997] indicates that the facility operated 1922-1936. Sludges were produced as well.)

As part of the Bingham Creek channel cleanup, in 1992, Kennecott demolished, decontaminated, and disposed of the structures associated with the Robbe Cells. Disposal of the concrete and related debris went to the Waste Rock Dumps where it was buried in the waste rock. At the same time, Kennecott removed most of the tailings in this area, and placed them in the Bluewater I repository. [Kennecott, 1992] Sludges from the containment cells were also placed in the Bluewater I repository [Kennecott, 1998]. The site was closed out by the Bingham Creek ROD of Sept 1998.

PRECIPITATION LAUNDERS (facility #40)

Once it was discovered that copper in solution from mine wastes could be recovered by reaction with scrap iron, many devices were installed in the canyon to precipitate the copper.

Boston Mine (facility 40.01)

At the Boston mine, workers noticed waters from the mine deposited copper on the steel rails. They built a small leaching plant in 1913. According to Kennecott [1997] the first shipment of precipitates was made on April 28, 1915. The net weight of the shipment of concentrates was "28,1915" [sic] pounds carrying 15,651 pounds of copper. [History of Utah

Copper, 1925]. The location of the Boston mine could not be found. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out in the Bingham Creek ROD of Sept 1998.

Apex Yard (facility #40.02)

Apex Yards noticed leach water from their railroad dumps and they installed a precipitation plant in 1916. The yard was located on the Carr Fork side. On Oct. 19, 1921, shipments of concentrates weighed 276,944 pounds and carried 214,630 pounds of copper (History of Utah Copper, 1925).

An internal Utah Copper memo [1937] outlined further information about precipitation plants including the Apex Yard. "Precipitation of copper from waters was first started by the Copper Company in 1915, with a small plant near the Apex Yard. This was the only stream of water carrying copper in sufficient quantities to justify the expenditure of any sum of money for precipitation plants." The cost of the plant was estimated at $1500.

The site has probably been subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Ohio Copper Mine (facility #40.03)

Other precipitating launders were built at numerous locations: Ohio Copper mine, Ute Copper Co at Tiewaukee dump, Rogge at McGuires Gulch, and others at Galena Gulch, Copper Center Gulch, Main Canyon, A Pit, Drain Tunnel and Ingersoll Gulch [Spencer, about 1922]. A description of the Ohio Copper leaching operations is given in the Ohio Copper Mill description (#51) in Lark.

Ute Copper Tiewaukee Dump (facility #40.04)

In 1925, the Ute Copper Company owned the underground mineral rights under the Tiewaukee Dump. They drove a raise to the bottom of the overlying dump and diverted water to precipitation boxes (History of Utah Copper, 1925).

Although Utah Copper owned the surface rights and the dumps, the Ute Copper Company (Montana-Bingham?) intercepted the water by extending their bedrock works and diverted the copper laden waters from underneath [Billings, 1952]. Billings [1952] further indicates that water flowing down Winamuck Gulch from the Utah Copper waste dumps were diverted from the gulch into the old Tiewaukee mine workings. The water flowed to the lower tunnel. The precipitating plant was located on the old mine dump at the portal of the Tiewaukee lower tunnel. Utah Copper then drove tunnels of their own in Winamuck Gulch to intercept the water. The competing companies engaged in a race with their competing tunnels.

The Supreme Court later ruled that this water belonged to Utah Copper. The Tiewaukee Dump was located in Winnamuck drainage approximately ½ mile below the confluence of Carr Fork, and Bingham Canyon. An internal Utah Copper memo [1937] indicated that the cost of the plant was $5100. Later, waters from this operation were combined with waters from other dumps at a central plant in Cuprum. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

McGuires Gulch (facility #40.05)

In the spring of 1919 George Robbe, chemist for Montana Bingham Consolidated Company, observed blue water percolating through the old mine dumps at the bottom of McGuires Gulch and by analysis found it carried approximately 30 pounds of copper per 1000 gallons of water (Billings, 1952). He also determined that the copper could be retrieved by introducing tin cans into the water. A small precipitating plant was built at the mouth of the McGuires Gulch. Water from the gulch was diverted to the plant to precipitate the dissolved copper.

An internal Utah Copper memo [1937] also contained a few details on this plant. The lease for the waters of McGuires Gulch was given to George Robbe and his plant cost $6600. In 1928, Robbe constructed a pipeline to divert waters from Dixon's Gulch to his plant at McGuires Gulch. Ownership of Dixon Gulch water was also disputed by Utah Copper (owner of upstream dumps) and the Stephen Hays Company who owned the land on which the spring emerged. Utah Copper won this dispute [Billings, 1952].

Ownership of the leach water from McGuires Gulch was the subject of several lawsuits. The spring in McGuires Gulch was originally used for drinking water by the McGuires via a pipeline. Shortly after Utah Copper began dumping in McGuires Gulch, the water quality became poor. According to Kennecott [1997], in 1916, water from McGuires Gulch Spring was contaminated by copper leached from tailings which had been dumped in the gulch. Utah Copper accepted responsibility, provided the McGuires with town water from Bingham, paid Mrs. McGuire $3000 in damages and eventually paid her another $1000 for all claims to the water (History of Utah Copper, 1925). Billings [1952] indicates the agreement stated that Utah Copper owned the copper and the McGuires owned the water. Robbe and Billings got a lease of the rights to the copper from Utah Copper. Montana Bingham Consolidated Company obtained an option of water from Mrs. McGuire and a lease on a royalty basis from Utah Copper to recover the copper that was in solution in McGuires Gulch. A court battle ensued over water rights when Utah Copper began diverting water upgradient from Montana Bingham's precipitation plant. The District Court ruled that Utah Copper owned the land between the surface and bedrock under its waste rock piles including the water percolating from the dumps. The U. S. Supreme Court upheld the lower court's ruling. This ruling was generally accepted by the property owners in Bingham (Billings, 1952).

In 1917, Salt lake County assessor tried to collect taxes on copper left in tailings. The assessor suggested that there was $68M worth of available copper in the 57 million tons of tailings that could be recovered by flotation. Utah Copper contested the taxes stating that the county was without the authority of the law to assess such taxes. In 1924, the Supreme Court ruled in favor of Utah Copper.

In 1926, the total shipments for wet precipitates from all sources amounted to 3,794,679 pounds and gross copper content amounted to 1,989,356 pounds. Facilities included Galena Gulch, Copper Center, Main Canyon, A Pit, Drain Tunnel, McGuires Gulch, Apex Yard, and Ingersoll Gulch.

Many of the precipitation plants obtained the iron needed from Hewletts Cannery in Salt Lake City and later from a source in California.

Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Galena Gulch (facility 40.06)

An internal Utah Copper memo [1937] indicates that a precipitation plant was built at Galena Gulch in the spring of 1922. The cost was reportedly $6000. It was one of several plants described as temporary as there was not enough space available at these sites for the construction of very large plants and it was necessary to lay pipelines to conduct these waters to a central site. Kennecott [1997] reported that Galena Gulch is located in upper Bingham Canyon. Galena Gulch and Bear Canyon join to make Bingham Canyon. The exact location of the precipitation launder is not known. The upper portion of Galena Gulch is covered by waste rock and the lower portion is mined out. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Copper Center Gulch (facility 40.07)

An internal Utah Copper memo [1937] indicated "By 1921 the waters from Copper Center Gulch had started to carry copper and in that year a test plant was constructed" [at a cost of $6000]. It was one of several plants described as temporary as there was not enough space available at these sites for the construction of very large plants and it was necessary to lay pipelines to conduct these water to a central site. Kennecott [1997] indicates that Copper Center Gulch is located in upper Bingham Canyon approximately 1.2 miles upgradient from the confluence of Bingham Canyon and Carr Fork. The exact location of the launder is not known. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Main Canyon (facility #40.08)

A precipitation launder at "Main Canyon" was mentioned in Spencer, about 1922. It was not mentioned in an internal Utah Copper memo [1937] describing historic precipitation launders. The location of this launder is not known. Since most of the main canyon is now buried with waste rock, it is inaccessible to residents, workers, and wildlife, and it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

"A" Pit Precipitation Launder (facility #40.09)

Spencer [1922] and an internal Utah Copper memo [1937] mention the construction of a precipitation plant at "A" Pit. The KUC memo [1937] indicates the plant was constructed in 1923, and was one of six plants constructed at the same time. The total cost of the six plants was $43,500. Kennecott [1997] indicates that the exact location of this plant is not known. It is likely this Precipitation Launder was located in the lowest level of the open pit at the time. It operated until the centralized facility was built near Copperton in 1929. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Drain Tunnel Precipitation Launder (facility #40.10)

Spencer [1922] and an internal Utah Copper memo [1937] both mention the construction of a precipitation plant at Drain Tunnel. The KUC memo [1937] indicates the plant was constructed in 1923 and was one of six plants constructed at the same time. The total cost of the six plants was $43,500. Kennecott [1997] indicates that the exact location of this plant is not known. The site was closed out by the Bingham Creek ROD of Sept 1998.

Ingersoll Gulch (facility #40.11)

Spencer [1922] and an internal Utah Copper memo [1937] both mention the construction of a precipitation plant at Ingersoll Gulch. The KUC memo [1937] indicates the plant was constructed in 1922 or 1923, and was one of six plants built around the same time. The total cost of the six plants was $43,500. It was one of several plants described as temporary as there was not enough space available at these sites for the construction of very large plants and it was necessary to lay pipelines to conduct these waters to a central site. Ingersoll Gulch is located immediately north of Muddy Fork Canyon approximately 1 1/3 mile from the confluence of Carr Fork and Bingham Canyon [Kennecott, 1997]. Ingersoll Gulch was later subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Starless (facility #40.11a)

Earl [1929] discussed a precipitation plant called "Starless". It was a small plant whose tailwaters could reach Bastian Ditch. The Starless group of patented claims adjoined the Utah Copper properties on the northeast. Starless ore was milled in the old days by the Dewey (Wall) mill. [Bingham Commercial Club, 1909]. This facility might be the same as the Copper Placer Plant, also known to treat waters from the Starless vein (see 40.12). Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

McGregor Plant (facility #40.11b)

According to an internal Utah Copper memo [1937], "The waters of Bingham Creek were leased to George Robbe, the lease being dated March 2, 1936, and in January of that year Robbe began the construction of diversion ditches and a precipitating plant located partially on the property purchased from Bastian under date of February 27, 1936. In the construction of diverting works and a precipitating plant for the handling of water under Application 11385, $30,833.09 was spent. A temporary diversion of the water was made on April 2nd of that year and on June 29 he began the operation of his new plant. From April 2, 1936 to July 15, inclusive, Robbe was operating the McGregor Plant."

There must have been a dispute about the use of these waters. According to the internal Utah Copper memo [1937], "On April 28, 1933, the Bastian boys leased certain lands bordering on Bingham Creek for the purpose of extracting any and all minerals upon same and such of the surface as is necessary for the treatment of said minerals. Included in this area is the so-called "Excelsior Placer which the Utah Copper Company purchased on February 26, 1936 and upon which the Bastians' did not have any mining rights..."

"Very shortly after this lease was executed, the McGregors began the construction of a precipitating plant which was completed about the last August of that year. They attempted to operate the plant for about eight or nine months when operations ceased, and from that time, the plant was not operated until Robbe began to construct his plant under Application No. 11385, when the McGregors' returned and they were notified that they had no right to use the land."

"About the middle of March of that year, the McGregors were forcibly ejected from this property." The site of this operation was probably in the Robbe Cell area. If so, any wastes would have been cleaned up during the Bingham Creek channel removal action.

Kennecott has copies of the various leases involved. The Bastians leased the surface of the land to McGregor to placer mine. He built a precipitation plant instead. The original lease was signed April 3, 1933. McGregor tried to exercise an option to renew the lease on March 18, 1936. [Bastian, et al., 1933, 1936]. The option was requested shortly after he had already been evicted from the property. McGregor was clearly unhappy about being evicted and finding George Robbe at the site. He sought damages and return of his property from the Bastians, Utah Copper, and George Robbe [McGregor, 1936]. On March 2, 1936, Kennecott Utah Copper had leased the water in Bingham Creek to George Robbe and gave Robbe the right to operate the "So called McGregor and Robbe precipitation plants [KUC, 1936]. The lease also gave Robbe the right to use Kennecott's tailings pond constructed for the settling and collection of acid waters. The site was closed out by the Bingham Creek ROD of Sept 1998.

Utah Copper Winamuck precipitation plant (facility #40.11c)

Utah Copper built a small precipitating plant about 200 feet north of the Denver and Rio Grande Railroad depot in lower Bingham. He plant was built to recover copper from Utah Copper dumps in Winamuck Gulch (see also Tiewaukee precipitation plant, 40.04). Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Copper Placer Plant (facility #40.12)

The Copper Placer Plant was probably located near the intersection of Carr Fork and Bingham Creek canyons. In 1892, the mill was completed (Engineering Mining Journal, Aug 6, 1892] and may have operated through the later 1890s. The earliest operator may have been Bingham Copper; in the late 1890s, Fred Mueller Company probably was the operator. A reference is made in the Jan 29, 1898 Engineering Mining Journal to a Mr. Mueller erecting a mill to process copper bearing water from the Starless vein. This area has been subsumed by the Bingham Pit. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

Cuprum Yard Precipitation Plant (facility #40.13)

An internal Utah Copper memo [1937] indicates that a precipitation plant was built at Cuprum Yard during 1927 and 1928. It was built to serve as a central plant with pipelines laid so that all the upper waters could be handled in one plant. The Cuprum Precipitation Plant was located on a hillside east of the current central yard near the Bingham Mine Truck Shop on the NE margin of the Bingham Pit [Kennecott, 1997]. The plant was a precipitation plant that extracted copper from waters that had passed through waste rock. Operations begin in 1928 and continued through the 1930s. Detinned scrap iron was used as a precipitating agent. Tailings and overflow from the settling tanks was conveyed by a wood-stave gravity pipeline to Bingham Creek. The site is near the edge of the pit; a portion has been mined away and another portion is under the dumps. The only remaining remnant of the site are some cement pillars. The date of demolition is not known. Kennecott suspects that any demolition debris was placed in the nearby waste rock dump. Eventually the entire site will be mined away. Because the site is currently non-existent or inaccessible to residents, workers, and wildlife, it has been given "No Action" status for CERCLA response purposes. The site was closed out by the Bingham Creek ROD of Sept 1998.

CHAPTER 6
HISTORIC RAILROADS IN BINGHAM CANYON

The entry of railroads in the west made mining profitable for the first time. Transportation of the ores, concentrates, and products became much less costly when the transcontinental railroad (Union Pacific and Central Pacific) arrived in 1869 and the Denver and Rio Grande arrived in the 1880s. The railroads also built branch rail spurs to the mining districts (hard rock and coal) along their routes to facilitate transportation of the ores to processing facilities or consumers. Some of the mining companies founded their own railroads. Kennecott had its own railroad. In yesteryears this rail system was extensive. In 2005, the Kennecott Railroad is used exclusively to haul sulfuric acid tank cars and metal products from the smelter to the main Union Pacific line nearby.

BINGHAM PIT RAIL OPERATIONS (facility #79.01)

The Copperton line or Copperton low line was completed in 1948. The line started at the Copperton Yards and went 16 miles to Magna. The line was electrified with a 3000 volt system. The electric system in the pit was 750 volts. Power was supplied with a new gas-fired power generation plant near Magna with a substation at Bacchus. The Bacchus plant to changed to a coal fired plant in 1965. The entire line was dieselized in 1979. The original cost of the line was $5 Million [Crump, 1978].

Rail operations in the pit itself began using steam switchers to haul ore from the pit to the Denver and Rio Grande yards. Stub end tracks were laid high in the foothills for waste dumping. In 1928, the pit rail operation was electrified using a 750 volt system to go with the 550 volt electric shovels. The constant relocation of electrical towers became costly and all the tracks were removed from the upper half of the pit by 1963. The entire line was dieselized in 1979. By 1983, the rail operations in the pit had ceased except for one spur from the loading area through the tunnel to Copperton Yard. This one spur was used until 2000. Trains of 20 ore cars (plus one locomotive) would leave Copperton Yard going up the canyon to the 5840 tunnel, through the tunnel into the pit. In the pit, the cars would be positioned next to a stock pile of ore. A steam shovel would scoop up the ore and load the ore into a railcar (about 3 scoops per railcar). After car was filled, the locomotive engineer would re-position the train for the shovel to fill the next car. The whole operation was choreographed very well between the shovel operator and the train crew. (If the shovel operator missed the railcar and dumped the ore between the cars, the whole thing would have to be cleaned up before the train could move. This didn't happen very often.) After all the railcars were filled with ore, the 20 cars were hauled out of the pit through the tunnel back to Copperton yard. When 60 to 100 filled cars were ready at the yard, another crew would haul them in one train to the Bonneville Crusher.

There were several tunnels built to give trains access to the pit. In 1944, a 3975 foot tunnel was bored at the 6040 level. In 1952, a 7000 foot long tunnel was bored at the 5840 level. Until recently, this tunnel was in use for Kennecott ore trains. [Carr and Edwards, 1989].

Recently the pit portal and several hundred feet of the tunnel was blasted away as the pit expanded. The canyon portal was buried in 2001, and all rail service in the pit ceased at that time. In 1959, a 17058 foot long tunnel at the 5490 level brought trains directly into Copperton Yard. The tracks were removed from this tunnel in 1988 when a new conveyor belt system was installed to bring the ores from the pit to the new Copperton concentrator [Carr and Edwards, 1989]. Slightly different information about the tunnel was given in Crump [1978]. He reports that construction of this tunnel began in 1956 and completed in 1961. The eastern portal was just southwest of the Copperton Yards. This site was excluded from the Bingham Creek ROD, and was not a part of the Superfund action. It is covered by a variety of environmental and operational permits.

NEW ORE LOADING AREA (facility #79.01a)

Between spring 2000 and fall 2001, trains no longer went into the pit to get loads of ore going to Bonneville Crusher. Instead, the huge mine trucks carried the ore out of the pit, down a haul road in the former Bingham Canyon to an artificial cliff near the intersection of Dry Fork and the canyon. Electric shovels and front end loaders then scooped up the ore and loaded it into the ore cars. In the pit, the maximum length of the trains was 20 ore cars. At the new loading area, there is space for 35 cars.

Two locomotives hauled a consist of 35 empty ore cars up the canyon to Dry Fork and then backed the cars into a wye. As the cars were loaded, the locomotives pushed more cars in next to the shovel. It took three scoops to fill an ore car. When the cars were full, the train backed down the canyon and left the 35 loaded cars in the Copperton Yard. The crew then went after another 35 empty cars and the process was repeated. The two sets of 35 cars were coupled together for a 70 car train to Bonneville.

When this system was first put into operation, there were complaints from citizens of Copperton about excessive dust fall. This was abated by use of electric shovels instead of entirely relying on front end loaders and the truck traffic was reduced now once the stockpile was established. The ore loading station is no longer used now that the Bonneville Crusher has been retired. The ore loading area was in use for less than three years and the tracks were removed in 2003. This area is due for burial by waste rock as the Bingham Canyon is filled. Trains are no longer used to haul ore to Magna. The Bonneville Crusher and Magna Mill have been closed and slated for demolition. All the ore cars were either sold or scrapped. The ore-loading area was closed out in the North End ROD of Sept 2002.

COPPERTON RAILYARD (facility #79.02)

The Copperton Railyard (assembly yard) was built between 1946-1948 when Kennecott constructed its dedicated ore haulage rail line between Copperton and Magna. "The yards were built to serve as a place where trains coming from the mine could bring loaded ore cars and pick up empty ones from the mill," [Crump, 1978]. The line between Magna and Copperton was electrified when it was first built, but the line between Copperton and the mine was operated at a lower voltage. The control building was red brick. Switching equipment installed at the yard in 1948 was only recently upgraded in 1996.

In 1949, there was a runaway train accident at Copperton yards. Brakes failed on a loaded ore train consisting of 12 ore cars. The locomotive and 5 cars jack knifed into the air about 3.5 miles out of the tunnel. The remaining 7 cars continued on at high speed into the yard. A switch in the yard was closed, and workers were warned. The ore cars sheared the rails and leaped the tracks. Ore "was spilled over a wide area," [Crump, 1978]. There have been other

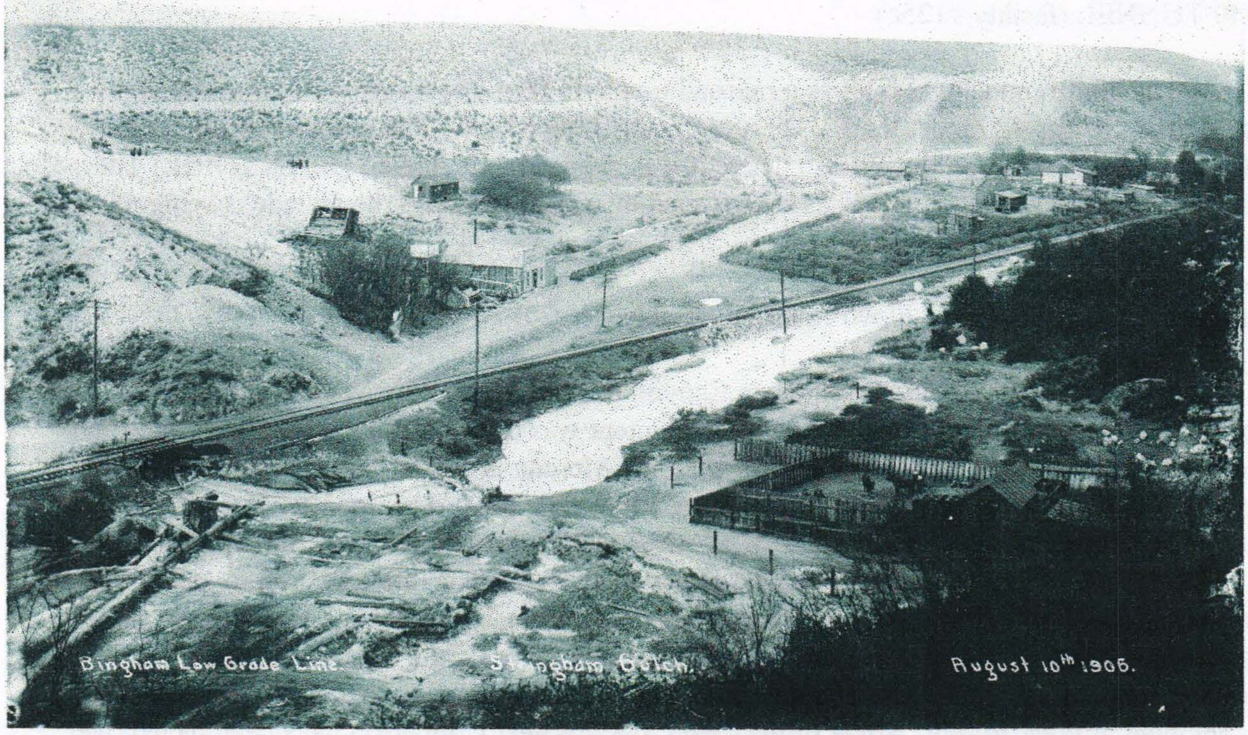

Figure 8: The Denver and Rio Grande Low Line near the mouth of Bingham Canyon in 1905

runaway trains but the damage was minimized by construction of a runaway train track on the mountain to the south of the yards on the old Denver and Rio Grande Western High Line tracks [Crump, 1978]. Dieselization of the entire rail system was completed in 1979. A modern signal and switch system was installed at the yard in 2000. When rail service to the pit ceased, the equipment was moved to the north end. The railyard is not abandoned, but has little use. The site was included in the North End ROD of Sept 2002.

5490 TUNNEL (facility #125b)

This tunnel was constructed in 1957 by Kennecott through an agreement for a perpetual easement with USSRM. The tunnel was to be used for haulage of ores from Kennecott property. Any ores found during the process of construction of the tunnel would belong to USSRM. Kennecott agreed not to use locomotives emitting fumes until it had first closed shafts to USSRM works [USSRM, 1957]. Kennecott collected water from this tunnel in 1990 to determine the water quality of groundwater in bedrock underneath the Eastside Dumps. A brief narrative about the sample collection was that not much unaltered water could be collected because the tunnel was grouted. (ABC, 1990). Kennecott [1996] indicates that the tunnel is part of the system for conveying ore from the Bingham Canyon to the Copperton concentrator. The Copperton Concentrator conveyor belt system goes through this tunnel. The current flow rate is about 50 gpm and is collected for use in the Kennecott process water circuit.

6040 TUNNEL (facility #125c)

The 6040 Tunnel was built as a railroad tunnel to facilitate transportation of ore and waste rock. It was 4200 feet long, 24 feet high and 18 feet wide. The tunnel was supported by 6" - 8" I beam sets except on the pit side where it was supported by timber. [Billings, 1952] The Bingham Creek side of the tunnel has been buried by waste rock, and the pit side is being mined away.

Bingham Canyon and Camp Floyd Railroad (facility #40.20)

The first track was laid in Bingham Canyon in 1873 by the narrow gauge Bingham Canyon and Camp Floyd Railroad. The original intent was to serve Bingham Canyon mine and climb over the ridge to serve the mines in Ophir and Mercur as well. The Galena Silver Mining Co. erected a smelter at Midvale at the eastern end of the tracks. The line was first bought by the Wasatch and Jordan Valley Railroad in 1879, who sold it to the Denver and Rio Grande Western in 1881. The Bingham Branch was standard gauged in 1890. The line was used to ship ore from Bingham Canyon to the Midvale and Murray smelters until construction of the Bingham and Garfield Railway and KCC's Copperton to Magna line. After that it was used mainly for shipping supplies and coal to the canyon. [Carr and Edwards, 1989]. Now the line is used only for shipping in West Jordan. Some of the road crossings near Copperton have been paved over but the tracks are still there. The portions of the right-of-way now owned by Union Pacific are not a part of the CERCLA action (ROD, 2002). The ROD requires characterization and remediation of the Kennecott owned portions of this railroad right of way.

Dalton and Lark Railroad (facility #40.21)

Several shortline railroads were built around 1900 including the Dalton and Lark from Lead Mine to the Dalton and Lark Mine and then to the Yosemite mines. [Carr and Edwards, 1989]. This area has been subsumed by later dumps and has been closed out by the OU 3, 6, 7 ROD of Sept 2001.

Copper Belt Railroad (facility #40.22)

Several shortline railroads were built around 1900 including the Copper Belt Railroad which extended from the Denver and Rio Grande Yard at Bingham up the canyon to the Jordan, Commercial, and Telegraph mines. It followed the route of a former mule tram way. [Carr and Edwards, 1989]. The route has been buried by waste rock or subsumed by the pit. The site was closed out by the North End ROD of Sept 2002.

Denver and Rio Grande Low Line and Cuprum Yard (facility #40.23)

The Denver and Rio Grande expanded their operations in the Canyon itself in 1906 when it built a low-grade line from Lead Mine (a.k.a. Loline Junction) to the south in the foothills then around a horseshoe curve back to the canyon, then up the canyon to a wide flat area where the railroad built a staging yard called "Cuprum Yards". The Denver and Rio Grande Western line was double tracked between Bingham and Welby, but not between Welby and Magna. This led to a bottle neck and the mine created their own railway company dedicated to hauling ore between Bingham and Magna. In 1925, the Denver and Rio Grande was not using their tracks in Bingham Canyon and this part of the line was sold to Utah Copper. Utah Copper continued to use Cuprum Yards. The portion of this line now owned by Kennecott has been closed out by the North End ROD of Sept 2002. The route on Kennecott has been buried by waste rock. The ROW in the valley is now owned by Union Pacific and is not a part of the Kennecott site.
It is suspected that the railbed used to construct the former Denver and Rio Grande spur from Midvale to Bingham Canyon originated at Midvale Slag. This slag from a former lead smelter is known to contain elevated concentrations of lead and arsenic. The railroad refused access to

EPA, Kennecott, and ARCO during the cleanup of the Bingham Creek channel. Denver and Rio Grande High Line, Cuprum Heights (facility # 40.24)

When Denver and Rio Grande Railroad Company in 1906 built its High Line to serve the Utah Copper open pit, it acquired easements on the surface in Ely Gulch for its roundhouse and track facilities and the location was called Cuprum Heights. Located above the canyon, it was reached by winding stairs starting at City Hall. [Billings, 1952]. The whole area has been buried by waste rock and was closed out by the North End Rod of Sept 2002.

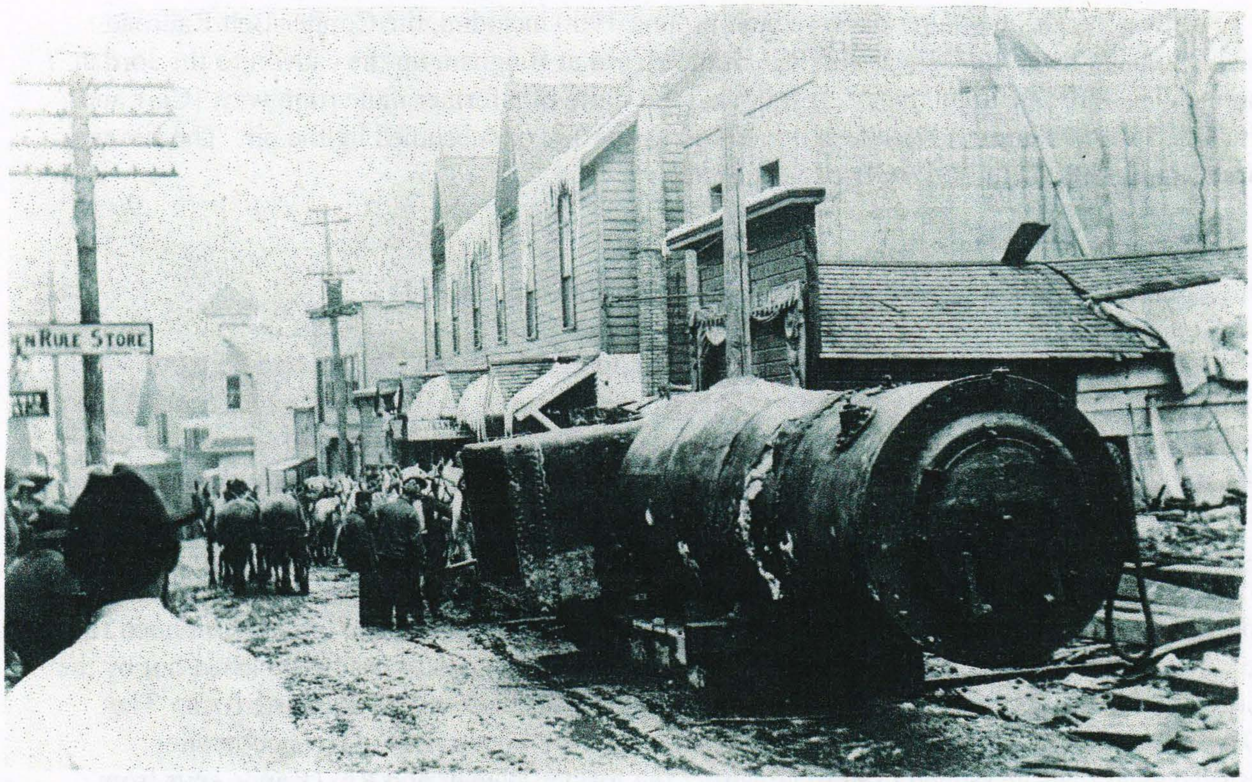

Figure 9: Railroad accidents in Bingham Canyon were a fact of life. In this case, the locomotive ended up on Main Street in Bingham City.

Bingham and Garfield RR, Bingham Yard, Auxiliary Yard (facility #40.25)

Utah Copper formed its own railroad subsidiary, the Bingham and Garfield Railway which completed its own line between Bingham and the Magna mills in 1911. The line is about 20miles long and included 4 tunnels in the Canyon and 3 trestles over Dry Fork, Markham Gulch and Dry Fork. The major assembly yard, the Bingham Yard was located between the Carr Fork and Markham Gulch bridges, with an Auxiliary Yard south of Carr Fork. Pit engines would bring out loaded ore cars to the Auxiliary Yard where they would brought to the Bingham Yard for assembly. Apex ores were brought directly to the Bingham Yard. "The only waste handled by the Bingham and Garfield was from the US Mine. The railroad hauled the waste to Magna where it was used to construct the dikes for the tailings pond." [Carr and Edwards, 1989]. The line was largely abandoned in 1948 when a new line solely dedicated to hauling KUC ores was constructed. [Carr and Edwards, 1989] The North End ROD requires characterization of the former railbed and remediation if needed. The route of this railbed may have been used as the base for the tailings slurry lines.

CHAPTER 7
INACTIVE MINE WASTE DUMPS AND PONDS IN BINGHAM CREEK AREA

There were early attempts to contain the wastes coming down Bingham Creek with only mixed success. Below are examples.

ANACONDA TAILINGS (COPPERTON TAILINGS, ARCO TAILINGS) (facility #45)

ARCO's subsidiary, Anaconda Minerals Company, owns about 96 acres of property including the area of old lead tailings known as the Anaconda Tailings. The three most likely sources of the Anaconda Tailings are the Lead Mill, the Markham Mill, and the Utah Apex Mill. Sources suggest that the Utah-Apex Mill was the primary contributor to this tailings area. In 1928, Utah-Apex Mining company signed an agreement with Utah Copper Company allowing Utah-Apex to construct a flume from Bingham Creek, across Utah Copper property, to the Anaconda Tailings area. This agreement states that Utah-Apex was constructing the flume for the purpose of depositing its tailings from a higher elevation in its tailings pond. [SAIC, 1991]

In 1914, the Utah Apex Company constructed a series of diversion structures on Bingham Creek upstream of the site. These structures diverted tailings into the site, an area which may have already been used for tailings disposal from earlier mills. During this period, a series of impoundments were constructed allowing the tailings to be deposited on the south side of Bingham Creek Channel. The tailings that accumulated in these impoundments are residuals from historic mining and milling operations in Bingham Canyon. Use of the site for tailings impoundment ceased in the early 1930s, and the site has since been inactive.

The tailings slurry was used to construct the tailings impoundment using a technique known as "upstream" construction. This technique consists of constructing a starter dam or embankment to retain the tailings slurry and supernatant water. A definite depositional pattern results from this process with coarser, sand-sized particles settling near the point of slurry discharge and finer, silt-sized particles settling throughout the impoundments.

The tailings impoundments were constructed by raising starter berms on the north and east perimeters. The impoundments were then progressively raised as the tailings were deposited and dewatered. This procedure resulted in approximately seven terraced surfaces. The tailings range in depth from approximately 35 to 40 feet in the two westernmost impoundments to approximately 5 to 15 feet in the easternmost impoundment. Relict wood trestles and other structures used to construct the impoundments and the tailings slurry diversion were still visible before remediation. [ESE, 1993]

A comparison of total tailings production by Utah-Apex with the volume in the impoundment suggest that there was more in the impoundment than could be accounted for by Utah-Apex alone. If all the Utah Apex tailings after 1914 were captured in the impoundment, this suggests that 661,000 tons came from elsewhere, presumably from relic tailings from other mills and alluvial material from the canyon. [Randolph, 1991]. Utah Apex wanted to retain title to the tailings in 1933, because they believed that the tailings had economic values [Randolph, 1991].

Estimates for the volume of tailings range from 1,245,000 cubic yards to 1,527,100 cubic yards. The exact mass balance of the tailings entering, leaving, and stored by the facility is controversial.

Tailwaters from these ponds were used for irrigation purposes (see Bastian Sink, Bastian Ditch). A letter from Utah Copper [1929] said "the first time we had any trouble with Bastian [referring to pollution of irrigation waters with copper] was the time when the Apex pumped a lot of water on the Cottonwood Dump which came at a time when there was considerable stream runoff, causing so much copper to run into Bingham Creek that the Apex company had to put tin in their launders at the tailings plant in order to precipitate the copper from these waters." [BCG, 1929]

Remediation of the site has been done by ARCO under a Unilateral Order using CERCLA removal authorities. Removal activities started in 1993. The tailings were consolidated, covered with a lined cap and soil layer, and revegetated. The OSC was Steve Way.

The Closure Report for this project was submitted to EPA in December, 1997. ARCO reported that the parcel of land involved was 95 acres, about 35.6 acres of which was used for the tailings impoundment. Another 5 acres of Kennecott property was also a part of the impoundment. Remediation of the site included the following activities:

1. Tailings on ARCO property, including tailings from the Bastian Ditch (that portion on ARCO property), were placed on the ARCO tailings impoundments.

2. Tailings lying on properties between ARCO's property and the Kennecott haul road were removed and placed on the ARCO tailings impoundment, including those areas in Bingham Creek Channel down channel from 3200 West in West Jordan.

3. Materials within areas along the historic Bingham Creek Channel floodplain that were "impacted by erosional releases" were removed, transported back to the ARCO property and placed on the impoundments.

4. Areas affected by the removal activities were regraded, including replacement of soil, and were revegetated with native plant species.

5. Samples were collected to verify that the removal of tailings was complete (or map where wastes were that could not be removed (near utility poles and trees)).

6. Disturbed tailings that were placed on the area to be capped were compacted to design specifications.

7. Soil borrow sources for the cap were identified and tested.

8. Cover material and geomembrane liner was installed in accordance to the design, and the north perimeter of the capped impoundments was armored with a concrete retaining wall structure and rip rap designed for an even equivalent to one-half the probable maximum flood in

Figure 10: Runoff ditch from the ARCO tailings cap going toward Bingham Creek.

the Bingham Creek Channel.

9. Interim drainage ditches for run-on and run-off control were constructed to prevent continued erosion of tailings to offsite areas during construction of the cap; permanent run-on and run-off controls were installed after completion of the cap.

10. Erosion protection was established in Bingham Creek Channel to prevent any future alignment of the channel from undercutting or destabilizing the base of the impoundments.

11. Monitoring systems were installed to detect the presence of groundwater infiltration into the tailings impoundments, to detect any leakage through the cap and liner system, and to monitor groundwater quality at the site.

12. Vegetation was established on the final cover and the area has been secured with a fence.

The impoundment area now capped is suitable for future land use as open space or as a waste storage area. No building is appropriate on the cap. The areas adjacent to the cap was cleaned up to industrial/recreational land use (2000 ppm Pb), but large tracts of it is appropriate for residential use (<1100 ppm Pb).

ARCO also owns a small 1 acre parcel of land just to the east of Kennecott's Large Bingham Reservoir. The soils are discolored. Sampling revealed that this is in a area of copper tailings; lead and arsenic values were low. No remediation was necessary at this location.

Figure 11: ARCO tailings prior to consolidation and capping.

The Anaconda Tailings area was closed out by the Bingham Creek ROD of Sept 1998. ARCO and the US Government settled the remaining financial issues shortly thereafter. A Five Year Review of this facility indicates that the cap has held up well. The presence of wildlife is evident. Wildlife seen at the site include owls, badgers, and deer.

MIXED TAILS (facility #46)

Near the Robbe Cells adjacent to Bingham Creek just downstream of the Large Bingham Reservoir and on the north side of the creek opposite the ARCO tails, there is a deposit of tailings called the "mixed tails" which, according to Kennecott, are a mixture of copper and lead tailings. These tailings originated from the area of the Large Bingham Reservoir and were removed from this area prior to construction of the original reservoir in 1965. These tailings were removed to the Bluewater repository, as part of the Bingham Creek Phase 2 removal. This site was closed out by the Bingham Creek ROD of Sept 1998. This area is now leased to a local nursery.

SOUTH JORDAN EVAPORATION PONDS (facility #47)

The South Jordan Evaporation Ponds are located on Kennecott property approximately 7 miles east of the Bingham Mine, 1 mile south of the Bingham Creek and 5 miles east of the Jordan River. It was located in the western portion of the City of South Jordan.

From 1936 until the Bingham Reservoir was constructed in 1965, the Evaporation Ponds were used to store and evaporate surface water from the Bingham Canyon watershed in order to prevent surface water discharge to the Jordan River. From 1965 until cleanup in 1994, the ponds were used only on an emergency basis in extremely wet years to store and evaporate excess runoff from the Bingham Canyon watershed. In 1983 additional pond capacity of 1279 acre-feet was constructed; these new ponds and one of the old ponds were lined with compacted clay. Before clean up in 1994, all the ponds had been drained and some had been treated with lime, capped, and vegetated.

There is no written record of the volume of water released to the Evaporation Ponds during 1936-1965, but engineering studies of the watershed suggest rates of discharge of about 900 acre-ft/year prior to 1965. Approximately 80% of this discharge is estimated to have seeped into groundwater annually [Kennecott, 1991]. From 1972 to 1984, untreated water entering the pond ranged from 160 acre-feet/year to 1700 acre-feet/year. Lime treatment started in 1982. During that period, treated water entering the pond ranged from 390 acre-feet /year to 3799 acre-ft/year.

There were approximately 3.1 million cubic yards of treated sludge in the ponds covering 375 acres. Besides the sludges in the ponds, additional soil contamination extended outward from the ponds into adjoining soils. About 830 acres were affected by untreated sludges. [Kennecott, 1991]

Another source indicates that there were 182 acres of clay-lined ponds, 87 acres of old sludge lined ponds, and about 271 acres of unlined ponds. It reports : "These ponds were constructed on a level area which was a historic river delta created by Bingham Creek when Lake Bonneville existed. Because the river delta is a deposit of composite materials overlaying

Figure12: South Jordan Evaporation Ponds prior to cleanup.

sedimentary clay material on the valley floor, use of the evaporation ponds resulted in seepage from the ponds surfacing at the face of the delta". This report shows two ponds built along the face of the delta to collect this seepage. They were called the Eastside Seepage Collection Pond and the Southside seepage collection pond. When this facility was in operation, the seepage could be discharged to the Jordan River or recycled back into the ponds. [International Engineering, 1985]

A groundwater plume of elevated sulfate concentrations originates in the evaporation ponds area. The ground water contamination was one of the reasons the State of Utah filed a Natural Resources Damages case against Kennecott in 1986. (See also SW Jordan Valley ground water plumes).

Leading to the evaporation ponds was a ditch which contained a visible lenses of tailings. In 1990, Kennecott reported that the ditch contained lead up to 2,480 ppm and arsenic at 80 ppm.

The 1200 acre South Jordan Evaporations Ponds area was consolidated into a 250 acre closure by Kennecott during the construction season in 1994. Work began on May 30, 1994 and was completed, except for revegetation in December, 1994. An AOC for this work was signed in December, 1994. EPA has provided oversight for this project from the beginning of the action.

Kennecott undertook the following scope of work: (1) Excavation, removal and placement of mine waste rock used to construct pond levees to Kennecott's East Side Dumps (Keystone Slot); (2) the excavation, removal and disposal of hot spots in Kennecott's Bluewater Repository, and (3) the excavation, transport, on-site consolidation and soil capping of the remaining pond sediments. The 250 acre site was covered with a 36" soil cap. The cap was vegetated in 1995. Areas outside of the capped closure were regraded to original landscape and reseeded. In order to facilitate future local transportation, Kennecott also prepared a road right-of-way through the site. Kennecott estimated that the cost of this project was $17 million. Kennecott reports that 12 million cubic yards of contaminated soils and 7.9 million cubic yards of waste were moved in this project. The remediation was closed out by the OU 3, 6, 7 ROD in Sept 2002.

Kennecott is exploring redevelopment of the site into a planned community (Daybreak). Kennecott plans to remove the wastes from the 250 acre repository to a site adjacent to the Bingham Mine Waste Rock Dumps (Copper Notch) and use the footprint of the repository to create a man made lake for the new development. EPA is providing oversight for this project which is expected to start in 2003. The additional project which is expected to start in 2003. The additional excavations are covered as an operations and maintenance activity under a CD signed in Sept 2002 and amended in February 2005. The area formerly known as Bastian Sink has also been added to the redevelopment site.

POND AO (facility #47.01)

Pond AO was the northernmost of the ponds which received water from the evaporation canal system constructed in 1934 (see evaporation canal #119). The pond contained 1 - 4 feet of tailings. Kennecott cleaned up this pond (and the canal feeding it) as part of the Bingham Creek Channel project. Work began in May, 1994. Approximately 64,636 cy were removed from the pond and placed into the Bluewater 1 North Repository. [Kennecott, 1995]. The highest lead remaining at the site is 307 ppm lead; the highest arsenic was 266 ppm. The average concentration was 217 ppm lead and 77.8 ppm arsenic. All the contaminated soils were removed except for soils near the roots of a grove of trees planted in 1975. Records indicate that any contamination associated with these trees are about 2 feet beneath ground surface. This site was closed out by the OU 3, 6, 7 ROD of Sept. 2001.

CEMETERY POND (facility #48)

The Kennecott Cemetery Pond is located near the intersection of 10200 South (Old Bingham Hwy.) and Utah Highway 48 (New Bingham Highway). The site is bounded on the north by the Old Bingham Hwy, on the south by the railroad, and on the west by the Bingham City Cemetery.

Beginning in 1981, substantially higher than normal amounts of precipitation fell in the Salt Lake Valley. To help alleviate this problem created by this excess runoff, the Cemetery Pond was constructed in 1984. Its original purpose was to store excess surface runoff water as well as excess meteoritic waters from within the mining area itself. The pond was to be used for emergency purposes only. No excess leachate was supposed to be held in the Cemetery Pond. The quality allowed by UDEQ in the pond was not to exceed 1700 mg/l TDS, but this was exceeded between 1984 and 1988. [Another source indicates the pond was built to store North Ore Shute water prior to treatment, International Engineering, 1985].

According to Kennecott sources, the chief sources of water entering the pond included Bingham tunnel water, Bingham Pit water, North ore shute (a mine shaft allowed to flood in the mid-1980s), various pumping wells at the precipitation plant, various barrier wells in the Crystal Springs area, Jordan River water, and meteoric and/or surface runoff from within the Bingham Canyon area. While no leachate water or water from the main Bingham Reservoir is known to have been diverted to Cemetery Pond, the water from some of these sources is suspected to have been low in pH.

Water contained within the Cemetery pond may have been released to the Jordan River via the Jordan River Pipeline or it could have been diverted in the Bingham Channel where it would have flowed eventually in the South Jordan Evaporation Ponds. The water could also have been re-circulated back into the Bingham Reservoir. However, it is thought that the vast majority of the water seeped into the ground as the pond was never lined but constructed using only gravel as a base.

As the water in the pond either seeped, evaporated, or was released downstream, the sediments suspended within the water settled out onto the bottom of the pond. Occasional treatment with lime was necessary to reduce the high acidity of the water and precipitate metals out of the solution and deposit them as sediments. These sediments were a thick, dark reddish-brown sludge which contained elevated concentrations of heavy metals, sulfates and lime. Analyses by Kennecott in 1990, confirm that the sludge contained very high levels of arsenic, copper, and zinc. [Highest arsenic concentration was 710 ppm]. Sludge was reported to be 6 - 10 inches thick. [UDEQ, 1992]

Cemetery Pond was taken out of service in 1990 by order of UDEQ, although it hadn't been used since 1988. In the spring of 1992, UDEQ conducted a PA/SI at the site. In the summer of 1992, Kennecott cleaned out the sludges from Cemetery Pond. This action was done originally without EPA oversight. Later, the site was included as an amendment to the Bingham Creek Channel removal action. Kennecott reports that the concrete structures were decontaminated and sent to the Waste Rock Dump. The sludge and tailings from the pond itself were sent to the Bluewater I repository [Kennecott, 1992]. Kennecott reports that they removed 9684 cy (or two feet from the bottoms and sides) of contaminated sediments from the pond [Kennecott, 1997]. The site is now wildlife habitat. Because the depression still exists, the site may be converted to water storage for municipal or secondary water in the future. Cemetery Pond was closed out by the Bingham Creek ROD of Sept 1998.

COPPERTON DUMPS (facility #49)

Some of the tailings from the Utah Copper Company mill, described earlier, were deposited in at least three locations in or near the town of Copperton.

Figure 13: Edge of tailings near Copperton Circle in adjacent industrial land

COPPERTON RESIDENTIAL SOILS (facility #49a)

One of the areas where Utah Copper disposed of its early mill tailings is located on the eastern end of Copperton, a portion of which is now occupied by residences. Based on interviews with long-time residents, Scott Crump's history of Copperton gives several details and some photographs of the tailings deposit [Crump, 1978]. Crump [1978] reported that construction of houses on the tailings was much more expensive than the other houses in Copperton because pilings had to be sunk deep into the tailings to provide a stable foundation. These homes were along East Fifth Street. A 1947 Kennecott aerial photograph indicates that 4 or 5 homes along Fifth East were built on tailings. Historic photographs in Crump's book clearly show the tailings area which extends from Fifth East for a block or two eastward. At the time Scott Crump's book was written (1978), there was no Copperton Circle just to the east of East Fifth. The Copperton Circle homes were moved into the area in 1980 from the former town of Lark. The area before this development was also described in the Crump book as being an unofficial playground for Copperton children. Substantial amounts of fill were brought into the area to provide a base for the Lark homes. There is more fill toward the north end of the street tapering to no fill at the south end of the street.

EPA conducted a Removal Assessment of the Copperton Circle area in May, 1994, and found evidence of tailings in many of the soil samples. However, the maximum concentration of lead was 195 ppm lead, significantly below the Bingham Creek action level of 1100 ppm lead. EPA recommended that no action be taken at Copperton Circle.

During a meeting with the Copperton Community Council, one resident (near the conveyor belt overpass on the west end of Copperton) complained that the conveyor belt produces dusts which settle out on his property. Kennecott collected samples in this part of Copperton. They reported that the highest lead found was 253 ppm, also well beneath the level of EPA concern.

Kennecott [1996] indicated that it does not know the source of the tailings at Copperton Circle. Crump [1978] indicated that the Utah Copper mill at Copperton was the source. Crump indicates that Utah Copper built a reservoir in 1905 to supply the steam-driven mill and also to carry tailings to "where they were dumped on the east side of present day Copperton, just below Fifth East Street." Crump gives further detail: "Three years after the mill was moved to Garfield, UCC purchased the land they had dumped their tailings on, along with almost all the site of Copperton and additional acreage from the Bingham Gold Placer Company." The tailings area underneath Copperton Circle extends to the south and east into currently undeveloped land. Kennecott collected a few samples in this area. The lead concentrations were low, ranging from 25 to 140 ppm.

SHOVELL PLACER DUMP (facility #49B)

In addition to the area previously discussed along Fifth East in Copperton, Utah Copper used at least two other dumping locations for its mill tailings. Utah Copper constructed one tailings impoundment on the Shovell Placer (which is now the location of the Precipitation Plant). Kennecott [1996] reports that the Precipitation Plant area may also be the site of a tailings impoundment built by Ohio Copper in 1907 to impound copper tailings. Due to extensive alteration of the landscape over the years, the exact location of the impoundment shown in the aerial photographs cannot be determined [Kennecott, 1996]. The Precipitation Plant area is covered in the North End ROD of Sept 2002.

REVERE SWITCH TAILINGS POND (facility #50)

In 1905, Utah Copper installed a tailings impoundment on "our ranch land above Revere Switch." [Utah Copper, 1905]. This was done to prevent damages due to tailings down the creek and Jordan River. Kennecott [1996] believes that the Revere Switch tailings pond was in the area of tailings on which the Large Bingham reservoir was later built. During the process of the Large Bingham reservoir removal, tailings were found underneath the reservoir sludges. These tailings were removed during that action and placed on the waste dumps. Kennecott analyzed the tailings underneath the reservoir and indicated that the lead ranged from 45 - 2470 ppm lead with an average of 372 ppm lead. If so, these tailings were removed as a part of the Large Bingham Reservoir removal action. The former Large Bingham Reservoir area was closed out by the Bingham Creek ROD in Sept 1998.

Figure 14: Revere Switch Tailings Pond Historic Photo about 1905.

CHAPTER 8
CURRENT FACILITIES IN AND NEAR BINGHAM CANYON

Mining continues in Bingham Canyon and nearby Barneys Canyon. Unlike the historic mining activities, today's mining is on a large scale with modern equipment. Waste handling is greatly improved. Only during "upset conditions" do the wastes go into unprotected areas. A brief history of the current mines and associated infrastructure is given in this chapter.

BINGHAM MINE and BINGHAM CANYON (facility #79)

The Bingham Mine is largely an open-pit copper mining operation. The development of large steam shovel technology made open-pit mining attractive, and open pit mining began in the Bingham Canyon area in 1906. Both surface mining and underground mining continued until 1914 when surface operations alone provided enough ore for the mills. During the early days of operations, both the ore and the overburden were transported by rail. As the pit got deeper, several rail tunnels were built out of the pit. It also became necessary for Kennecott to buy up more and more land as the pit grew in size. Eventually, Kennecott bought USSRM's interests at Lark, and Anaconda's interests in Carr Fork. The pit subsumed a number of older facilities.

In 1963, Arrington described the transportation process. Then the waste material was loaded into 80 ton dump cars which are pulled by electric locomotives to the disposal areas in trains of seven cars each. The usable ore was loaded in a similar manner into railroad cars of 90-ton capacity and hauled in trains of 13 to 21 cars seven miles to the Copperton assembly yard. Here trains are made up for movement to the Magna and Arthur concentration mills 14 miles distant. Up to 92 cars are handled on the trip to Garfield by two 125 ton electric locomotives operating as a single unit. By 1961, the excavation area alone covered more than 1000 acres. At that time Kennecott began purchasing homes and businesses in Bingham. In 1962, Kennecott also acquired rights to 7,400 acres of land in the Lark-Bingham district from USSRM. In 1963, Kennecott was negotiating for the Anaconda properties west and southwest of the pit. In 1963, it was estimated at 2.2 billion tons of overburden had been removed. [Arrington, 1963] Improvements were made in 1988 [BPMA, 1988]

More recently, only a portion of the ore was transported by rail (that portion going to the Bonneville Crusher); most is crushed in the pit itself and carried by conveyor belt to the Copperton Concentrator. Water management includes diversion of snow melt and stormwater from the pit through the pipeline system to the Copperton Concentrator to be used as process water and diversion of in-pit drainage to the treatment facilities at the Copperton Concentrator. [Kennecott, 1991]. Now, all of the ore is transported by haul trucks to the in-pit crusher and sent by conveyor belt to the Copperton Concentrator. All milling facilities in the Magna area have been retired. The tracks from the Copperton Yard to Magna still exist but are rarely used.

In 1988, the pit covered 1,900 acres, was 2.3 miles wide, and 1/2 mile deep. A total of 4.8 billion tons had been removed, with 1.665 billion tons of ore and 3.228 billion tons of overburden. Approximately 25% of the overburden is not appropriate for leaching. This is placed on separate dumps. Until recently, the leachable overburden was leached with 10,000 - 15,000 gal/min of water sprayed on the dump surface [another source said 30,000 gal/min, Kennecott, 1984]. The leachate was collected as it emerges from the toe of the dumps by the Eastside Collection System. Most of the water used for leaching was recycled. [BPMA, 1988]. [See also East Side dumps] Now the waste rock dumps are no longer actively leached. Water which falls during rain and snow events still percolates through the dumps and is still collected by the East Side Collection System. Flows are about 1000 gpm.

The mine is located in Bingham Canyon near the former headwaters of Bingham Creek. The Canyon is intersected by several tributary canyons, most of which had mining activities in their watersheds. The water from these canyons is "uncontaminated" until it reaches the areas disturbed by mining activities. These waters include Copperton Canyon, Dry Fork, Markham Gulch, Freeman Gulch, and Upper Carr Fork. Other watersheds are classified as "moderately contaminated". According to International Engineering, 1985, these include the Pit drainage water (ave. flow = 908 gpm), Carr Fork ditch (ave. flow - 900 gpm), Carr Fork underground water (ave. flow = 2500 gpm), North Ore Shoot underground water (ave flow 2500 gpm). About 4.6 sq mi drains into the pit itself.

Additional water flows in the area are reported by Bingham Engineering [1986]: "5840 Tunnel" and "6040 Tunnel (1100 gpm), Cort Order (250 gpm), Markham Gulch (1350 gpm), Freeman Gulch (350 gpm), Anaconda air shaft (2000 gpm), Carr Fork ditch (5000 gpm), 5940 Tunnel (2800 gpm), upper Freeman Gulch (280 ac ft/yr), upper Dry Fork (166 ac ft/yr), Markham Gulch #3 (79 ac ft/yr), and Cottonwood 1&2 (78 ac ft/yr).

Kennecott did sink an underground shaft called the North Ore Shoot. In 1985, it was 3000 ft deep. In 1981, Kennecott indicated that the purpose of the North Ore Shoot was to permit underground development of the copper ore body. It is not in operational use. The portal was recently buried by waste rock, but a pipe was drilled to it to mark its location.

In 1997, Kennecott reported that it has eight large rotary drills preparing holes 55 feet deep which are then loaded with explosives (ammonium nitrate and fuel oil). Blasting occurs 2-4 times a day. Nine primary electric shovels move into the blasted areas. The largest shovel, with a 56 cubic yard dipper, can pick up about 98 tons of material for loading into the beds of haul trucks. Kennecott's fleet of 44 haul trucks have 190- and 240-ton capacity. (They are also experimenting with two larger trucks provided by Caterpillar.) In 1997, 160,000 tons of ore copper ore are hauled out of the mine via conveyor or rail, and 160,000 tons of waste rocks are hauled via truck to the waste dumps.

The bottom of the pit is equipped with a gyratory crusher (60" x 109") where the rock is crushed to a maximum diameter of 10 inches. The crushed ore is transported by a five mile conveyor system - 3 miles in a tunnel in the mountain and 2 miles above ground near Copperton. About 130,000 tons of ore per day are transported in this way. Until recently, another 30,000 tons of ore per day were transported to the North Concentrator via rail. [Kennecott, 1997]. The RCRA facilities ID is UTD000826404. This site was excluded from the Superfund action in the Bingham Creek ROD. It is covered by a variety of environmental and operational permits.

Figure 15: Large haul trucks transport the ore to the gyratory crusher near the bottom of the pit.

BARNEYS CANYON HISTORIC FACILITIES (facility #40.19)

Gold claims were first staked in Barneys Canyon in 1878. Approximately 30 existed, with main prospects being the Salt Lake and the Cave. Activity was sporadic and not much work was documented in this area due to competition from Bingham Canyon. Several tunnels have been driven in the canyon over the years for water. The town of Copperton receives its water from lower Barneys Canyon from two wells. The Current Barneys Canyon Mine claims were staked in 1980, and open-pit mining commenced in 1987. It was operated under Kennecott Minerals Corporation. The deposit contains two main pits and satellite pits. The oxide ore is heap leached with cyanide, while reduced ore is concentrated for eventual processing at Kennecott Utah Copper. It was anticipated that ore reserves will be depleted in 2000.

Current facilities include pits, associated waste rock dumps, heap leach pads, water ponds, crushing and grinding facility, and concentrating and refining plants. The current facility operated under a Utah DOGM permit. It also has a groundwater permit. It was not investigated during the CERCLA studies.

Generally, the geography of Barneys Canyon consists of a lower part characterized by low topographic relief, volcanic bedrock, and moderately abundant grasses and oak scrubs. The upper part consists of high topographic relief, Paleozoic sandstone and limestone bedrock, abundant scrub and trees and steep canyon walls. The Barneys Canyon drainage also hosts a water tunnel that produces approximately 50 gpm. Historically, this water was used for domestic, industrial, and culinary water. Water from this tunnel is currently used for make-up and process water at the Copperton Concentrator. Kennecott asserts that there are no environmental problems associated with historic facilities in Barneys Canyon. [Kennecott, 1997].

As of 2002, the heap leach operations are in the process of closure. The closure is being conducted by Kennecott Utah Copper, and the copper company occupies the former administration buildings on site. This area was deleted from the CERCLA action site based on response by other authorities (ROD, 2002).

BARNEYS CANYON GOLD MINE (facility #80)

Barney's Canyon has been the location of gold mining since discovery in 1878. In 1885, there were 30 claims in the area. Now, the Barneys Canyon Gold Mine is an open pit gold mining and heap leaching facility located about 3 miles north of Copperton. There are two mines at the facility: the Barney Canyon Mine and the Melco Mine. A prominent part of the facility are three heap leach pads of 35 acres, 30 acres, and 50 acres. Also at the facility are ore stockpile, crushers, agglomeration facility, conveyors, truck shop, machinery maintenance facility, and a gold recovery and refining plant. The facility opened in February 1989 and now mines about 6700 tons of ore per day. The total disturbed area is about 550 acres.

After mining, the ore is crushed, smaller particles agglomerated, and then placed on a heap leach pad. The ore is piled 17 feet high and a solution containing about 150 ppm NaCN is sprinkled on it, at a rate of 2000 gal/min. NaOH is added to keep the solution basic. The pregnant solution is stored in a lined pond. Then the pregnant solution is cycled through activated carbon. The barren solution containing the cyanide is recycled after enrichment with more cyanide. The gold is stripped from the carbon using hot water, and then recovered by electrodeposition on steel wool. A furnace is used to separate the gold from the steel. Further refining is done off-site.

In September of 1991, heavy rainfall resulted in a release of pregnant solution on the south side of the pregnant pond where a pipe penetrates the liner. The gravel layer under the pond was pumped dry and the leak repaired. A full report of this incident was filed with UDEQ's Division of Water Pollution Control. In the spring of 1993, heavy snow melt nearly caused the system to overflow. UDEQ is suggesting that additional pregnant water holding facilities be constructed to prevent recurrence of this emergency.

In the Fall of 1993, one monitoring well was determined to be out of compliance with respect to TDS. Kennecott believes this is an analytical error. UDEQ was not convinced and called for additional monitoring. Chloride seems to have been the culprit. The source is unknown but may be related to dust suppression or deicing procedures.

Figure 16: Barneys Canyon Gold Mine (on the left in the mountains) and the heap leach pads on the right.

There are two open pit mines associated with the operation presently, but two additional pits are planned. UDEQ has expressed concern that sulfide ores, which cannot be processed using CN procedures, are being stored on unlined ground. Weathering of these materials could produce sulfate contamination in the groundwater down gradient. There is also a concern that additional sulfates could be produced through exposure of veins of sulfide rich ore when new pits become operational. [UDEQ, 1993].

The runoff from the Barneys Canyon mining area reports to the Dry Fork dumps in Bingham Canyon.

UDEQ in currently in discussions with Kennecott regarding the disposition of tailings and waste rock produced by the mining operations. [UDEQ, 1994]

This site has a Utah Groundwater Permit with compliance monitoring required quarterly. [PA Report, 1992].

In May, 1996, the BLM and Kennecott reached a land exchange agreement so that both parties could consolidate holdings. The land transferred from BLM to Kennecott were unpatented claims between the Melco Mine in Barneys Canyon and the Bingham Canyon Pit and also in the Anaconda-Carr Fork and Settlement Canyon area. The land transferred from Kennecott to BLM was on the western side of the Oquirrhs in Tooele County in the Bates Canyon area.

The Barneys Canyon operations are now in closure. The site was not included in the Superfund actions and was not investigated.

TRUCK AND RAIL MAINTENANCE YARDS (facility #146)

There are several truck and rail maintenance yards on site. Such facilities have been known to be involved in spills of petroleum products and cleaning solvents.

Kennecott [1997] indicates there are several building located a few hundred feet south of the Magna Concentrator which are used to support the facility. Those buildings include truck and rail maintenance shops, utility shops (electrical and piping) and emergency response equipment. Some of the buildings appear to have been renovated. However, early 20th century architecture is evident at most buildings.

Although Kennecott [1997] asserts that spills there do not be a significant threat to the environment, they did find one well with <6" of diesel sitting on top of the water table. This is being addressed through a Corrective Action under a State Groundwater Permit.

Currently, all tanks have a secondary containment and are inspected. Waste oil generated at the facility is collected for off-site recycling. Waste part cleaning solutions are burned as fuels at off-site incinerators (D001 Hazardous Wastes).

The South End also has truck and rail maintenance facilities. The truck maintenance facilities are located at the head of Bingham Canyon at the 6190 ft elevation and service over 50 large haul trucks. The South End rail maintenance facilities are located at Dry Fork and service

KUC's locomotive and ore haulage cars. Both facilities are located on waste rock.

An anonymous complaint to DEQ indicates that leaks of lubricants and hydraulic fluids

Figure 17: Facility to maintain large haul trucks used at the mine.

are a routine problem with the haul trucks working in the pit. The caller indicated that this was well-known and occurred because replacement parts for the trucks are expensive.

COPPERTON CONCENTRATOR (facility #82)

The Copperton Concentrator is a new facility built in 1988. Ore from the pit is transported to the facility by means of a conveyor belt. The ores are crushed, and ground to a silty grain size. The fine particles are then sent to a froth flotation unit. Process waters are kept at a pH of 8.4 using lime treatment in a water treatment plant associated with the facility. Cresylic Acid and an alcohol are used as reagents in the foam flotation process. The concentrates

Figure 18: The conveyor belt, carrying ore from the mine, dumps the ore into a storage facility next to the Copperton Concentrator (on the right side of the photo).

are then sent to the smelter in Garfield, and the tailings are sent via the slurry pipeline to the Magna Tailings Pond. Approximately 122,000 tons per day of tailings are slurried to the Magna Tailings Pond. There is a wastewater treatment facility at the site. [Kennecott, 1996].

The Copperton Concentrator includes four grinding lines composed of four Semi-Autogenous Grinding (SAG) Mills and eight ball mills and corresponding flotation cells. The concentrator, built in 1988, was expanded in 1992. It contains some of the largest SAG mills (36 feet x 17 feet) and ball mills (20 feet x 30 feet) in the world. In a SAG mill, much of the grinding is done by 5 1/4" steel balls, each weighing about 22 pounds. As the mill revolves, the balls and the ore pound against one another in an aqueous slurry. The ore leaves the SAG mill smaller than 5/8" in diameter, and is then transported as a slurry by gravity to two ball mills where 3" steel balls, each weighing 4 pounds, further grind the ore to the consistency of "face powder". After the ore is crushed and ground, a cyclone cluster separates the fine ore and sends it to the flotation cells. The flotation cells at Copperton are among the world's largest (3000 cubic feet). The fine slurry is mixed with reagents. The flotation cells agitate the mixture to a bubbly froth and particles containing metal adhere to the bubbles which float over the sides of the flotation cells. This material is called concentrate. After filtration, the copper concentrates are pumped through a 6" diameter steel HDPE lined pipe to the smelter, location 17 miles to the north. Copperton produces about 910,000 tons of copper concentrate annually. [Kennecott, 1997]. The current capacity is 140,000 tons of ore per day.

A by-product of the Copperton concentrator is 24,000,000 pounds of molybdenite concentrate. An additional flotation circuit separates the copper concentrate (also containing gold and silver) and the molybdenum concentrate. [Kennecott, 1997]

Kennecott [1997] reports that pH control is provided by lime; the flotation collector of copper is sodium dicresyldithiophosphate; the frother is MIBC alcohol; the pyrite suppressant is sodium cyanide; the moly collector is No 1 Diesel; the copper depressant is sodium hydrosulfide; the filter aid is sodium silicate; pH control is sodium hydroxide and sulfuric acid; defoamer is D4000 (polyethylene glycol). Waste oils and solvents are sent to Oil and Solvent Process Co, and baghouses are used for dust control. The facility has 2 DOGM operating permits, a groundwater discharge permit and an air quality permit. It also has a Spill Prevention Control Countermeasures Plan. The RCRA facilities ID is UTD00082640.

Water is used to slurry tailings to the Magna Tailings Pond. The water quality averages:

pH	7.4
TDS	4790 mg/l
As	0.003 mg/l
Ba	-
Cd	0.0016 mg/l
Cr	-
Cu	0.0272 mg/l
Pb	0.0027 mg/l
Se	-
Ag	-
Zn	0.0305 mg/l

Most of the citizen complaints about this facility involve the noise and the dusts associated with the ore conveyor belt as it passes through the town of Copperton. Fallout of dusts from the conveyor have been studied by Kennecott. The soils do not have levels of metals with health significance and air quality standards have not been violated. The data were submitted to EPA.

The ore conveyor is 5 miles long with three miles through a tunnel (at the 5490 level) and two miles above ground through Copperton. The concentrator has a ore storage area with a

Figure 19: The ore conveyor belt near the tunnel exiting the mine. The Town of Copperton is nearby.

capacity of about 500,000 tons. The site was covered in the North End ROD of Sept 2002.

COPPERTON CONCENTRATOR PROCESS WATER RESERVOIR (aka Copperton Reservoir) (facility #93.01)

Located near the new Copperton Concentrator is a reservoir which feeds the process water circuit of Kennecott. The reservoir receives water from the following sources: Bingham Canyon mine pit water and storm water from Upper Bingham Canyon, Water from the North Ore Shute mine, upper Freeman, and upper Dry Fork drainages, water pumped from the Carr Fork underground workings, Bingham Tunnel water, Water from deep wells 60 and 109 (see acid extraction wells), water from the sulfate extraction well and Lark Well, Dry Fork wells (clean and acid extraction well), water from Queen Mary drop shaft, Barneys Canyon mine pit drainage water, water from the Water Disposal Pump Station, the Large Bingham Reservoir, the Small Bingham Reservoir, the West Mountain Shaft, the Bingham Creek cutoff wall, Curtis Spring.

Some of these waters (North Ore Shoot, Freeman, Dry Fork, Bingham Tunnels and wells (K60, K109, Lark, and sulfate extraction) can be routed either to the reservoir or to the Moly filter water tank.

Some of the process water in the reservoir can come from the Concentrator itself including water from overflow from the tailings thickeners (up to 15,000 gpm) and overflow from the clarifier (6,100 gpm). When these waters are commingled with the tailings, the combined flow going to the Magna Tailings Pond via the tailings pipeline can be as much as 50,000 gpm.

EAST SIDE DUMPS, (North Disposal Area), EASTSIDE LEACHATE COLLECTION SYSTEM (facility #88)

Shortly after beginning surface mining operations, Utah Copper, Kennecott's predecessor, began to buy surrounding properties for use as dumps. Sometimes only the surface rights were bought to avoid taxes. In 1903, Utah Copper obtained the rights to dump on the Ireland and Watson Placer claim, the Servelles Placer and the Curtis Placer. In 1908, large areas of the Copper Center Gulch and Commercial Gulch were acquired for dumping. In 1919, the US Mining properties were acquired for dumping. In 1925, the Chicago Mine holdings in Dixon, Markham and Freeman Gulches were acquired for dumping. By 1919, Galena Gulch already had 8 million cubic yards of waste rock and room for 15 million more. Tiewaukee, McGuire and Little Eddy Gulches already had 20 million tons by this time. It was planned to send these latter deposits to a leaching plant in the valley. This apparently did not happen because Robbe acquired leaching rights to McGuire Gulch in 1923 (see Robbe) [Rickard, 1919].

Leaching of waste rock dumps was underway by 1935 when Utah Copper reached an agreement with USSRM for all leach waters to divert those waters [USSRM, 1935]. In 1936, USSRM granted an easement to allow Utah Copper to create slopes on USSRM land to prevent slides [USSRM, 1936]. It also gave Utah Copper the right to follow and to save and recover mineral bearing water percolating through the ground underneath the dumps. Dumping privileges on USSRM land leases cost Kennecott $560/acre [USSRM, 1937]. By 1949, Copper Center Gulch was completely gone, Muddy Fork partially gone, and the following historical gulches largely covered: Freeman Gulch, Markham Gulch, Dixon Gulch, Damphool Gulch, Winnamuck Gulch, Ely Gulch, Cottonwood Gulch, Sap Gulch and Log Fork [Addy, 1949]. In 1997, Kennecott began filling the Main Bingham Canyon with waste rock. By 1998, it had reached the eastern portal of the Bingham Pit railroad tunnel. By 2001, Bingham Canyon had been filled down to Dry Fork.

Approximately 3.228 billion tons of overburden (waste rock) has been deposited on the eastern slopes of the Oquirrhs just to the east of the pit. Kennecott has installed a leaching system, whereby water is sprayed on the top of the dump and allowed to percolate through the waste rock. The waste rock is acid generating and produces sulfuric acid as it leaches sulfur from the waste rock. The sulfuric acid leaches metals from the rock and the "pregnant liquor" emerges from the waste rock along the toe of the dump. Kennecott seeks to recover as much of this leachate as possible, sending it to the precipitation plant for recovery of copper. Some of this leachate was thought to escape the current collection system thereby contributing the groundwater contamination problem in Salt Lake Valley. Until recently the leach system entailed the spraying of approximately 14,000 gpm of water on top of the waste rock. The resulting leachate has a pH 3-4, sulfates 40,000 - 60,000 mg/l, and metals (Cu 52 mg/l, Zn 187 mg/l and Pb 5 mg/l) [RI/FS Workplan, 1995]. Kennecott [NRDC, 1995] said that the leachate production in 1995 was 15,000 to 20,000 gpm and within error of measurement (500 gpm) is equal to the amounts sprayed on the surface of the rock. Kennecott also reported that the water quality of the leachate approximated the water quality of the water sprayed on the top except that it was greatly enriched in sulfate and copper and depleted in iron. Water emerged from the toe of the waste rock disposal area at an elevated temperature of about 80 degrees F, due to exothermic oxidation

Figure 20: Mine trucks dump waste rock in Bingham Canyon. The waste rock is at the angle of repose. Earlier dumps were created by dumping waste rock out of railcars.

reactions.

In 1971, a Scientific American article on industrial microbiology indicated that bacteria were being used at Kennecott's dump to enhance copper leaching. "The bacteria, mainly members of the genus Thiobacillus, assist in the leaching operation by converting iron in various compounds from the ferrous form into the ferric. The ferric iron, an effective oxidizing agent, then performs two useful functions: it oxidizes pyrite to form sulfuric acid, thereby maintaining

Figure 21: Mining trucks haul the waste rock to a point above the toe of the dump, turn around, back up, then dump more rock over the side. This photo was taken from the other side of Bingham Canyon.

the high acidity of the leaching solution, and it oxidizes insoluble copper-containing-sulfide minerals to produce soluble copper sulfate, which migrates in solution to the bottom of the dump, where it collects in catch basins. The solution is periodically pumped out to facilities where the copper is recovered. Huge numbers of bacteria are involved in the leaching operation: in places more than a million per gram of ore."

According to Kennecott [1984], leaching actually began around 1900, but did not go into full scale operations until 1923. It also reports that "Evidence shows the mineralized water was occasionally diverted out of Bingham Creek to open areas to prevent contamination of irrigation canals from the Jordan River." It is not known what open area this refers to.

The waste rock containing low carbonates are generally deposited on the northern end of the East Side Dump. These are actively leached. The higher carbonate soils which produce less acid are deposited near the southern end. These waste rocks are not actively leached but do receive rainfall and snowmelt.

The Eastside Collection system has undergone two renovations in the past few years [Kennecott, 1997]. Prior to 1980, any ditches used to collect leachate were clay lined. In 1980, the leach collection system was rehabilitated to improve the recovery of leachate at the toe of the dumps. In 1993 through 1995, the Eastside Collection System underwent modernization to improve water collection and monitoring and to include collection of stormwater from the southern drainages. The new pipeline system replaced the canal system installed in 1980. The 1980 system serves as an emergency/service network.

The waste rock dumps have been surveyed and divided into different areas [Bingham Engineering, 1986]:

East Side - 3.32 sq mi
East Side Dumps - 4.18 sq mi
Pit - 2.92 sq. mi.
Pit dumps - 0.27 sq mi
Trib to pit - 0.26 sq mi
Carr fork - 1.28 sq mi
Carr Fork Dumps - 0.94 sq mi
West side - 1.30 sq mi
West side dumps 1.45 sq mi
East Canyon dumps - 0.95 sq. mi
Dry Fork - 3.95 sq mi
Dry Fork Dumps - 0.56 sq mi
Reservoir watershed - 1.52 sq mi

Kennecott has investigated and expanded the Eastside Collection System. Cut-off walls to trap surface and subsurface waters have been upgraded, replaced, or installed in the following drainages which serve the area of the dumps which are actively leached (listed from north to south):

Bluewater half
Bluewater I (a tributary to Midas Creek)
Bluewater II (a tributary to Midas Creek)
Bluewater III (a tributary to Midas Creek)
Midas (a tributary to Midas Creek)

unnamed (a tributary to Midas Creek)
Congor (a tributary to Midas Creek)
4 unnamed (tributaries to Midas Creek)
Keystone Gulch (no outlet)
N. Copper Gulch (no outlet)

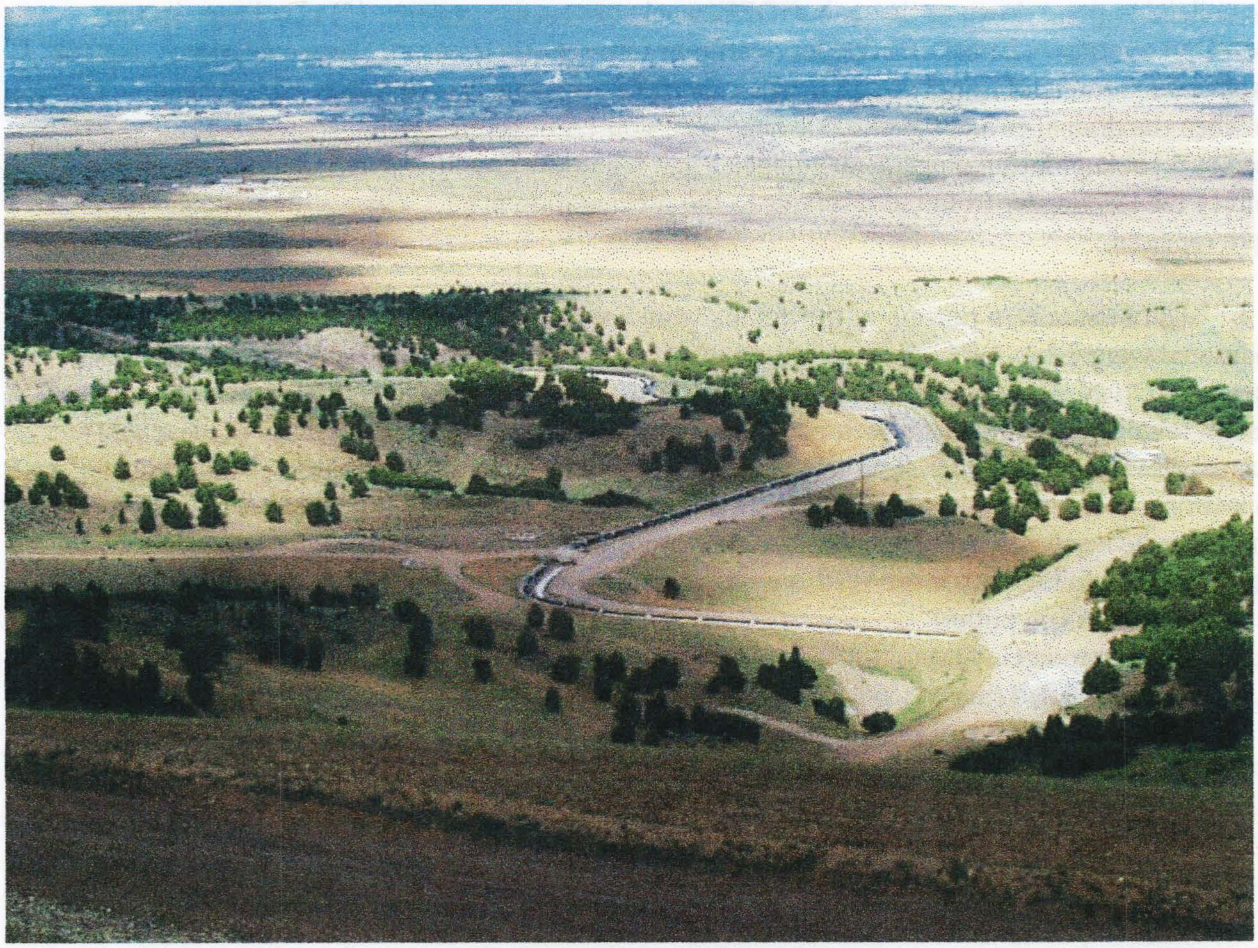

Figure 22: HDPE pipe drains the water collected in each gulch for transport to the process circuit.

Leachate waters from these is sent through the leachate collection system. In general, the leachate collection system included the following structures (from dumps proceeding east): (1) french drain system (to leachate system); (2) new cut-off wall (to leachate system); (3) old cutoff wall (to stormwater system). Monitoring wells are located downstream from each structure.

Kennecott [1995] described the elements of their upgraded leach water system. The purpose is to intercept the water flowing in the stream channels, as well as water flowing in the thin veneer of alluvium which exists on the slopes and channels at the toe of the waste rock.

The elements in this system contains: (1) A clay or synthetic lined sediment collection pond to collect leach water immediately downgradient from where it emerges from the toe of the waste rock; (2) a concrete containment wall keyed into the underlying bedrock which collects the leachate and directs it into the collection system (also has a spillway for 10 year storms); (3) pair of seepage collection trenches (french drain); (4) HDPE pipeline to conduct the leachate from the collection pond down to the main HDPE/canal conveyance system; (5) clay lined rip-rap protected overflow channel to conduct overflows into the stormwater collection system; and (6) leach collection HDPE pipeline and canals - an HDPE pipeline is the primary conveyance between the drainages and the eastside head reservoir (A concrete canal installed in 1980 will be used as a backup during pipeline maintenance and high flow conditions; twin HDPE pipelines convey the leachwater from the reservoir to the precipitation plant.) Cracks in the concrete canal were repaired.

Until recently, a portion of the dumps were not actively leached (Kennecott does not add additional water), but rainfall and snowmelt add water naturally and the same chemical process occurs. Active leaching stopped altogether in 2000. Therefore, Kennecott has installed a similar system to collect stormwater which could have a similar chemical composition as the leachate. The stormwater collection system will be installed generally a mile downstream of the leachate collection system and extend beyond the leachate collection system to the south. The design is similar to the leachate collection system and includes cut-offs, canals, and piping. Cut-offs were installed at the following locations [this area is also called the Southside disposal area]:

unnamed (no outlet)
N. Keystone Gulch (no outlet)
Copper Gulch (not outlet)
Yosemite Gulch (tributary of Butterfield Creek)
Saints West Gulch (tributary of Butterfield Creek)
South Saints West Gulch (tributary of Butterfield Creek)
Castro Gulch (tributary of Butterfield Creek)
Butterfield I (tributary of Butterfield Creek)
Olsen Gulch (tributary of Butterfield Creek)

Kennecott [1995] described their design for the stormwater collection system. It included the following elements: (1) concrete cutoff wall installed at the toe of the future limit of waste rock disposal areas in the drainage (the wall is founded in bedrock and intercepts all storm water and meteoric leach water which flows on the surface or through the alluvium); (2) small desilting basin where silt is allowed to settle out (capacity 0.05 acre feet); (3) spillway to pass flood flow through the basin in event of 10 year storm; (4) inlet structure in cutoff wall to conduct water to a drainage pipeline (HDPE, buried 3 feet below surface); (5) tributary collection box system at the junction of the pipeline and the stormwater collection header pipeline; (6) HDPE collection pipeline which conveys collected storm waters north to the Copper drainage diverter box; (7) a diverter box in the Copper drainage allows water collected south of the Copper drainage to be diverted into the stormwater collection canal or the leach water pipeline; and (8) the stormwater collection canal (formerly the leachwater canal) to conduct

Figure 23:Close up view of Eastside Collection System HDPE pipes and adjacent canal (the former leachate collection canal, now used for stormwater collection).

the stormwater collected from Copper, Keystone, N. Keystone, Congor and Midas drainages to the main Bingham stormwater reservoir system (formerly Large Bingham Reservoir). In addition to the main storm water collection canal, there is an upgradient secondary storm water cutoff canal (clay-lined) beginning at Bluewater III extending north to the former Large Bingham Reservoir.

Monitoring wells were installed downstream of each cutoff wall to measure effectiveness of the system. A Utah Groundwater Permit covers monitoring of this sytem.

In summary, the current Eastside Collection System consists of 15 miles of pipelines and cement lined canals, 23 cement cutoff walls anchored into bedrock, 4 lined reservoirs, and all auxiliary equipment to direct and monitor flows [Kennecott, 1997].

Reclamation experiments are underway at the dumps. There are two projects: (1)

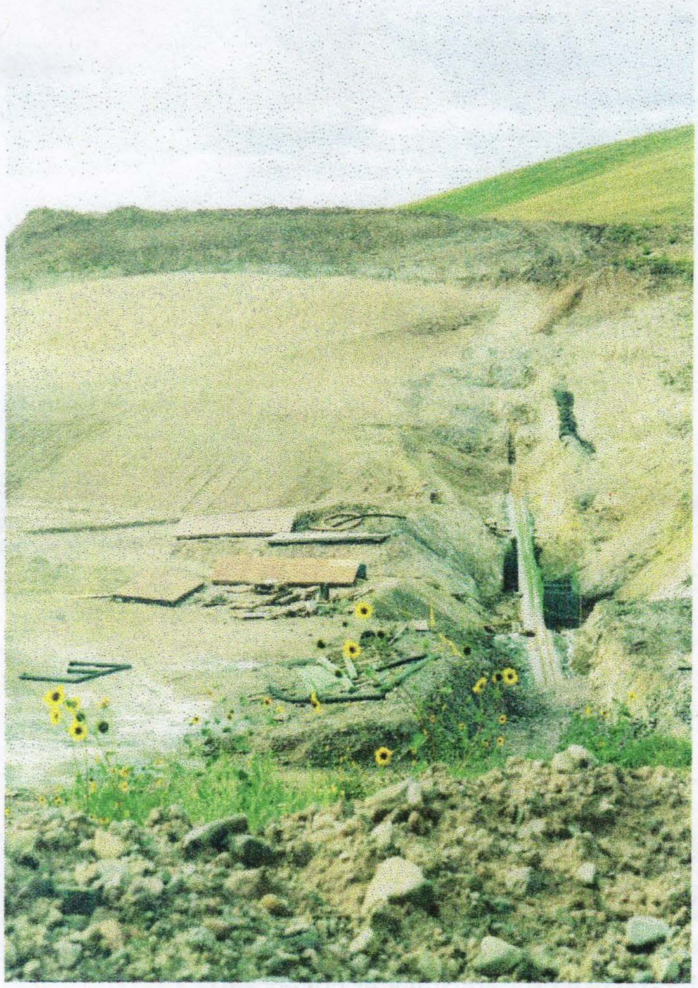

Figure 24: Construction of cutoff walls (underground dams) to trap the water flowing from the waste rock dumps into the alluvium in the gulches.

relaxation and (2) revegetation. Relaxation involves changing the angle of repose rail dumps to a much gentler slope more amenable to revegetation. Angle of repose slopes are not stable when they receive too much water or in earthquake situations. These slides are fairly common and Kennecott thinks that a buffer zone near these angle of repose slopes will be necessary in the future. Slopes have been relaxed at the area of the dump close to the Bluewater I repository. Revegetation experiments are underway on the newly relaxed slopes. Permission by EPA to apply sewage sludges as fertilizers has been granted.

Kennecott [1997] reported the average metal concentrations of the East Side Waste Rock including arsenic at 37.9 mg/Kg (range = <0.25 - 259), Cadmium at 2.3 mg/Kg (range <0.1 - 23.4), Copper at 818 mg/Kg (range = 9.9 - 7670), and Lead at 288.6 mg/Kg (range - 0.2 - 4120).

The cost of the Eastside Collection system is estimated at $48.5 million.

Figure 25: The toe of the waste rock dump in Bingham Canyon approaches Dry Fork. The ruins on the right are the foundations of the Utah Copper Mill. The tracks going up the canyon to the mine tunnel were removed just before this photo was taken.

According to Kennecott's UPDES permit application, Kennecott has begun to phase out active leaching at the dumps. The waters during drain down will be mixed with tailings in the tailings pipeline. The tailings slurry, slightly alkaline, will neutralize the acid in the drain down waters. The drain down flow was estimated at about 500 - 2000 gpm. The gypsum product is deposited along with the tailings at the Magna Tailings Pond. No drain down waters will be discharged to Bingham Creek or the Jordan River. Excess flows can be diverted to the Large Bingham Reservoir.

Kennecott ceased active leaching operations in the fall of 2000. Flow rates from rainfall are about 1000 gpm. The Eastside Collection System was closed out by the OU 3, 6, 7 ROD in Sept 2001.

DRY FORK DUMPS (Westside Disposal Area), also Dry Fork Tunnel and Queen Mary Pond (facility #89)

Kennecott has used the Dry Forks Gulch area for disposal of much of its recent waste rock. Runoff from the Barneys Canyon operation also reports to the Dry Fork. Dry Fork Gulch is a tributary to the north of Bingham Creek. The waste rock dump is located approximately 1/4 mile above the confluence of Bingham Creek and Dry Fork. The lower part of the canyon serves as a repository for over 300 million tons of waste rock from the Bingham Pit. At that time, Kennecott planned to install cut-off walls downstream of the waste rock in the area. As of 1986, this area was 0.94 sq. miles. A reservoir was planned for construction in this area. [Bingham Engineering, 1986]. This pond was later built and named Queen Mary Pond. This part of the site has since been buried by waste rock [Kennecott, GW permit 2000]

Waste rock dumping began in this area in the late 1940s. The first Dry Fork collection tunnel was constructed in 1962-1963. When leaching started, it was estimated that only 50% of the water was recovered. A new collection tunnel was constructed in 1968. With this system, recoveries were estimated at 90%. Two additional tunnels exist for water supply purposes for the towns of Bingham and Copperton. The first driven during the early 1920s at the 5929 elevation had a 0.55% grade with a length of 853 feet. It only produced a small amount of water. The second tunnel at an elevation of 6152 feet was driven in 1934 for 1400 feet with a gradient of 0.33%. It produces 200 gpm, is upgradient of the waste disposal area, and is used to collect mine water. [Kennecott, 2000]

Kennecott (1996) reports that they initiated active leaching in this area in 1963. [Kennecott, 1997, indicates that this area has been leached since 1958]. Until recently about 50 acres are leached. Dry Fork Gulch in 1996 contained 250 million tons of waste rock. The 1997 estimate was 300 million tons. Leachate reports to the Dry Fork Tunnel located beneath the dumps. The leachate is conveyed through pipelines to the Precipitation Plant for recovery of copper. In 1998, operations began placing more waste rock in Dry Fork. Many of the wells and monitoring wells were buried; the Dry Fork decline tunnel and Queen Mary Pond were also buried. The only existing entrance to the Dry Fork Tunnel is the lower elevation portal located in Bingham Canyon. Active leaching ceased in 1999 [Kennecott, 2000]. Another source indicates that active leaching ceased in 2001 [Kennecott, 2002].

In 1993, Kennecott began a drilling program to develop designs for leachate and runoff collection in the area. In the process, Kennecott discovered leachate in the bedrock underneath the alluvium. At one time, acid leachate also reported to Queen Mary Pond upgradient of the toe of the dump. (This pond was buried by waste rock in 1997, Kennecott [1998]). Kennecott has expanded its drilling program to discover the extent of the leachate in the bedrock and determine where this leachate may be travelling. This project is currently under the supervision of UDEQ groundwater permit staff. [Kennecott, 1994]. A ground water modeling effort is also underway in cooperation with USGS.

The drilling study found that there was a significant fault and fracture system in Dry Fork Canyon and that leach water had entered bedrock along this system [Kennecott, 1997]. The study revealed that the plume in the bedrock is 6300 feet long, 700 feet wide with a thickness of 250 - 300 feet. The hydraulic gradient is SE toward Bingham Canyon. The eastern extent was found at the West Mountain Shaft. Particle tracking indicated the plume flowed either to the Dry Fork Tunnel or to the West Mountain Shaft. The estimated volume of contaminated water in the bedrock under the dump is about 8000 acre-feet. [Kennecott, 2000]

Between 1997 and 2000, KUC extended the Dry Fork tunnel and installed a well to cut off clean water recharge up gradient of the dumps. The Dry Fork tunnel was extended and several drop shafts and a clean water well has been placed in upper Dry Fork Canyon. The drop shafts will be intercepted by a tunnel and further enhance the efficiency of water collection by the tunnel. The clean water well, located above the future dump limit plan, was designed to capture groundwater before it can commingle with waters exposed to the dump. [Kennecott, 1997].

According to a Continuous Discharge application to Emergency Response [Kennecott, 1996], the leakage rate into bedrock was estimated by Kennecott to be 100 - 500 gpm, representing a release of $CuSO_4$ at 1400 - 7000 lbs/day.

On Sept 14, 1997, Kennecott reported that a 1,000,000 gallon spill of leach water spilled from a collar in a pipeline that carried barren leach water from the West One pump station to the Dry Fork Dumps. Most of the water was caught behind a berm. The rest infiltrated into the Dry Fork Dumps. A similar spill occurred on Nov 16, 1997 when 30,000 gallons of leach water was spilled from the another pipeline (24" stainless steel) which carrries barren leach water from the p-plant to the West One pump station. The water flowed down the road until it collected in a depression on the uphill side of the Dry Fork access road. Most of the water, which became mixed with stormwater, was recovered along with the tainted stormwater.

According to the UPDES permit application [1999], the Dry Fork Well has a maximum flow of 500 gpm and the Dry Fork Acid Extraction well has a maximum flow of 500 gpm. This was an active dumping ground and was not included as a part of the Superfund action.

SOLVENT EXTRACTION AND ELECTROWINNING PILOT PLANT (facility #89.01)

A new facility was installed at the Dry Forks in 1995 called the SX-EW pilot plant. SW-EX stands for Solvent Extraction and Electrowinning. A leach pad was constructed in the summer of 1994 and operations began in May 1995. It was due to run for 2 years. The goals of the pilot plant were to study leaching and recovery of copper. The leaching pad was established with a three liner protective system underneath it. The dump esd 50 - 60 feet thick and contained 1 million tons of intermediate ore (ore where copper is too low to be economically recovered by grinding and flotation). Water is sprayed on the dump and leachate is recovered at a rate of 200 gpm. The solvent extraction circuit contains one extraction unit and one stripping unit. The plant also had an electrowinning facility which used the same process as used at the refinery except that the anode is different. Copper in the electrolyte is plated onto a stainless steel cathode. Cathodes are replaced every 10 days. The electrowinning facility consists of 4 cells each containing up to 33 cathodes. Maximum production is 1.5 tons of 99.99% copper per day. [Copper Pipeline, 1996]. The first operational period went from May, 1995 to December, 1996. At that time, a second lift of ore was added to the heap leach dump and operations continued until 1997. This facility is currently "mothballed" for potential reopening if active leaching resumes.

A previous leaching experiment in Dry Forks was described by Kennescope [1950s]. Two 50,000 gallon redwood tanks were erected at the base of an experimental dump containing freshly mined waste rock. The tanks stored iron bearing water and bacteria. The bacteria convert ferrous to ferric, then the water is pumped to the dump. The copper leachate was treated with scrap iron (same as at the p-plant) in redwood tanks. The iron in solution is recycled back to the bacterial treatment tank. The theory here was that the bacteria can aid in conversion of sulfide rocks to sulfate so the copper can be leached immediately rather than "aging" (oxidizing) the rock through normal weathering. This area was not investigated and was not included as a part of the Superfund action.

BLUEWATER I NORTH REPOSITORY (facility #90)

Bluewater Repository I is located near the toe of the dumps in the Bluewater drainage above the Eastside Collection system. Top soil down to bed rock was removed, a clay liner and a drainage system was installed for collection of any leachate. Tailings from the Bingham Creek removal, Robbe cells, and Cemetery Pond were placed in the repository and then covered with clay and topsoil, and then revegetated. The capacity of this repository is 750,000 yds. This is permitted by UDEQ-Water Quality.

BLUEWATER I REPOSITORY (facility #91)

Bluewater I repository, just south of the Bluewater I North repository, is similar in construction and was built in 1993 to contain tailings from the Bingham Creek Phase II and Lark removal projects. The capacity of this repository is 4 million yards. This repository later received mining wastes from South Jordan, and Herriman. It will remain open in the summers, until 2007, for use by Herriman agland owners.

LARGE BINGHAM RESERVOIR (facility #86)

Figure 26: The Large Bingham Reservoir before remediation

The Large Bingham Reservoir on Bingham Creek is owned and operated by Kennecott Utah Copper Corporation. The reservoir was created in 1965 to impound runoff water from the upper reaches of Bingham Creek which originates in and flows through the open pit mine. The original unlined reservoir had a capacity of approximately 500 million gallons and historically received flow from (1) groundwater that is collected and pumped from Bingham Creek alluvium above the reservoir, (2) a storm water and leachate collection system which routes water from disturbed mining areas to a treatment facility, (3) a concentrator, and (4) from leachate of mine waste dumps during emergency overflow conditions.

In 1987, diversion structures were constructed and lined storage ponds on the mine waste dumps were installed. More recently, uncontaminated runoff water from the upper canyon and Bingham Tunnel was separated out and diverted to the process water reservoir at the Copperton Concentrator. Mildly contaminated water from the mine is sent to a new pipeline to the new water treatment plant at Copperton and though the tailings pipeline to the Magna Tailings Pond. [Kennecott, 1991]

The Large Reservoir is located in western Salt Lake County, Utah, approximately 11 miles above the confluence of Bingham Creek with the Jordan River.

Between 800,000 and 1,000,000 cubic yards of tailings from earlier mining activities were present in the area which became the water reservoir when the dam was constructed in 1965. The reservoir also contained between 900,000 and 1,000,000 cubic yards of sludge that overlays the tailings and has resulted from settling of suspended material and precipitation of metals. Water from the reservoir is evaporated or recycled to waste dumps where it is used for dust suppression. Reportedly, no water has been released from the reservoir to down-gradient Bingham Creek since 1985.

This reservoir has been implicated as the main source for the Bingham Creek ground water plume (Zone A). It is estimated that the reservoir leaked about 1 million gallons per day from the day it was put into service until it was retired in 1991. Some records collected in 1986 suggest that the maximum leakage rate was 1270 gpm, but leakage was a function of the depth of water in the reservoir. This was not due to increased head, but rather the reservoir was probably leaking out the sides rather than the bottom.

Removal of material from the reservoir began February 4, 1992. The excavated material included (from top down) between 4 to 6 feet of iron rich red sludge, 5 to 7 feet of gray tailings, 4 to 6 feet of dark brown relic topsoil, and finally 4 to 6 feet of silty clay, for a total excavation depth of 20 to 30 feet.

The material was transported and deposited on the waste dumps of the Bingham Mine at the 5816 and 5960 bench levels. The sludge was mixed with dry alluvium (high in calcium carbonate) prior to hauling to facilitate handling and amend the pH of the sludge. It was then dumped down the slope of the waste dump bench to mix with waste rock and where it was allowed some time to dry out. Then it was pushed down off the slope to a lower bench which mixed it with more waste rock and where it was wind-rowed and allowed some more time to dry out. The organic rich soil from the reservoir was excavated separately and brought up the bench to be mixed with the amended sludge-waste rock mixture where it was blended to create a soil capable of supporting plant growth. The new soil was pushed out as an eight to ten inch cap on the newly modified gentler slope of waste rock and the slope seeded and hydromulched.

After the sludges and tailings were removed, the reservoir bottom was graded and a double lined system installed according to state permit specifications and under state oversight. [Griswold, 1992]. The reservoir will now only be used for stormwaters except in emergency situations. Kennecott reports that 4 million tons of sludges and tailings were removed as a part of this project at a cost of $41 million.

The action on the reservoir has been completed. The closeout letter was sent to Kennecott in June, 1994. This removal was done under an AOC; Hays Griswold was the OSC.

Upstream of the two basins of the new Large Bingham Reservoir, Kennecott has also reconstructed the debris basin. Formerly, the debris basin was an unlined structure to catch debris before entering the reservoir. Kennecott has divided the debris basin into 3 separate areas and lined the structure with concrete for ease in removal of the debris. UDEQ expressed concern when Kennecott announced an intention to use the basin for dewatering sludges from the Small Bingham Reservoir [UDEQ, 1993]. More information regarding alternative uses of the debris basin was requested.

In Kennecott's UPDES permit application [1999], the Large Bingham Reservoir can receive waters from the mine, stormwater runoff, groundwater seepage and drain down from inactive waste rock dumps. It also can receive waters from the West Mountain Saft, Bingham Creek cutoff wall, Curtis Spring, the Dry Fork extraction well, the acid plume well, and the Copperton channel well. Alternatively, these waters can be sent directly to the Water Disposal Pump station which can pump 6000 gpm to the Concentrator or tailings pipeline. The Large Bingham Reservoir can also be used to collect overflows from the Small Bingham Reservoir. The historic wastes associated with the Large Bingham Reservoir were closed out in the Bingham Creek ROD of Sept 1998.

Figure 27: The new Large Bingham Reservoir has three basins. The closest one is a debris basin to collect large objects coming down Bingham Creek during floods. The next one is the primary basin with the final used for overflows.

SMALL BINGHAM RESERVOIR (facility #87)

The Small Bingham Reservoir was apparently constructed to receive waters from the precipitation plant and the town of Copperton in 1965. It does not show up in 1965 maps. The capacity of the reservoir is 61 acre-feet. It was not lined until reconstruction in 1990. It is located 1/4 mile east of Copperton on the north side of Bingham Creek and adjacent to zone 2 of the Large Bingham Reservoir. Due to accumulation of sludge, Kennecott cleaned out the reservoir and lined it in 1990. Clay, geotextile and HPDE liners were installed along with a leak detection system. One plan in the Kennecott 104e request shows a "mine waste treatment facility" and the "North Ore Shute and pit water treatment facility" near the small reservoir. Another report calls it the "Lime storage and slacking facility", built in 1984 to inject lime into runoff and underground water before discharge to the evaporation ponds [International Engineering, 1985].

In the spring of 1993, Kennecott announced to the residents of Copperton that Kennecott would no longer be able to accept sewage from the town of Copperton because they could no longer clean out the sludges from the Small Reservoir effectively. Kennecott had agreed to accept the town's sewage when the town was built in the 20s, so long as it was compatible with Kennecott leachate operations. The low pH and high metal content of the leachate was apparently an effective disinfectant for the town's sewage. The flow in 1985 was estimated at 75.2 gpm or 121 acre-feet/year [International Engineering, 1985]

The Small Bingham Reservoir is now used for collection of leachate overflow with pumping and pipeline system, treatment and recirculation of excess water. [Kennecott, 1991] Gunfire is used to keep waterfowl from landing in the reservoir. The cost of the reconstruction project was $13.5 million. The monitoring is through a Utah Groundwater Permit(UGW 3500004) last renewed on Dec 1, 1995. If the capacity of the Reservoir is exceeded, flows can be diverted to the Large Bingham Reservoir. The capacity of the reconstructed Small Bingham Reservoir is about 85 acre-feet. This site was closed out by the Bingham Creek ROD of Sept 1998.

MIDAS POND (facility #92)

Midas Pond, built in 1980, is a 2-3 acre body of water which was originally thought by the state to contain stormwater. Chemical analyses revealed that the water had the composition of leachate. The pond, according to Kennecott, was used only temporarily for leachate and is clay-lined. It was built as a part of the original leachate collection system.

Kennecott [1996] reports that the pond was built in 1982 and is clay lined with 2 - 4 feet of compacted clay, and contains about 3 feet of leach and stormwater during operations. They report a leakage rate of 1/10 to 1 gpm. It was until recently used to temporarily store leach water before pumping to the Precipitation Plant. The pond was retired in 1996 and replaced with a concrete stilling box and diversion. The pond was excavated of waste rock and sludges

[Kennecott, 1997].

The pond was located at the convergence of 6 tributary drainages including Midas I, Midas 2, Congor 1, Congor 2, South Congor 1 and South Congor 2. The pond had a storage capacity for a 30 minute retention of 23,000 gpm leachate flow. Leach water flows were directed to the Midas Pump Sation from whence it was pumped up to the primary leachate collection system. It was in operation until June, 1996. The wastes excavated from the retired pond were placed on the main dumps at Keystone Notch.

Current flows to the new concrete basin include 50 gpm stormwater, 25 gpm of wetlands return flow and 25 gpm from the Old Bingham Tunnel. Additional capacity is available to handle a piped return flow from the upper wetlands fee header and filter treatment plant. [Kennecott, 1997].

EASTSIDE RESERVOIR (facility #93)

The Eastside Reservoir is a part of the Eastside Collection System. It feeds leachate to the Precipitation Plant and is concrete lined. It is located 1/4 mile south of Copperton on the plateau south and above Bingham Creek. It was built in 1980. It is in current use and its integrity monitored under the provisions of a pending state groundwater permit. Periodically, the concrete collection basin is cleaned by mine operations. The wastes are drained to the desilting basin portion of the Large Bingham Reservoir complex [Kennecott, 1998].

CHAPTER 9
GROUND WATER ISSUES NEAR THE BINGHAM MINE

SW JORDAN VALLEY GROUND WATER PLUME (facility #123)

Downgradient of the Oquirrhs in the Salt Lake Valley is a plume (or plumes) of contaminated groundwater on top of the principal aquifer in the valley. The plume is largely characterized by elevated concentrations of sulfate, but it starts as an acid solution of both sulfate and metals. The exact sources of the contaminated water are unknown, but the shape of the plume suggests three sources: (1) a source near the mouth of the Bingham Canyon, most likely the Large Bingham Reservoir; (2) a source in the Lark area, most likely acid mine drainage from historical tunnels and adits; and (3) the South Jordan Evaporation Ponds. Contributing to the plume in some as yet unquantified way are natural sources and irrigation water seepage. At present, the acidic metal bearing portion of the plume extends over a 2 to 4 square mile area; the

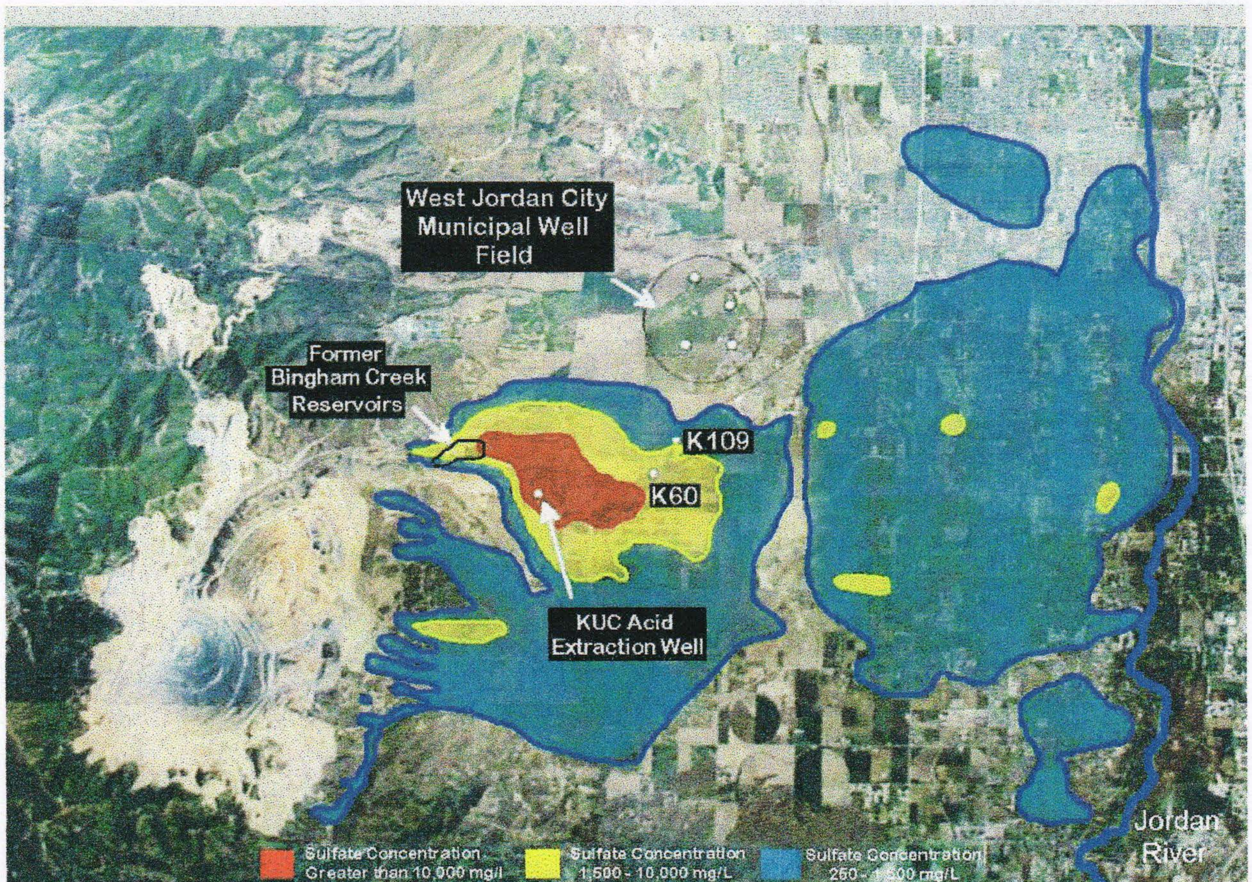

Figure 28: The two contaminated ground water plumes near the Bingham Mine. The left plume (Zone A) originated at the Large Bingham Reservoir. The right plume originated at the South Jordan Evaporation Ponds.

area exceeding 1000 ppm sulfate is 17 square miles; the area exceeding 500 ppm sulfate is 52 square miles; and the area exceeding 250 ppm sulfate is 77 square miles. There are 260 private wells in the area, but it is unknown how many are still in use and what the water is being used for. Most of the large residential areas are served with municipal water. There is one municipal well very near the boundary of the plume on the south (Riverton).

In 1986, the State of Utah filed a law suit against Kennecott for the damages caused to the aquifer. CERCLA Natural Resource Damages provisions were the basis of the suit. Because not much was known about the vertical and lateral extent of the plume, the court proceedings were put on hold until a five year study could be completed. After completion of most of this work, Kennecott and the State of Utah reached a settlement, and that settlement was filed in Federal Court. There was substantial public comment received, most of which thought the settlement was too low. The judge held several hearings on the issues. In 1992, the judge refused to accept the settlement. The State of Utah and Kennecott appealed the decision to the Circuit Court of Appeals. The appeal was rejected and the case went back to the Federal District Court. Utah and Kennecott then appealed the appellate court decision and sought certification to the U. S. Supreme Court. The Supreme Court refused to hear the case, and again the case went back to the district court. Negotiations began anew and a new settlement agreement was reached. The new settlement was accepted by the Federal District Court in August 1995. In addition to a cash payment, the settlement has provisions for a trust fund set up by the state trustee and funded by Kennecott. Kennecott was eligible for reimbursement from the trust fund if they would treat contaminated water and provide it to municipal water purveyors in the impacted area. The trustee and EPA have agreed to approach the selection of the remedy under CERCLA and the provisions of the NRD settlement in a holistic manner and coordinate the two actions. The primary emphasis of the EPA-CERCLA action will be the parts of the plume exceeding 1500 ppm sulfate which includes the parts of the plume with low pH and elevated metals. The primary emphasis of the NRD settlement provisions will be the portions of the plume with sulfate levels between 500 ppm (the Utah primary drinking water standard) and 1500 ppm. For convenience, the portion of the plume with sulfate, pH and metals concerns is called the "acid plume", and the part with only elevated sulfates is called the "sulfate plume".

Meanwhile, under CERCLA authorities, in 1992, Kennecott conducted a Focused Feasibility Study about the groundwater in this area to examine all the options for addressing the problem, and choose which ones deserved further study and consideration. The options which will be further examined either separately or in combination were no action, source control, point of use management, and hydraulic containment of the acidic metal bearing plume.

In May 1994, EPA, UDEQ, and Kennecott met with a Technical Review Committee to begin discussions on what should be included in a RI/FS for this area. A monitoring workshop was held in June, 1994 to discuss what additional monitoring wells should be installed. A work plan for the RI/FS was approved by EPA in April 1995 and the revised QAPP in August 1995. The work included characterization of the plume, modeling, and treatability studies in addition to alternatives evaluation.

The final RI/FS report was received by EPA in March, 1998. The RI report greatly expanded previous studies of ground water contamination. Principal aquifer (quartz-bearing alluvial material) characteristics of water quality, hydrologic properties, lithology, thickness, etc., were primarily defined from the addition of 64 new multiple completion monitoring wells, mostly installed downgradient of former mining sources. The new wells created 181 separate water sampling depths.

Kennecott also prepared a Well Inventory Report, which EPA reviewed and later segregated the wells by water right classification in a summary memorandum. Well sites identified in the study totaled 1,688 of which 526 were monitoring wells (430 Kennecott and 96 non-Kennecott). Five hundred fifty nine (559) wells were in use for culinary, stock watering, irrigation and commercial purposes. Of this total 347 wells were used for drinking water. The remaining 603 wells were either not in use, damaged, or could not be located in the field. Only two drinking water wells in the study area exceeded primary drinking water standards for total dissolved solids (TDS) and for lead. EPA and Kennecott have concluded that only a few of the drinking water, irrigation, or stock watering wells and water right sites are actually in the pathway of the low pH, very high sulfate groundwater plume at least for the first 50 years, regardless of the plume remedial alternative selected.

Kennecott concluded that the largest source of ground water contamination to the Southwest Jordan Valley was the former Large Bingham Creek Reservoir. The aerial extent of the high sulfate (>2000 ppm) plume from this source is about 16,000 feet long and up to 11,000 feet wide embracing 4.1 square miles containing 94,000 acre feet of groundwater. Approximately 43,000 acre feet of this total has a pH of less than 4.5.

Another large area of ground water contamination is east and downgradient of the former South Jordan Evaporation Ponds. However, sulfate levels are less than 1,500 ppm, except for a few hot spots. Within this area, the acidic water is essentially neutralized. Similar sulfate values are described by Kennecott for the other two source areas of contamination, the Lark area and the Eastside Collection System area. Kennecott believes that the surface sources of mining contaminated surface water and groundwater are being controlled now, but contaminants will continue to migrate eastward in the groundwater beyond Kennecott property if hydraulic containment practices are discontinued.

Specific conclusions of the RI report are:

1. Aquifer pumping tests indicate that the quartzitic alluvium in the Principal Aquifer has a range of hydraulic conductivities of 3 - 80 feet/day. The hydraulic gradient from the Oquirrh Mountains to the Jordan River averages 0.025. Groundwater flow velocities are estimated to rance from 330 to 650 feet per year in the Principal Aquifer.

2. Kennecott developed a groundwater model to determine flow directions and rates. Field studies, together with application of the model, suggest that the acid and elevated sulfate

plume is moving at a rate of 330 feet per year in contrast to the 600 feet per year for uncontaminated groundwater. Isotopic trace studies generally confirm the flow rates of the modeling studies.

3. Groundwater elevations have declined substantially during the 1986 - 1996 period, up to 81 feet in the West Jordan City well field and near Kennecott process water wells K60 and K109.

The Feasibility Study evaluated six different remedial alternatives for the "acid plume":

1. No Action, including monitoring and natural attenuation

2. Institutional Controls (plus No. 1)

3. Point of use management (plus No. 2)

4. Hydraulic containment and delayed treatment of acid plume, delivery of water to cities (plus No. 3)

5. Hydraulic containment, treatment of acid plume, delivery of waters to cities (plus No. 3)

6. Hydraulic containment, treatment of acid plume, water not delivered to cities (plus No. 3)

In December 2000, EPA selected Alternative 5 as the remedy for the groundwater contamination. A final design for the remedy was received in late 2002. The final design calls for reverse osmosis treatment of ground water withdrawn from the leading edge of the Zone A (Bingham Canyon) plume. The water withdrawn from the acid portion of Zone A will not be treated, but will be combined with acid rock drainage and neutralized in the tailings pipeline. If the tailings do not have sufficient neutralization capacity, lime can be added. The reverse osmosis facility for Zone A is slated for completion in late 2005.

The "treatment" of acid waters from Zone A depends on the neutralization capacity of the tailings. At mine closure, the tailings will no longer be available and a separate treatment facility for the acids will be necessary at that time. In 2005, the plans call for a lime-treatment facility, but the disposal location of the lime sludge residues has not been decided. Kennecott hopes to remove as much of the acid core from Zone A as possible to minimize the acids requiring treatment post closure.

The major concern of the public regarding the Zone A treatment design was the potential for severe drawdowns in the aquifer. Water levels in wells could drop all over that part of the valley. Therefore, the remedy calls for compensation to private well-owners who lose the use of their wells because of Kennecott pumping of plume waters. Compensation could be monetary or lengthening of the wells, or replacement of the wells.

The Zone B remediation is now being managed by the Jordan Valley Water Conservancy District using funding provided by Kennecott in their NRD settlement with the State of Utah. The State Trustee for Natural Resources approved the plan for Zone B in August, 2004, and the District let the first contract (for location of the extraction wells in Zone B) in February, 2005. An ancillary project of the District is the treatment of groundwater from the shallow aquifer near the Jordan River. This water has been called by several names including the lost use project (compensation for the loss of Zone B waters during treatment), and the Jordan River water project (the water in the shallow aquifer is linked to the Jordan River as a source or as a sink). The major concerns for the Zone B work has been interference with other well owners in Zone B due to drawdowns, impacts on wetlands adjacent to the Jordan River (particularly the shallow aquifer project), and discharge of treatment concentrates into the Jordan River (particularly Se).

The Zone B project has changed somewhat by changing the point of discharge from the Jordan River to the Great Salt Lake (near Kennecott's main discharge). Also, the shallow aquifer project has been put, at least temporarily, on hold while the state determines what the safe level of Se is in the Great Salt Lake. The Se content comes from the shallow aquifer and is thought to originate in agricultural irrigation return waters from the canals parallel with the Jordan River. The Zone B projects are combination water supply and remediation projects - the state trustee being interested in the remediation part and the District in the water supply part.

UPPER BINGHAM CREEK GROUNDWATER CONTAMINATION (facility #124)

The presence of underground flow in the alluvium of Bingham Creek as it flows through Bingham Canyon has been known since the days of the West Mountain Placer Mining Co in the late 1800's. This water lead to a water rights dispute which landed in the Utah Supreme Court in 1907. In Chandler v. Utah Copper, the Supreme Court ruled that the water under Bingham Creek flowed in a well known defined channel and that Utah Copper could not get water rights for it if downstream users rights would be prejudiced.

The disappearance of surface water into stream gravels was also noted in Boutwell [1905, page 30].

This groundwater plume travels in alluvium beneath Bingham Creek upstream of the reservoir. There are two aquifers in this area. The upper aquifer is 35 feet thick in a bed of alluvium which fills the canyon to a maximum depth of 130 feet. Under this is a fractured bedrock aquifer extending at least 200 feet and probably deeper. The water quality in the upper aquifer is poor, and a little better in the lower aquifer [International Engineering, 1985]. There were several feasibility studies done about this in the 1980s.

Kennecott [1995] proposed a new method to address the groundwater flow through the alluvium of Bingham Creek near the mouth of the canyon. "The Bingham Creek cutoff is designed to control and capture all ground water flow through alluvium deposited in two buried bedrock channels at the mouth of Bingham Canyon; this cutoff system has been designed to control leachate seepage from the westside waste rock disposal area in Bingham Canyon. It replaces the barrier (pumpback) wells which had been used previously to evacuate the main Bingham Creek alluvial channel. The cutoff wall system consists of two principal structures: the main cutoff wall, and an adit and smaller cutoff wall which will drain a second alluvial channel beneath the town of Copperton. Each wall is keyed into bedrock and serves as a final containment measure for any remaining groundwater which has escaped capture by upgradient barrier well systems in Bingham Canyon.

" The main cutoff wall extends southwesterly across the main part of lower Bingham Creek channel and will be over 300 feet long at the top, about 80 feet and the bottom, 107 feet high, and a maximum of 24 feet wide. Placement of the wall was contingent upon the exact condition and location of bedrock once initial excavation is complete. The wall is designed to contain two large sumps which will collect water from both the main channel alluvium and the adjacent shallow buried channel that is accessed through the adit. Water is diverted to the reconstructed Bingham reservoir system or the pump house from this point.

"The adit is about 450 feet long and is designed to intercept water within the adjacent buried alluvial channel at the low point of the channel, located at the current site of the Kennecott railroad yard and railroad operations building.

"The Curtis Spring barrier well located upgradient of the Bingham Creek cutoff will continue to pump while the wall and adit are constructed and after they are complete. Work on the Bingham Canyon cutoff structures and relocation of pipelines began in fall 1994. It is estimated that construction will take approximately two years to complete." Excavation work for this project began in the summer of 1995 and was completed at the end of 1997. Water is pumped from the three wells associated with this alluvium cut-off wall system (West Mountain Shaft, Curtis Springs, and the main Bingham Canyon cutoff wall) and sent to the process water circuit of the Copperton Concentrator.

(See also Dry Fork Dumps, page 92)

CHAPTER 10
BINGHAM CREEK, NEARBY PROPERTIES AND PROJECTS

For convenience and speed, the wastes which washed downstream from the Bingham Canyon mining district were addressed in a series of small removals and private actions. The more extensive work was done in phases over a period of several years. This chapter has two kinds of descriptions: (1) cleanups and studies of Bingham Creek segments; and (2) work done by Bingham Creek neighbors (not necessarily a part of the site)

RESIDENTIAL PROPERTIES IN WEST JORDAN ALONG BINGHAM CREEK (JORDAN VIEW ESTATES; THE DELTA) (facility #113)

It is theorized that flood events carried tailings down Bingham Creek, as described earlier. In West Jordan the topography flattens out considerably. In one location construction of an aqueduct for an irrigation canal interfered with Bingham Creek stormwater flow, and the creek backed up behind the aqueduct flooding a portion of West Jordan. Stormwaters thus dammed, slowed down and deposited their sediments laden with tailings behind this constriction. The spreading of these water created a "delta" -like pattern of tailings deposits. Additional spread of contamination has been observed consistent with irrigation from the creek. Irrigation in this area began as early as 1848. [Holt, 1989]. Later catastrophic flood events were prevented by upstream flow modifications, including the Bingham Reservoirs and the Evaporation Ponds, and the entire delta area was developed with residences and industries. The exact timing of the deposition of the mine waste in the former floodplain is the subject of much debate.

UDEQ studied the Bingham Creek in the summer of 1990 as a part of a PA/SI, and found the contamination extended the entire length of Bingham Creek. EPA started a removal assessment in Dec. 1990, examining both the channel and the creek historical flood plain. The highest values in the floodplain were found in the Jordan View Estates area. Fifty-four residential properties had concentrations of lead in the soil exceeding 2,500 ppm. The Action Memo for this area was signed May, 1991, and the removal of contaminated soils from this subdivision was completed Dec. 1991.

The removal consisted of removal of contaminated soil down to a depth of 18 inches, backfilling with clean soil and top soil to the original grade, vegetation of the soil with seed or sod (sod for yards, seed for pastures), and placement of the contaminated soils in the Bluewater I repository (Removal on 48 properties of a planned 50; two refused access). Any further remedial action will depend on the final action level chosen for the site. The OSC for this action was Steve Way.

Following an extensive risk assessment analysis, the final action level for Bingham Creek residential areas was set at 1100 ppm Pb and 100 ppm As. Scientific studies included dosing juvenile pigs with Bingham Creek soils. Bioavailability of this lead was about 15 - 19%. The lead and arsenic in garden vegetables was determined. There was a relationship between lead in the soil and lead in the vegetables, but the absolute concentration in the vegetables was low. ARCO and Kennecott funded the University of Cincinnati to conduct a blood lead study. Although the number of children with elevated blood leads was low when compared to all tested, the number of children exceeded EPA guidance for children living in the contaminated zone. Several models were tested to relate blood lead to soil. IEUBK worked to best to predict actual conditions.

The final action was performed by ARCO under the provisions of an Unilateral Order issued in 1995. [Cleanup activities by both Kennecott and ARCO along Bingham Creek have been conducted in three phases. Phase I removal addressed about 50 properties, and removed lead concentration in excess of 2500 ppm. Phase II removal addressed the removal of tailings in the creek channel extending between Kennecott Bingham Dam downstream to and including the Brookside Trailer Park. Phase III provided for the removal of residential soils from 86 properties containing lead concentrations exceeding 1100 ppm and arsenic concentrations exceeding 100 ppm to a minimum depth of 18 inches.]

In the Phase III removal conducted in 1995 and 1996 by ARCO, only those zones which were determined to exceed the action level were included. Sod areas, such as established lawns, were not removed if the lead and arsenic concentrations were below the action levels with in the immediate top six inches below the surface. Within the residential areas, yards, pastures, corrals, stables, decorative and vegetable gardens were all subject to removal if lead and/or arsenic were at or above the action levels. Agricultural lands outside the residential area were not addressed.

The areas excavated were restored to their original grade by placing select fill and topsoil. Six inches of topsoil was placed in lawn areas and 18 inches in shrub and garden areas. Irrigation ditches were replaced with compacted clay or with pipe. Future monitoring of construction/excavation activities through imposition of special conditions on building permits is needed because some remediated properties contain elevated lead and arsenic below 18 inches of the restored surfaces. The location of these areas has been provided to local government agencies. Located just to the north of Jordan View Estates is a triangular tract known as IRECO. IRECO (now wholly owned by Dyno-Nobel) has a plant in West Jordan along the Bingham Creek floodplain to manufacture pump trucks used for the delivery of explosives to the mining industry. The ingredients transported in separate tanks, are mixed in bore hole on site to form the explosive materials. IRECO (Intermountain Research and Engineering Co.) was founded in 1958. The company owned a significant parcel of land along Bingham Creek. The lands were cleaned up as a part of Bingham Creek Phase 2 (removal of top 3 feet of contamination followed by capping). Later the eastern portion of the land was sold to a developer which built an apartment complex on the site. Dyno-Nobel still owns the western end of this property.

A CERCLA Five Year Review was conducted in the area (2003). There were 14 new developments along the creek, residential neighborhoods and industries. The City of West Jordan did a good job of supervising the development construction so that contamination was not uncovered.

Note: The Southern Pacific Railroad denied access to the railroad right of way through the Bingham Creek cleanup areas. It is suspected that the source of the slag used for railbed construction originated from the old USSRM smelter in Midvale. This slag is known to contain high levels of lead and arsenic. The railroad right of way was not cleaned up as a part of this response. This railroad right of way has been officially deleted from the Kennecott site for a separate action, if needed.

WEST VALLEY HIGHWAY (Bangerter Highway crossing of Bingham Creek) (facility #111)

In 1994, the Utah Department of Transportation submitted a work plan on how they would deal with contaminated soils which would be encountered during construction of the West Valley Highway in the vicinity of Bingham Creek. Soils in the vicinity of the crossing indicated lead contamination varying in thickness between 0 and 10 feet. The thickest contamination was in the channel itself. Tailings in the channel were removed to 4 feet. UDOT enclosed the channel in a corrugated metal culvert, using clean backfill material around the culvert. UDOT removed tailings and transported the tailings to ARCO Tailings Repository.

KERN RIVER GAS PIPELINE crossing of Bingham Creek (facility #112)

The Kern River Gas Transmission Company sought to install a pipeline across Bingham Creek close to the UP&L substation near 10200 South St and the old Bingham Highway. The contaminated soils in the KRGT right-of way were estimated at 5,100 cubic yards. The pipeline was installed by boring horizontally beneath the contaminated surficial soils within the Bingham Creek crossing area and the Evaporations Ponds canal crossing area. These crossings were made a sufficient depth to allow for subsequent clean up of other contaminated soils without disturbing the pipeline. Contaminated soils were sent to the Bluewater I North Repository. Work was started in October, 1991, and was completed by December 1991. Steve Way was the OSC. In 2002, Kern River began planning for a second pipeline crossing of Bingham Creek close to the original crossing.

3200 WEST CROSSING OF BINGHAM CREEK (facility #117)

In 1992, the Public Works of the City of West Jordan requested help from EPA in constructing a bridge crossing across Bingham Creek for 3200 West. The city undertook this project with informal guidance from EPA.

WATER PIPELINE CROSSING (facility #120)

The Salt Lake County Water Conservancy District (now the Jordan Valley Water Conservancy District) constructed a drinking water pipeline across Bingham Creek. They submitted plans for this activity to Steve Way. No enforcement action regarding this project was taken as it was covered under the UAO with Kenneoctt and ARCO, relating to Bingham Creek Channel Phase II. Kennecott worked with the District to remove tailings. (See further information in the Bingham Flats description).

REDWOOD ROAD POND (facility #121)

In 1905, following the opening of the original Copperton mill, Utah Copper officials reported that "one pond, on a small ranch near Redwood Road on Bingham Creek, has been entirely filled up" [Utah Copper, 1905]. No further information has been found. Steve Way, EPA-OSC for the Bingham Creek Channel, speculates that his pond may have been located in an undeveloped field across from the Sugar Factory. Other areas below 4800 W may also fit this description. In the process of removing material from the channel, a particularly deep deposit of tailings was found immediately to the west of Redwood Road. It is now believed that this is the area referred to in the 1905 document.

ARCO conducted a soil removal cleanup at this area in 1995-6 as part of the ARCO Bingham Creek Phase 2 removal.

HOLY CROSS HOSPITAL [now Paracelsus Jordan Valley Hospital] (facility #117.01)

In 1992, Kennecott removed contaminated soils from the Bingham Creek Channel adjacent to the Holy Cross Hospital property as a cooperative effort between the hospital and Kennecott. The hospital was initiating an expansion project that year and did not want to wait for the later Bingham Creek Channel project. Kennecott did this work as a community service. According to Kennecott, all the contamination was removed and no further work was necessary during the later Bingham Creek Channel cleanup action.

LOWER BINGHAM CREEK CHANNEL (facility #121.01)

The extreme eastern section of Bingham Creek between the Brookside Trailer Park and the Bingham Creek confluence with the Jordan River has been called Lower Bingham Creek. This area was not cleaned up as a part of the Bingham Creek removal actions.

Between the Brookside Trailer Park and 1300 W., the Creek flows through a culvert underneath an industrial park and the land surface is covered either with buildings or with paved parking lots. Between 1300 W. and the asphalt plant, the creek flows through agricultural lands. This section is currently used for ranching. Adjacent to the creek near the confluence with the Jordan River is an asphalt plant. The asphalt plant has also bought substantial lands surrounding its facility for open space buffer. Between the asphalt plant and the confluence with the Jordan River, the land is used for agriculture. Historic railroad maps of the area suggest that the current channel of the creek is not at the location of the channel in 1900. The historic channel was located about 300 feet to the north of the current channel at the confluence. The flow in the Lower Bingham Creek is low and originates from springs near the Trailer Park and from overflow from irrigation canals.

According to the plans of the City of West Jordan, this land will be used for open space and recreation, agriculture, industry and perhaps cultural purposes in the future. Because most of the land lies in the floodplain of the Jordan River, no residential development is slated for this area. To facilitate city land use planning for this area, EPA characterized this area in 1997 - 8. Contamination along the channel above residential goals ranged 0 feet to 368 feet on each side of the channel. Higher levels downstream of the asphalt plant were found, perhaps associated with the historic channel course. The highest lead level found in this study was 18,600 ppm Pb. The average concentration was 1801 ppm lead. All contaminated soils adjacent to the Jordan River to the north of Bingham Creek and south of 7800 S. were cleaned up as a part of the Sharon Steel remedial action in 1996. A few samples have been collected by others including UDEQ in 1990 and Kennecott, also in 1990.

Figure 29: New channel for Bingham Creek

In 2001, the City of West Jordan obtained an EPA grant to construct a wetlands area adjacent to the Bingham Creek outfall to the Jordan River. The excavated floodplain material was hauled off-site to Kennecott for use in reclamation purposes. The FWS wanted an action level of 200 ppm lead for this project. The soils were rich and attractive for non-wetland reclamation purposes. Kennecott accepted the soils for use in reclamation projects.

About this time, the lower part of Bingham Creek was re-routed in a new channel located near the Jordan River on the south side of the asphalt plant. The older channel was left in place to serve as an overflow channel to the Jordan River. The new channel was designed to enhance the capacity of Bingham Creek to carry stormwater runoff from new nearby developments.

Figure 30: Control structure for lower Bingham Creek to divide waters between the old channel and the new channel.

JORDAN RIVER (facility #122)

Shortly after the original Copperton concentrator was opened in 1904, tailings began washing down the creek and even into the Jordan River. In 1905, three separate lawsuits were filed. Plaintiffs asserted that tailings had filled the bed of the Jordan River causing it to overflow its banks and damage their agricultural lands. In one case, the plaintiff won (the other two had an unknown fate). Several other cases Utah Copper settled out of court. One involved Bennion's flour mill. Two irrigating canals which left the Jordan River just below the confluence with Bingham Creek, filled up and had to cleaned regularly in order to get water to the mill. Bennion also had to clean out his wheel pit. Utah Copper tried to get other mining companies in the area to share the costs. Ohio Copper kicked in for a 1/4 share. (Ohio Copper reported its mill in Bingham was treating 175 tons/day at the time. They suggested that Dewey and Shawmut mills also contribute.)

Bennion noted that he cleaned the ditch before 1905, but his costs had escalated:

1902	$41.85
1903	$88.50
1904	$48.00
1905	$189.00

Bennions mill was located near Murray.

According to Bennion [1981], Hyrum Bennion was the part owner of the flour mill built in 1880 by the pioneer mill builder Archibald Gardner. It was located on the Jordan River at Taylorsville at around 4700 South and the west bank of the Jordan River. The mill burned in 1909.

Utah Copper proposed that an impoundment be constructed on its ranch land above Revere Switch. They wanted Ohio Copper to share the cost because it would take care of tailings from both sources. Problems still continued because Bennion sent Utah Copper another bill for ditch cleaning in 1907.

Kennecott [1997] has provided this explanation: "The original Utah Copper Mill started operation in April 1904; the company constructed a tailings impoundment in upper Bingham Creek near Copperton in 1905. The impoundment has been incorrectly referred to as the Revere Switch Tailings Pond, Copperton Dumps, and others. Complaints from the Bennion Mill about tailings in their operation ditch preceded the construction of Utah Copper Mill by several years. The contribution of the Utah Copper Mill to the tailings in question would have been minimal during the start-up and first year operation with the mill's smallest configuration of 400 tons/day. Complaints from the Bennion family as well as bills for ditch cleaning continued long after the impoundment construction. Utah Copper developed a joint proposal for containment of tailings with the Ohio Copper Company. Ohio Copper rejected the offer and continued dumping in Bingham Creek."

Little reclamation of the tailings in or adjacent to the Jordan River has been done other than the removal of some tailings at the confluence of Bingham Creek and the Jordan River as a part of the Sharon Steel removals. This was a disposal area used by USSRM for tailings. The tailings were removed and placed into the main Sharon Steel repository on the other side of the river.

Elevated levels of lead and arsenic have been found in the soils of the Jordan River floodplain, particularly in low spots where drainage collects. One study indicated that this contamination persisted from Midvale Slag to the I-215 overpass in Murray (the limits of this study, see Midvale Slag OU1, RI/FS report, 1992?).

Although historic records and actual analyses suggest that there is contamination in the Jordan River floodplain, the sources of this contamination are numerous including mining, milling, and smelting wastes from the Bingham Canyon Mining District, processing and smelting facilities in the Jordan Valley at Sandy, Midvale, and Murray. Other potential sources include sewage plants, industrial discharges, urban runoff and agricultural canal return flow.

The Kennecott Copper Mine does have a permitted outfall on the Jordan River (Outfall 005). The outfall hasn't been used in some time. Treatment is described as lime neutralization in the cemetery settling pond then via a pipelineto the Jordan River. Since the Cemetery Pond was cleaned up some time ago, Kennecott is considering rerouting the intake of this pipeline to the second basin of the Large Bingham Reservoir. Cemetery Pond will not be used for this. Kennecott retains this outfall in their permit for possible use during upset conditions. This outfall was originally approved for storm water and mine drainage discharge from the mine in 1984. The limits were based on Ore Mining Limitations (40 CFR 440.103) or a waste load allocation for the Jordan River. The Jordan River water classification is 2B, 3A, 4.

BINGHAM FLATS (facility #115)

Bingham Flats, an area close to the Old Bingham Highway and Rt. 111 near the UP&L substation, contained approximately 172,796 cubic yards of contaminated soils, presumably due to past irrigation using mine waters contaminated with tailings. It is also in the area of the Revere Smelter.

The Bingham Flats is bounded by the Bingham Creek channel on the south, Old Bingham Highway on the north, Trans Jordan Landfill on the west, and Interstate Brick Co. on the east. According to Kennecott [1995], the deposition of tailings at the site in a shallow depositional pattern across the gently sloping terrain is either a relic of pre-1900 milling activities on the site or a remnant of tailings left by diversion of tailings-laden waters of Bingham Creek during floods. The waters slowed down, deposited their tailings, and then re-entered the creek near the Interstate Brick Co. The depth of the tailings ranged from 2 - 12 inches and could be distinguished form the native soil visually by color.

This area is a part of the Bingham Creek Channel Removal Phase II. Removal activities began in May 1994. In 1994, property owners included:

Kennecott	91.1 acres cleaned up	86,450 cy removed
Lehmitz Family	43.9 acres cleaned up	40,794 cy removed
Interstate Brick	26.9 acres cleaned up	23,530 cy removed

SLC Water CD	1.5 acres cleaned up	728 cy removed
Utah Power	24.8 acres cleaned up	21,294 cy removed

All the removed soils were excavated and placed in the Bluewater 1 North Repository. The action level required in the UAO for this area was 2000 ppm lead. The highest lead level remaining at this site was actually 927 ppm Pb. This area is suitable for unrestricted land use. Please note that the Southern Pacific Railroad denied access to both EPA and Kennecott in this area. The railroad right of way through this area was not cleaned up. It is suspected that slag from the old USSRM smelter in Midvale was used in the construction of the rail bed. This slag is known to contain high levels of lead and arsenic.

TAILWATER DITCHES (facility #116)

There are two tailwater ditches which carried tailwater from operations upstream to the Evaporation Pond canal and are located north of the Bingham Creek Channel. Reclamation of these ditches occurred in 1992, and contaminated sediments from the canals were placed in the Bluewater I Repository. [Kennecott, 1992]

BASTIAN DITCH (facility #118)

The early history of the Bastian Ditch was described by Earl [1929]. His review of historic records indicated that Chandler bought the Butcher ranch in the "latter part of the '90s". The irrigation canal, later known as Bastian Ditch, was originally constructed by the Butcher family in the 1880s to irrigate their lands located in Section 22, T3S,R2W. The point of diversion of the ditch was located at the bottom of Bingham Canyon above the area later occupied by the ARCO tails. The original ditch was approximately 2 feet wide by 1 foot deep and flowed along the foothill on the south edge of Bingham Creek southward across the foothill slope to the area upgradient of Herriman. Along the route, the ditch crossed Midas Creek, Mascotte Ditch, Copper Creek and other small drainages presumably using wooden flumes. [Kennecott, 1998].

During the 1890s, Chandler and his partners, Watson and the Bingham Investment Co, bought the ranch and the irrigation ditch. By 1903, Chandler was using all of the water in Bingham Creek conveyed to his property via the "old Butcher ditch" which was the same ditch Bastian was using in 1929. Chandler used the water to irrigate 400 - 500 acres of alfalfa and wheat. It was Chandler and Watson that complained in 1905 that Utah Copper was polluting the creek and his irrigation waters. Utah Copper began impounding their tailings at that point.

Chandler later sold the property to Grace in 1909. Grace's partners included the Fort Herriman Land and Stock Co., and the Revere Land and Stock Co. Grace expanded the capacity of the ditch to carry 3 times the water. Grace used the water between 1909 - 1923 and was the first to use the water to irrigate the Kiel ranch. Bastian, who bought the ranch in 1921 and used the ditch water, complained that the mining companies were stealing his water. In 1929, the flow was estimated at 2.8 to 3.5 MGD. If the ditch capacity was expanded in 1909 by a factor of 3, the flow prior to that would have been about 1.2 MGD. In 1927, the water quality of the Bastian Ditch was monitored. The water contained 0.12 to 12 mg/l Pb and 0.002 to 0.25 mg/l As. Another observation in 1929 indicated that the ditch "was carrying considerable tailings". Kennecott [1990] reported that sediments in the Ditch near ARCO ranged from 26,500 - 27,200 ppm Pb (80 mesh).

Through an agreement with Utah Apex, irrigation water was supplied to nearby farmers through the Bastian Ditch. Apparently the water was contaminated and surrounding farmland was contaminated (see Bastian Sink). The Ditch carried water as far south as Copper Creek. Kennecott asserts that high levels of lead found in Copper Creek may have come from this ditch. According to maps provided by Kennecott, this ditch originates in the vicinity of ARCO Tails and roughly follows Rt. 111. Lead concentrations along the path of the ditch are very spotty. Wooden flumes were sometimes used to carry water over gulches [ESE, 1993]

Kennecott further investigated the Bastian ditch system in 1996. Aerial photography traced the ditch system nearly to Butterfield Creek. Two systems were found, both called Bastian ditch by Kennecott [1996]. The West Branch travels from Utah Apex tails in Copperton south through the Lark tailings area toward the Butterfield Ditch. The East Branch travels from the Bastian Sink area southwards east of the Lark Tailings area along roads toward the Herriman cemetery and then westward toward the Butterfield Ditch. Kennecott studied these historic ditch areas [Kennecott, 1996]. They collected 8 samples along the southern end of the West Branch. The maximum lead was 2420 ppm Pb; most were above background but below 2000 ppm Pb. Two samples were collected along the southern end of the East Branch. The maximum lead was 270 ppm.

Sections of the Bastian Ditch were cleaned up under the provisions of several actions. The ditch adjacent to ARCO Tails was cleaned up as part of the ARCO Tails cleanup. This section was located just to the south of the Utah Apex (Anaconda, ARCO) tailings impoundments. It was about 5000 feet long starting at the Kennecott ARCO property line (at the dam) on the west going easterly to about 100 feet west of State Hwy 111 where the ditch turned south onto lands currently owned by Kennecott. All the tailings in this section of the ditch were removed and placed in the ARCO tailings pond repository [ARCO, 1997].

The section of the ditch on Kennecott property just south of the ARCO property on the west side of State Hwy 111 was cleaned up as a part of an addendum to the Lark cleanup. This section of the ditch was about 1200 feet long beginning on the north at the ARCO property boundary ending at Kennecott Gate #47 (Tailings Haul Road). Approximately 5850 cubic yards of tailings and soils were excavated and placed in the Bluewater I Main Repository. A 200 foot section underneath the highway was not remediated - the highway serves as a cap. The excavation work was completed in 1997 [Kennecott, 1998].

The sections near Midas Creek, including the Mascotte Pond (a potential settling basin for the ditch), and the area near Copper Creek such as the Lone Tree area, were cleaned up under provisions of the Lark Waste Rock Removal.

EVAPORATION PONDS CANAL (facility #119)

There is a canal which transported flood and stormwaters from Bingham Creek to the South Jordan Evaporation Ponds. The Rock Dam on Bingham Creek was the beginning of the evaporation canals built in 1934 to convey waters from the creek to the South Jordan Evaporation Ponds. Water diverted into the canal system carried tailings and lime-treated waters. These contaminated materials were deposited along the entire canal system which terminated at Pond AO. The depth of tailings ranged from 1 - 3 feet at the bottom, 6 - 12 inches on the canal banks. The main canal split approximately halfway between Deep Well #60 and Pond AO. One branch entered Pond AO at the north and one turned south at the SW corner of Pond AO. The southern branch along ponds A1 - A5 contained tailings 2 inches to 1 foot deep. No tailings were found in A5 at the terminus of this canal branch.

Cleanup of the evaporation ponds canal began in June 1994 as a part of the Bingham Creek Channel removal action. Approximately 44,902 cubic yards of material were removed and placed in the Blue Water 1 North Repository. The current status of the site is reclaimed agricultural land.

MINE WASH AREAS (facility #122.01)

According to the Soil Conservation Service [1974], there are several occurrences of stained soils that indicate either alluvium that has been overwashed by tailings water or deposits of tailings. [SCS, 1974]. Kennecott [1997] indicates that these lands exhibit poor to no vegetation and usually have moderate amounts of iron staining. Those areas not already mentioned include:

(1) 1/4 sq. mile, east of Rt 111 (Bastian Sink?)
(2) 1/10 sq. mile, north of 11800 South, in section 22, T32,R2W

Kennecott [1997] reports that these two areas are associated with the Bastian Ditch, Bastian Sink, and lands adjacent to the south of Bastian Sink. Both received water for irrigation purposes from Bingham Creek during the late 1800s through the late 1930s. The water was probably low pH and contained tailings. (See Bastian Sink #114)

(3) Two locations in section 27 9T3R, R2W) one at the right angle bend in Copper Creek, the second 0.5 mile west of Herriman Cemetery.

Kennecott [1997] reports that the Copper Creek bend area was characterized and the soils removed under the Lark AOC, Addendum 1. The second location, known as Lone Tree, was sampled by KUC under the Lark AOC, Addendum 3, and also by SAIC during the off-site environmental assessment investigations. Both sampling events did not show metal concentrations high enough to merit further action. However, the KUC investigation did find that the soils were very acidic so they were removed as a groundwater protection measure.

(4) 9250 linear feet along Midas Creek in sections 26 and 27.

Kennecott [1997] indicates this area contains tailings along the creek banks and was sampled by SAIC in 1994. Some of the samples had elevated lead concentrations. These samples, located near the intersection of Hwy 111 and 11800 S, near the silos, were cleaned up as an addendum to the Lark Tailings cleanup.

(5) 1600 linear feet between Midas and Copper Creek, north of Fassio Egg Farm in Section 25.

Kennecott [1997] indicates this was a deposit of Lark tailings. It was sampled by SAIC in 1994. The metal concentrations were low.

(6) 5 small locations east of the Old Evap Ponds (this is probably included in the Evap Pond action.)

Kennecott [1997] indicates that these locations were seep ponds that captured water that escaped from the South Jordan Evaporation Ponds. The seep ponds were removed under the AOC for the South Jordan Evaporation Ponds.

BASTIAN SINK (facility #114)

The Bastian Sink is located approximately 1/2 mile south of the Trans Jordan Landfill. Kennecott speculated in 1990 that the area is a topographic low used to hold waters diverted from Bingham Creek via the Bastian Ditch. In describing the area in 1990, Kennecott said that the north half is farmed and the south half has salt grass. The area near and on the abandoned canal is yellow-brown and devoid of vegetation. It also appeared that an abandoned railroad track is parallel and down gradient 1/8 mile from the abandoned canal. Apparently contaminated waters that escaped the canal were trapped on the west side of the railroad grade. The soil in this area also have a yellow-brown color. Concentrations in this area have lead as high as 27,000 ppm, and arsenic as high as 660 ppm.

A 1929 memo from Utah Copper indicates they tested the soil at the Bastian Sink in 1927. It found "that there was considerable lead in the soil of the Bastian Ranch. The author noted considerable tailings in the Bastian Ditch water. He concluded obliquely that Utah Copper is probably the source of the copper, but the lead and zinc could only come from Apex. Irrigation apparently occurred only in the summer. A map contained in a Kennecott presentation (1986) labeled the area as "Historic Adverse Water Deposition Area". If the area was drawn to scale, it measured 3000 feet by 6500 feet.

In a memo contained in Kennecott's 104e request regarding Bingham Creek, the source of contamination in the Bastian Area was described. According to Kennecott, Utah Copper wanted to use the waters after flowing through the Utah-Apex Ponds (ARCO Tails) to irrigate farmland in the Bastian area. The water was conveyed to the area by Bastian Ditch by an agreement in 1933. However, the water entering the ditch was apparently contaminated and lands on which the irrigation water was used was also contaminated. Kennecott estimates that there is approximately 800,000 cubic yards of lead contaminated material in the Bastian area. [Kennecott 104e, 1991]. Kennecott owns the south half of Bastian Sink and the north half is owned by David Bastian. ARCO included this area for investigation pursuant to the UAO for ARCO Tailings. The EPA OSC is Steve Way.

ARCO's contractor, ESE, reported that seven of the 37 surface samples collected at the Bastian Sink exceeded 2000 ppm lead; at the one foot depth 5 samples exceeded 2000 ppm Pb; at the 2 foot depth one sample exceeded 2000 ppm Pb; and at the 3 foot depth no samples exceeded 2000 ppm Pb. The highest concentration found was 5467 ppm Pb. The average concentration at the surface was 1347 ppm Pb.

In 1994, EPA contractors collected wheat samples grown in the Bastian Sink area. David Bastian says that he has been unable to get any production out of wheat sown in the middle of the sink. 100 wheat and 100 soil samples were collected for risk assessment purposes. Little uptake into wheat grains was found, but there is evidence of phytotoxicity. According to David Bastian, wheat sown in the most contaminated areas failed to grow. In nearby areas with moderate contamination, the wheat grew but produced no heads. These effects may not be due to lead or arsenic, but rather soil acidity.

The future land use for this area is unclear. Half of the area is owned by David Bastian and the other half by Kennecott. Both the Trans Jordan Landfill and Kennecott have expressed interest in the Bastian property. Landfill officials have indicated they would use the property as a transportation corridor between the landfill and the sludge farm and perhaps for storage of construction debris. Kennecott has expressed an interest in the property to provide access to groundwater monitoring and future production wells. City of South Jordan planning suggested that, following closure of the landfill, the area would be appropriate for a golf course. Because future residential development seemed unlikely, EPA determined that cleanup of this area is not justified in terms of current or future exposure scenarios. Kennecott has recently bought David Bastians half of the property for use in the ground water project. At the time of purchase, Kennecott planned to either lease the land back to David Bastian for use as farmland or include it in the Sunrise Development. Since then, Kennecott plans to include the Bastian Sink area into the new Daybreak Development (formerly known as Sunrise). Kennecott plans to remove the contamination down to the residential action level for unspeciated soils (500 ppm lead), under the provisions of an amended O+M Plan. The work plan is similar to that used at Bingham Creek neighborhoods. After characterization and excavation, Kennecott plans to import fill from the new pit area of the Trans Jordan Landfill to regrade the area for better drainage.

TRANS JORDAN LANDFILL (facility #84)

The Trans Jordan Landfill is located at approximately 10600 South 7250 West near Copperton Utah. The entrance to the landfill is just south of the Bingham Creek on Rt. 111. The landfill was opened in 1958 and received residential/industrial trash and reportedly small amounts of hazardous waste. The landfill discontinued accepting sewage solids or liquids and other hazardous waste in 1977 when Kennecott's lease with the landfill prohibited these wastes (UDOH, 1985). Another reference (EPA, 1981) indicates that the practice of sludge dumping at the site took place between 1965 and 1981. (Sludge farming still occurs in an adjacent area.) According to one source (the four city board) the hazardous waste was digested dry raw sewage from local city government sanitation districts. The landfill is operated and governed by a multi-city board composed of the cities of Murray, Midvale, Sandy and West Jordan. At one time, the property was owned by Kennecott and was leased to the cities on a yearly basis. Then the landfill had a 50 year lease with Kennecott which was due to expire in 2048.

The landfill is approximately 50 - 75 acres in size consisting of two pits. In the summer of 1989, the landfill started to use a new pit area adjacent to the old landfill. It is the home of a flock of seagulls. A Preliminary Assessment for this area was completed in 1990. [E&E, 1990] The cities have approached Kennecott to lease an additional 120 acres for expansion of the landfill. Some negotiations were proceeding in 1998 for purchase of adjacent lands owned by David Bastian as well.

In 1998, in the course of improving the access road to the landfill, crews unearthed some of the Bingham Creek tailings on the south side of Bingham Creek just east of Rt. 111. The damage was repaired. Also, in order to accommodate heavy truck traffic, Rt. 111 in the area of the landfill was widened. In order to do this, suitable fill had to be brought in to replace shoulder materials. Tailings unearthed in digging out the older fill were hauled to Kennecott's Bluewater Repository. About 1600 cy were removed from the shoulders of the road [Trans Jordan, 1998]. The Trans Jordan Landfill is not a part of the Kennecott site.

During an inspection associated with the Bingham Creek CERCLA Five Year Review in 2003, government inspectors discovered that runoff from the landfill entrance road and the adjacent highway had begun to cut a gully into the banks of Bingham Creek. The gully had not yet cut all the way through the cap and no tailings had been exposed. However, a better way of handling the runoff had to be designed in order to protect the cap covering the tailings in the creek. The Trans Jordan Landfill management agreed to repair the damage and re-route the drainage into a pipe. The landfill provided the labor, and the City of South Jordan provided the materials. (The highway adjacent to landfill, formerly State Route 111, is now maintained as a city street by the City of South Jordan.) Landfill personnel dug a trench, installed a drainage pipe, riprapped the outfall to prevent erosion, and built a new inlet structure.

Figure 31: Gully in the Bingham Creek Channel cleanup area created by runoff from Rt 111 and the Trans Jordan Landfill entrance road.

Figure 32: New outfall for road runoff.

SLUDGE FARM (facility #85)

Just to the south of the Trans Jordan Landfill is a sewage sludge farm where sludges from the South Valley Water Reclamation Plant (West Jordan) are plowed into the soil. Further south is the composting plant where wood wastes are mixed with sewage sludge to form a compost which is then sold for landscaping. Residents of Herriman often complain of the odor. The reclamation plant and composting plant are not a part of the Kennecott site.

PROLER (facility #36)

Until 1992, Proler leased a parcel of Kennecott property on the south side of the Old Bingham Highway between Rt. 111 and the Cemetery Pond. According to Bridgewater Group (2000), the site consists of 14 acres located at 10200 S 7200 W. Bingham Creek is 1000 feet south of the southern edge of the site. Proler was a scrap iron dealer which processed shredded and detinned "tin" cans for use in Kennecott's precipitation plant. The Proler facility was operational between 1965 and 1985. EPA did not try to find out what exactly they did to the cans. Bridgewater reports that the facility operated from 1966 to 1988. It received scrap metal and processed the metal to produce a "precipitate iron product". Process waste included shredder residue and baghouse residue. The facility structures and equipment were dismantled and removed from the site when the site was shut down. Proler vacated the property in 1993.

When Proler relocated their operation in 1992, the lease required Proler to return the site to Kennecott in the same environmental condition in which it was originally leased to Proler. Elevated lead concentrations were observed in the soil at the site and were attributed to lead solder in old tin cans that were processed at the site. Proler initiated a soil cleanup program to remove soils from the site that contained elevated lead concentrations. The contamination was described as dark stained containing lead with concentrations of 1000 to 10,000 ppm.

In the process of doing this Proler disposed of 28,000 tons of soil at the Trans Jordan Landfill. Kennecott was concerned that these soils might be contaminated. A Kennecott analysis in 1990 just south of the Proler Site had lead values between 400 - 1200 ppm. After Proler was made aware of the lead issue, 13,427 tons of soil were shipped to ECDC (industrial land fill) for disposal.

According to Bridgewater (2000), between 1988 and 1993, Proler removed 28,000 tons of soil and shredder residue from the site. Later sampling revealed remaining lead contamination in the southeastern portion of the site. Additional soils were removed in 1997 (1,500 tons). In 1998, another 190 tons were removed to an off site hazardous waste landfill. Solidified masses were removed at this time. The solidified masses, presumably an agglomeration of solder from the cans were rather heavy. The masses, sometimes called nuggets, appeared to be melted rock, metal clippings, and iron fragments. It took a jackhammer to break them into small enough pieces to be accepted by the landfill.

Ownership of Proler has changed hands several times. It was originally sold to Kaiser and is currently owned by Schnitzer Steel. The original lease arrangement with Proler indicated that the site should be returned to Kennecott clean. Kennecott has set the cleanup standard so that the land would be suitable for unrestricted land use. Schnitzer Steel's contractor evaluated the site and estimate that there were 500 cys of soils remaining that exceeded 500 ppm lead and failed TCLP. Later in August, 1997, Proler's representative excavated a series of trenches to delineate the 500 cys of soil to be removed. The contaminated material was visually distinct and the extent of the contamination was confirmed by sampling. To date, Proler has excavated and disposed of 1100 cys to licensed TSDs. An estimated 500 cys of material remains to be removed in 1998. Proler will provide Kennecott with a post removal sampling report.

The new owner, Schnitzer Steel, contested the 500 ppm cleanup standard. Further cleanups were put on hold pending resolution of this dispute. This was resolved in 2000 and the work was completed in the summer of 2000. A final report was submitted to the property owner, Kennecott, by Proler's contractor, Parsons Engineering in January 2001. The following table is a summary of cleanup activities:

Date	weight or volume	waste description	disposal location
1991-1992	40,400 tons	recycle residue	Trans Jordan Landfill
1994	10,000 tons	recycle residue	ECDC
1997	664 tons	D008 char hazwaste	Grassy Mountain
1997	787 tons	D008 char hazwaste	Grand View, ID
1998	179 tons	slag-like solid broken apart with jackhammers	Waste Mgt of Oregon
1998	192 tons	contaminated soil near slag masses	Grand View, ID
2000	559 tons	contaminated soil near slag masses	Grand View, ID
2000	5208 tons	char hazwaste	Grand View, ID
1990	110 tons	diesel contaminated soil	ET Technol, West Valley City, UT

This site was closed out with a "no further action" in the OU3, OU6, and OU7 ROD in September, 2001.

ZINC CONCENTRATOR (facility #40.18)

This plant was constructed in 1917, but it never was in operation due to the inability of Utah Apex Co. to produce the concentrate. The plant is assumed to have been demolished in 1922. There is no evidence of any remaining structures.

The plant was located about 2 miles north of Barney's Canyon in SE/4, NE/4 of section 29, T2S, R2W. No wastes were generated, apparently, by the plant. Kennecott [1998] reported that the plant was constructed by the Zinc Concentrating Company near Harker Station which was serviced by a spur from the Bingham and Garfield Railroad. An agreement with the railroad indicates that the mill was to be constructed in 1917. An inquiry from the railroad to the Zinc Company in 1920 suggested that the mill had been built, had never operated, and some equipment was being sold off. The company indicated that the concentrates for the mill were to be delivered by Utah Apex, but during this period, Utah Apex was involved in a lawsuit and was unable to deliver. By 1922, the lease of the land from the railroad was canceled. The lease agreement required the mill be dismantled within 6 months. [see Kennecott, 1998]. Because this concentrator did not operate, no wastes were produced, and the site has been given "No Action" status for CERCLA response purposes.

The site area is now used for grazing. Some cement footings were found in the general vicinity, but these are probably for a water tank along the Bingham and Garfield Railroad. [Kennecott, 1997] This site was closed out by the Bingham Creek ROD of Sept 1998.

CHAPTER 11
LARK MINES, MILLS, WASTES

Lark was a mining camp established in the Midas Creek watershed about 3 miles south of Bingham Creek. The miners near Lark were mining from the same ore body as Bingham miners, but were approaching it with tunnels from another side. At the time Lark developed, space was getting very limited in Bingham Canyon and miners began projects to access the same ore body from adjacent areas. At Lark, the miners found space for their tunnels, their drainage, their wastes, and their railroad. A small community developed there, including miner dormitory, residences and a general store. The land went from Ohio Copper ownership, to USSRM ownership, then to Kennecott. Kennecott moved the houses and the residents to Copperton. There was one elderly holdout who refused to move. Kennecott did not press the issue. Eventually, she got lonely and moved to Copperton with the rest of her neighbors. Some of the industrial buildings are still in use by Kennecott as offices, labs and workshops. During the cleanups, the foundations of the former town houses and businesses and even the pavement of the streets were broken up during the cleanup of the mining wastes.

OHIO COPPER COMPANY MILLS (facility #51)

There were four mills operated by the Ohio Copper Company. The Ohio Copper Mine claims were located on the east slope of upper Bingham Creek Canyon and extended from the canyon floor up to the ridge above Copper Gulch. By 1906, the Ohio Copper Company had developed the Ohio Copper mine disseminated copper ore body which carried an average of 1.64% copper (Billings, 1952).

A. OHIO COPPER-WINNAMUCK MILL: Ohio Copper originally sent the copper ores to the Winnamuck Mill (see site #3) to experiment with reduction of prophyry copper ores before Ohio Copper built its own mills at Lark. Ohio Copper bought the Winnamuck Mill in 1904 and operated it as an experimental mill until 1911.

B. OHIO COPPER - FIRST LARK PLANT: Ohio Copper's first mill at Lark was constructed in 1906 [Bailey, 1988], 1909 [Kennecott, 1997], or 1910 [Arrington, 1963]. Billings [1952] reports that excavation for the mill started in March 1907, and by November 1907 the concentrator was about completed except for the installation of equipment. But due to lack of funds, construction was shut down. Later after selling other interests, Mr. Heinze got the mill operational by the summer of 1909.

Sources seem to give different data on these mills. Further research will be necessary to determine if they describe different facilities or the same facility. Bailey [1988] reports that the first Ohio Copper Mill was built about 3/4 mile east of the Lark portal of the Mascotte tunnel about 1906. Production was about 250,000 - 300,000 tons of copper annually. The daily capacity was 4,500 tons of ore. [Bailey, 1988]

Figure 33: Historic ruins of older Ohio Copper facilities near Keystone Gulch.

Another source [Arrington, 1963] reports that the Ohio Copper Company erected a 2,000 ton concentrating mill in 1910. This operated intermittently until 1919. In this period it milled 7 - 8 million tons of copper. Billings [1952] indicates a flotation circuit was added in 1919. When copper prices fell, the Ohio Copper began to dismantle and sell what they could of the mill equipment.

Yet another source indicates that the Ohio Copper Company mill began processing copper ores from the Mascotte Mine workings in 1909. Before it burned in 1918, the mill obtained a production rate of 3,000 tons/day.

A publication of the Bingham Commercial Club in 1909 reported that a 4,500 tons/day capacity mill was under construction, 3/4 mile east of the Mascotte Tunnel. It was to be constructed of structural steel and concrete floors. It was connected to the Rio Grande Western railroad by a spur line running to Revere. A photo in the same book indicated a capacity of 3000 tons daily.

Kennecott [1997] indicates the mill was located 3/4 mile east-southeast of the Mascotte Tunnel portal. The mill building was built in 1908, and the machinery installed in 1909.

Operations of the first two of the four sections began in 1909. The operation had financial complications and never got its third and fourth sections fully operational. From these two sections, production was 2200 tons/day. This facility halted operation in 1918 after a mill fire, then was rebuilt and operated for a short time in 1919 [Kennecott, 1997].

C. OHIO COPPER LEACHING FACILITIES: In 1923, the company used leaching methods to recover the copper. The company used untreated creek water and mine drainage waters. The water apparently was collected in the Mascotte tunnel. At least some of the precipitation boxes were located in the tunnel itself. Leaching operations continued at a gradually declining rate until 1937 when the company sold its surface and mineral rights to Utah Copper. Active leaching ceased in 1931.

When Augustus Heinze obtained control of the Ohio Copper Mine in 1906, he extended the Mascotte Tunnel to the Ohio Copper Company mines. Between 1906 and 1919, the tunnel was used as a haulage route to the Ohio Copper Mill at Lark. The Ohio Copper Mine workings were connected to the Mascotte tunnel 1000 feet below the surface.

Prior to the 1920s, the Ohio Copper Company used block caving to mine ore. This method produced large holes on the surface. The Utah Copper Company found these holes a desirable place to dump its overburden. An agreement between Utah Copper and Ohio Copper Company stated that Utah Copper could dump overburden by track into the holes. However, Utah Copper was required to maintain the track and agreed that once the overburden was dumped, the waste rock could not be removed [Kennecott, 1997].

In the 1920s it was discovered that the water flowing from the Mascotte tunnel contained an appreciable amount of copper. The Ohio Copper Company built an experimental precipitation plant in the Mascotte tunnel to recover the copper by introducing the water to detinned cans. The process was aided by spraying the cap rock and waste rock fill with water from the Bingham Creek. Additional water was obtained for leaching the cap rock and fill from Bingham Mines Company who discharged its mine water into the Mascotte tunnel. This water was pumped to the surface to spray the cap rock and fill. Sulfuric acid was later added to the spray to increase the waters leachability.

A larger precipitation plant was constructed at a widened portion of the Mascotte tunnel near the bottom of the Ohio Mine, approximately 12,000 feet from the Mascotte tunnel portal (Billings, 1952). The copper precipitate or copper cement was pumped from the precipitating tanks into mine cars, hauled through the tunnel to surface bins for loading into railroad cars on the Lark Branch of the Denver and Rio Grande Railroad and shipped to the Garfield smelter. Eventually, the leaching of copper became ineffective and unprofitable and operations were suspended in 1931. The precipitation plant produced approximately 40,000,000 pounds of copper during this period.

D. Ohio Copper Reprocessing Mill: The decline in profitability of the leaching

PS 78

Figure 34: Foundations of the reprocessing facility were uncovered during cleanup of the area.

operations led the company in 1937 to erect a 1000 ton selective flotation mill to re-treat over 5,000,000 tons of tailings from earlier milling operations. (The Ohio Copper Mining properties were bought by Utah Copper in 1937). The new mill was about one mile north east of the old mill site. The mill and precipitation plants were operated until 1945 and 1947, respectively, at which time they were closed due to the exhaustion of the copper and old tailings dumps. The properties were worked intermittently by leases until 1950 [Arrington, 1963]

Billings [1952] described the process used to recover copper for the older wastes. In general, the method of leach-precipitation- flotation was used. The method involved leaching of the soluble copper, precipitating the copper on metallic iron in the pulp, followed by flotation of the copper precipitate with the copper sulfides in the same circuit. The pilot plant was located about 3/4 mile below the tailings with a capacity of 1000 tons/day. The tailings consisted of sands and slimes with the bulk of the copper in the slimes. The Ohio Copper discovered that mixing the sands and slimes together had two advantages: the mixture flowed better between the ponds and the mill than the sands alone, and the sands appeared to "condition" the minerals in the slimes. Water for the operation came from the Mascotte Tunnel.

These mills were the source of waste rock and tailings in the Lark area [see Lark Waste

Rock and State Motorcycle Park]. The wastes and remnants of the mill foundations were cleaned up in 1993-4. The site was closed out in the OU 3, 6, 7 ROD of Sept 2001.

FORTUNE MILL (facility #53)

The Fortune Mill was located on Keystone Gulch about 2 1/2 miles west of Lark [Bingham Creek, 104e,1990]. A 1994 Kennecott map indicates that the mill operated from 1900 - 1906 and 1916 - 1917. The map also indicates that the site has been subsumed by the Bingham pit and dumps. A 1909 publication of the Bingham Commercial Club indicates that the Fortuna Mining Company owned claims between Ohio Copper and Utah Copper and had a 100 ton mill at the site. Kennecott [1997] reports it was originally a lead mill and later may have extracted gold, silver and copper. According to Kennecott [1997] it operated from 1900 to 1906.

Boutwell [1905] reported that the Fortune Mine, located in the middle portion of Keystone Gulch 6300 feet E-SE of the mouth of Carr Fork, had a mill but did not describe the works.

Billings [1952] reported that the Fortuna Mining Company was controlled by Simon Bamberger, a governor of Utah. About 1916, George Eccles, an Ogden industrialist, obtained an option on the property. A mill of about 100 tons capacity was constructed on the north slope of Keystone Gulch near the portal of the tunnel. The mill was constructed of wood covered with corrugated iron and "was equipped almost entirely of old second hand machinery except for the Wall corrugated rolls. The water for the mill was pumped from the Montana Bingham tunnel through a 4 inch pipe. The milling ore was not enough to justify mill construction, so the option on the property was turned over to the Montana Bingham Company." The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

NEW MAMMOTH MILL (facility #54)

The New Mammoth Mill was located on Keystone Gulch about 2 1/2 miles from Lark. A 1994 Kennecott map indicates that the mill operated from 1899 - 1901. The map also indicates that the site has been subsumed by the Bingham pit and dumps. According to Kennecott [1997], it was probably a lead, zinc, and silver mill. Billings [1952] indicates that a small cyanide mill was erected near the portal of the Mammoth group of mines. It treated developmental ores and small amounts of stoping ore, bu the operation was unsuccessful. The Mammoth mines started at Copper Gulch and ended near Keystone Gulch.

Boutwell [1905] also refers to the "new Mammoth mill" on Keystone Gulch. The new Mammoth Mine was on the north side of Copper Gulch. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

DALTON and LARK MILL (facility #55)

The Dalton and Lark Mill was located on Copper Gulch about 1 1/2 mile west of Lark. A 1994 Kennecott map indicates that the mill operated from 1895 - 1901. The map also indicates that the site has been subsumed by the Bingham pit and dumps. A 1909 publication of the Bingham Commercial Club indicates that by 1909 the Dalton and Lark was making daily shipments of ore to the ASARCO Smelter in Garfield. Billings [1952] reported that Dalton and Lark Mining and Milling erected a mill near the collar of the #2 incline. No other details were given.

According to Kennecott [1997], it processed lead, zinc and silver ores. The 1905 Boutwell paper has a map that shows a tram from Dalton and Lark to the Lead Mine in Bingham Canyon. Boutwell [1905] reported the total production at 32,826 tons. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

MASCOTTE TUNNEL, DITCH, and POND (facility #57)

MASCOTTE DITCH (facility #57.02) pg. 71

There was a ditch which connects the tunnel to the Mascotte Pond which is just to the north of the Lark Tailings. Kennecott [1996] suspects the ditch conveyed water from Mascotte tunnel to Midas Creek, but found no evidence of the ditch during their cleanups in the area. A later Kennecott report [1996] indicates that the Mascotte Ditch was built around 1942 to convey water for irrigation from the Mascotte Tunnel Portal to ponds located about 1000 feet N-NE of Lark Tails. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

MASCOTTE POND (facility #57.03)

Mascotte Ponds received water from the Mascotte Tunnel via the Mascotte Ditch built in 1942 [Kennecott, 1996]. From thence the water may have been sent via Bastian Ditch to farmland locations further south. Kennecott also asserts that the Mascotte Pond also received waters from the Bastian ditch which ran between ARCO tails as far south as Copper Creek south of Lark. Sediments in this pond were contaminated, containing up to 12,300 ppm lead and 1100 ppm arsenic. Kennecott [1996] suspects that earlier the pond may have been used as an irrigation water settlement basin between 1920 - 1935. The discharge from the pond was believed to flow into Midas Creek. The Sediments in this pond were removed and placed in the Bluewater I Repository as a part of the Lark Tailings Removal in 1993. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

MASCOTTE TAILINGS (Randolph Peterson Gate soils) (facility #57.04)

Approximately 1/2 miles northeast of Lark, there is an area comprising 200-300 acres characterized by little vegetation and red-stained soil. The area is on the west side of Hwy 111, near the Randolph Petersen Gate. Kennecott has called this area "Mascotte Tails" in the Regional Tailings Report [1991]. It is unknown how the material got to this location. Kennecott [1996] suspects that the area was contaminated by waters with arsenic in solution or suspension which collected in low spots in the area. The 1991 data indicates that the highest lead level was 310 ppm. Four of the ten samples exceeded 100 ppm As (max 240 ppm).

This area is also is shown on a map in the Site Inspection Report for the State Motorcycle Park [1986] and one sample was collected (the area was labeled "red-stained soil"). It has low lead, but had arsenic at 106 ppm.

Kennecott reports that they have conducted further sampling at the site and determined that the contamination was very surficial and may have been residues of some historic spill because the soils were acidic. Calcium carbonate alluvium was added to neutralize the soil. This was tilled into the surface soils in 1993 and the whole area reseeded, as part of their Lark cleanup effort. This area was covered in an amendment to the Lark Removal Work Plan. Post removal data are available. The site was colsed out by the OU 3, 6, 7 ROD in Sept 2001.

MIDAS CREEK SILOS AREA (facility #57.05)

After the identification of lead contamination in Midas Creek near the culvert under SH 111 [UDEQ, 1993], Kennecott conducted further investigations in this area. This portion of Midas Creek is located to the north of Lark Tailings and just to the south of Midas Silos (3 concrete structures on the southeast corner of Rt 111 and 118th S St.)

The area was characterized by layers of tailings (similar to Lark Tailings) in the channel and along the banks of Midas Creek near its intersection with Mascotte Tunnel Ditch. The material, according to Kennecott (1996), had lead ranging from background to 2643 ppm lead and arsenic as high as 142 ppm. In addition, some of the materials were acidic (3.56) and some areas exhibited retarded vegetative growth.

Based on results of sampling an area 100' x 1500' (3.5 acres), contamination was found to be limited to 200' of the channel and banks. In October 1994, approximately 962 cy were removed and taken to the Bluewater Main repository. Afterwards, the area was regraded and recontoured. This work was covered by an amendment to the Lark Removal Action Work Plan. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

EXPERIMENTAL WETLANDS (facility #57.06)

Experimental wetlands above Lark were used in 1995 - 1998 supplied with 1200 ppm sulfate water. Supply of the water has ceased and the wetlands dried up. After the surface experiments were completed, flow from the Mascotte Tunnel decreased. The water now goes to the lower level canal of the Eastside Collection System. The wetland treatment experiment area has been replaced by an open range vegetation and the area has been reclaimed. Wetland experiments continue near the footprint of the former Ohio Copper mill building west of Highway 111 at Lark (see 57). Current flow from the springs is about 5 - 10 gpm, but there is no surface flow past the wetlands. This site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

STATE MOTORCYCLE PARK (LARK TAILINGS) (facility #59)

The State Motorcycle Park (Lark Tailings) is located just east of the abandoned townsite of Lark, Utah. The site is bordered on the north and west by Midas Creek and Mascotte Tunnel Ditch, and on the south by Copper Creek. Utah Highway 111 is adjacent to the northwest

Figure 35: Lark tailings produced by the Ohio Copper Company reprocessing mill.

boundary of the site and 11800 South Street is on the north. Copperton is approximately two miles north and Herriman is about one and half miles southeast.

The site covers approximately 470 acres and contains approximately 5 million tons of tailings that were produced by the Ohio Copper Company Mill which was located just east of the long dump near Lark. The mill began processing copper ores from the Mascotte Mine workings

Figure 36: Lark Tailings site after cleanup and revegetation.

in 1909. Before it burned in 1918, the mill obtained a production rate of 3000 tons/day. Copper ores treated by the Ohio Copper Company mill averaged about 0.9% copper, and mill recovery of the copper was only about 45%. In 1937, the Ohio Copper Company constructed a new mill about one mile northeast of the old millsite, and began reprocessing their old tailings to recover the copper that had been left by the original mill. Reprocessing activities continued until about 1950. [See also Ohio Copper Company Mills.] The reprocessed tailings had the consistency of sand, and the deposits resembled sand dunes. There was little vegetation. Kennecott subsequently purchased the property and in 1977 leased it to the Utah State Division of Parks and Recreation for use as a motorcycle park, an activity that continued until 1989 when it was closed by the state and the lease canceled due to health concerns.

Kennecott was sued by Edward Loosli in 1991. The court determined that Kennecott was not liable for personal injuries (use of a 3-wheeler)at the State Motorcycle Park because Utah limits liabilities for injuries on lands leased to the state for recreation. Kennecott canceled the lease to the state on Oct 6, 1989, citing problems with fugitive dust. An article in the Salt Lake Tribune indicated that the lease to the state was for $1/year. The newspaper indicated that usage of the park was about 150 - 200 vehicles /day on weekends and about 25 vehicles/day on the weekdays. Vandalism was a problem.

In 1991, the site contained tailings in two primary areas: An upper (or western) area and lower (or eastern) area. The tailings in the lower area were covered with 6 - 12 inches of soil and revegetated. The upper Lark areas appeared to have been regraded and an attempt at direct revegetation was made. In 1991, the upper area was sparsely vegetated. Depths of tailings ranged from a few inches to 20 feet. [Kennecott, 1991]. Because the tailings were dry, they were susceptible to wind erosion and fluvial transport.

A removal assessment found that most of the tailings had low heavy metal content, except in three areas: an old pond area on the western side of the site, the Mascotte Pond sediments, and sediments in the upper reaches of Copper Creek. A removal action started the summer of 1993. Approximately 60,000 cubic yards of the tailings in the pond area and 10,000 cubic yards from the Mascotte Pond were removed and placed in the Bluewater I repository. The remainder of the tailings will be regraded, covered with topsoil and revegetated to prevent further wind erosion and transport down the creeks. [Kennecott, 1993]. The original estimates were inaccurate because some of the wastes were placed in and on gullies rather than on flat land.

There is a small wetland on the site which is spring fed. The wetland has no outlet and originally covered about one acre. It had some tailings, old foundations and trash, which were cleaned up during the removal. Excavations in this area revealed a concrete foundation underneath the wetland. Underneath the foundation was a landfill for building debris. All of these materials and foundations were removed. It is thought that the wetland is fed by water traveling in alluvium from upstream gulches. Since cut-off walls are to be installed upstream of this wetland, the source of water to the wetland may be affected in the future. If this is the case, the water to replenish the wetland will come from nearby tunnel discharges. The wetland was revegetated with the original trees saved prior to the excavation, and other plants.

Installation of cut-off walls in alluvium upgradient of the wetland did not affect the flow of water to this wetland. Because of this observation, Kennecott believes the source of the water is bedrock. The water has elevated TDS and sulfate concentrations. Due to evaporative losses, the water discharged can reach as high as 3000 ppm SO4. To remediate sulfate, the original restored wetland was converted to an anaerobic treatment system. The ponds were deepened and organic debris added. The wetland converts the sulfates to sulfides. Hydrogen sulfide is lost to the atmosphere from the wetland. Water then flows into an aerobic basin before it overflows downstream and sinks into the ground.

Reclamation of the site began in late 1993 and was completed in 1994.

Also close to the site, is the dry Copper Creek, which "flows" just to the south of the Tailings Area. High levels of lead were found in the now exposed creek sediments. As part of the removal, the sediments (6,423 cu. yds) were removed to the Bluewater 1 North repository.

Kennecott originally thought that the lead came from the Bastian Ditch, whose terminus, according to old maps was the Copper Creek. Since then, tailings were found upstream of the terminus suggesting other sources as well. A nearby area of 45 acres between the Lark tailings and Copper creek has been dissected by historical ditches. Approximately 16,640 cu. yds were removed from this area. Eva Hoffman was the RPM/OSC, aided by Bill Carlson.

Kennecott estimated that it cost $13.8 million to complete this project. This site was closed out by the OU 3, 6, 7 ROD of Sept 2001.

LARK WASTE ROCK (LARK TAILINGS IN CERCLIS) (facility #60)

The Lark Waste Rock site consists of several abandoned mine waste dumps located directly east and north of the abandoned townsite of Lark. Mining operations began at the Lark Mine in the late 1800s. In 1909, the Mascotte Tunnel was constructed by the Bingham Central Railway to remove lead-zinc- silver ores from the Lark and the Ohio Copper Company Mines. Ohio Copper Company had a mill on the eastern end of what was called the Long Dump and a mine in Bingham Canyon. Waste rock produced while constructing the tunnel and the waste rock from the Ohio Copper Company mill were the sources of the material on this dump.

The U. S. and Lark Mine, which began operations about 1905, also used the Mascotte Tunnel for removing waste and ore. Waste from the Lark Mine was placed on what was called the Miscellaneous Dump. The U.S. and Lark Mine was owned by USSRM; USSRM records indicate that the Lark mine was operating in 1959 [USSRM, 1959]. All USSRM properties in the Lark area were sold to Kennecott in 1962 (7400 acres for $7M) [USSRM, 1962].

When Kennecott's pit began encroaching up USSRM and Montana Bingham operations in 1941, Kennecott agreed to relocate the USSRM facilities to the Lark area. Facilities were built including offices-changehouse building, store house - machine shop - blacksmith shop - electrical shop - welding shop - repair shop - garage building, a compressor plant, saw mill, heating plant, culinary water tank, ore dump trestles, railroad spurs, powder magazine, lumber yard, parking lot and roads. A large area was leveled off at the port of the tunnel and the facilities were close by. Plans were made for the new "Bingham Tunnel" which would connect with the workings of the US, Lark, and St. Joe mines [Billings, 1952].

The Bingham Tunnel was constructed to provide a second access adit to the Lark Mine in about 1950. Waste rock from the Bingham Tunnel, and the most recent Lark Mine waste, was placed on the Round Dump. Kennecott currently owns the land on which the dumps are located. The dumps occupy about 40 acres.

There are approximately 1,300,000 cubic yards or 2,000,000 tons of waste rock at the site: [Kennecott, 1993]

Dump	Common Name	volume (cubic yards)
1	Long Dump	223,221
2	Round Dump	817,783
3	Road Dump	145,948
4	Keystone Dump	66,727
5	Shop Dump	80,000
6	Misc. Pile	1,915
7	Pond Dam	12,000
8	Pond Dikes	4,800
9	Misc. Pile	1,281
10	Misc. Pile	500

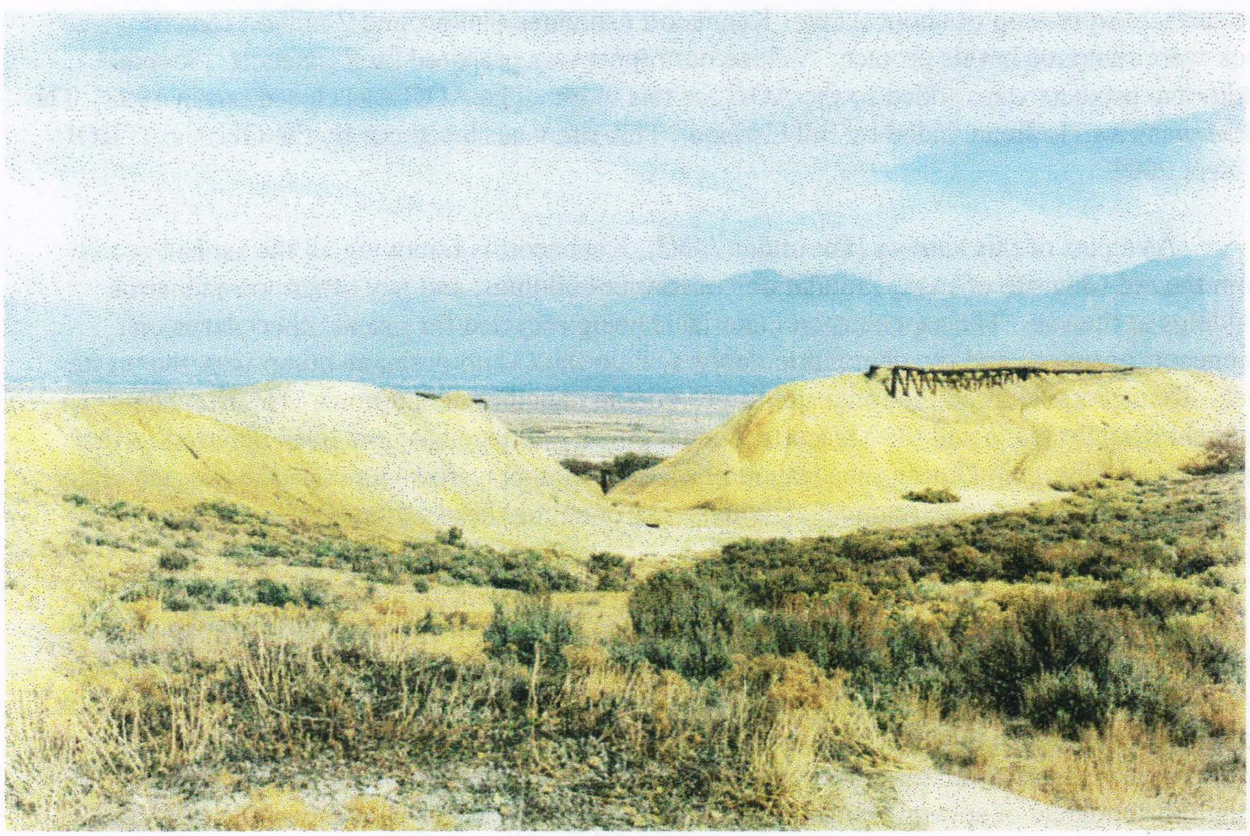

Figure 37: The Long Dump prior to excavation and removal.

These are estimates which have been revised upwards because several of the dumps were not placed on flat ground, as originally assumed, but rather placed in gullies. First the gullies were filled and then additional wastes formed mesas, hills, ridges, mountains, etc.

The waste rock has acid generating potential and may affect sub-soils and surface and ground water in the area. Some of the smaller particles in the dumps eroded off the dumps forming an apron around them.

A removal action was started the summer of 1993. All the waste rock piles were removed and transported to the main Bingham mine waste dumps in the Crapo drainage. This repository is within the leach collection area so that any leachate generated will be collected. The long range plan for this notch between Keystone and the Eastside Rail Dumps calls for another high dump that will connect the above dumps with code 51 dump. Future copper mining operations will generate million of tons of non-lead waste rock that will cover the relocated lead/zinc waste rock. Covering the Lark waste rock will eliminate erosion transport and dermal contact hazards. Subsequent leaching will recover metals from all the placed material. After removal of the waste rock, the area was revegetated. [Kennecott, 1993] Recent discoveries indicated that some of the miscellaneous dumps near the new buildings were much deeper in extent than first estimated. One entire section of canyon in the Midas Creek just below the Bingham Tunnel had been filled with waste rock and consisted of 800,000 cubic yards instead of the surface expression of about 2,000. Kennecott estimates that around 2 million tons of waste rock were removed in this project. A close out report was prepared by Kennecott. Several additional projects were added to the AOC for this work. The AOC was closed out in 1998. The RPM was Eva Hoffman, aided by Bill Carlson. This site was closed out by the OU 3, 6, 7 ROD of Sept 2001.

As a part of this activity (not under AOC), Kennecott is removing all the asphalt roads from the old townsite of Lark, foundations of former buildings, and any other non-industrial buildings at the site. The asphalt road material is being recycled for use at other places on Kennecott property, and the demolition debris will go the Crapo drainage dump with the waste rock. Kennecott returned the town site to pre-human habitation conditions. The Bingham Tunnel Portal drainage and the Mascotte Tunnel Portal drainage has now been diverted to the process water system. During the cleanup phases, the tunnel waters were used to provide water for dust suppression during removal activities. At one time these waters were used for irrigation.

In 1998, it was discovered that the Fassio Egg Farm chicken coops in Herriman were built on a foundation made with Lark Waste Rock. This waste rock (about 15,000 cy) was removed from Herriman and placed along the main waste rock dump in Keystone Notch. Additionally, it was discovered that in the 1950's when Herriman Main Street was first paved, the Utah Dept. of Transportation used Lark Waste Rock as a road base. A portion of the road base is exposed along the shoulders of several Herriman streets. The county plans to pave over the exposed waste rock.

COPPER GULCH MINES (and COPPER GULCH POND) (facility #61)

In 1885, there were two mines mentioned in the Copper Gulch area of Butterfield Canyon. The Lead mine was started in 1871 and relocated in 1875 by the Yosemite Company. The waste dump was "very small". They were saving the wastes for later processing. Also mentioned was the Yosemite mine started in 1865. In 1885, it had a large dump of second class ore containing 7 - 22% lead [Census, 1885]. See also Copper Creek discussion in State Motorcycle Park. There is also a area on a 1994 Kennecott map called "Copper Gulch Tailings Pond." Kennecott (1996) reports that this pond was formerly used as a collection area for the previous leach collection system. Leach water was then piped to the concrete canal of the Eastside Collection System. A cut-off wall has been installed in this area and the pond area has been reclaimed [Kennecott, 1997]. This area has not been subsumed by the Bingham pit and dumps.

Kennecott [1996] also reports the following mines: Antelope, Blue Jay, Dalton and Lark, Evergreen, Lead, Mayflower, Miners Dream, Olympia, Richmond, Sampson, Union Flag, Vanderbilt, Washatch, and Yosemite #2. Kennecott [1996] suggests that waste rock generated during early days of underground mining was probably placed at or near the mine entrances. All such waste rock is now buried under the Bingham Canyon Mine Dumps. After the turn of the century, waste rock from active mines was transported through the Mascotte Tunnel and deposited near Lark. These materials would have been removed during the Lark cleanup project. Kennecott [1996] did not mention the Copper Gulch tailings pond. This site was closed out in the OU 3, 6, 7 ROD of Sept 2001.

MASCOTTE TUNNEL (facility #57.01)

Bingham Consolidated Mining and Smelting Company worked on a drainage tunnel in 1901 to drain the Brooklyn and Dalton and Lark shafts. It was 8000 feet long and served as a drainage and ore-hauling tunnel. The tunnel outlet was connected to the Rio Grande Western by the Dalton and Lark Railroad in 1902 [Hansen, 1963]. Heikes, 1920, reports that the tunnel was 14,000 feet long, built to intersect with the Ohio Copper ore body. The Mascotte Tunnel was also used as a collection point for a leaching process started in 1921. Water was added to the caved surfaces of the Ohio Copper properties and the water was collected in the tunnel. Apparently precipitation boxes containing scrap iron were hauled into the tunnel itself. A Utah Copper letter [1927] indicated the water was returned to Bingham Creek after leaching. An internal Utah Copper memo [1929] indicates that around 1910 waters from the tunnel were being used on the ranch just south of the Bastian homestead near Herriman. Utah Copper at that time was investigating the feasibility of getting water from Butterfield Creek in trade with the farmers for other waters. The memo also indicates that Mascotte Tunnel served as a drainage outlet for waters coming from the Utah Copper pit.

The active leaching was shut down in 1931. [ARCO, 1993]. USSRM apparently bought the property in 1933 and agreed to continue to sell the Mascotte Tunnel water rights to Ohio Copper [USSRM, 1933]. In 1937, USSRM reported that Ohio Copper was using Mascotte Tunnel water for sluicing and slurrying tailings at the Ohio Copper Mill at Lark. [USSRM, 1937]. Another 5 year agreement for the water was executed in 1947 [USSRM, 1947]. The water which continues to drain from the Mascotte Tunnel has been diverted to a process water system which currently provides water used for dust suppression during removal activities in the Lark area. Until recently, the portal of the Mascotte Tunnel was buried, but was uncovered during recent remedial activities at Lark. The water from inside the tunnel is diverted to a box culvert. Historic data indicates a pH of 6.9, sulfate 867 mg/l, TDS 1310 mg/l. [RI/FS Workplan, 1995]

Kennecott [1996] cleaned up the waste rock which came from this tunnel as a part of the Lark area removal project. The tunnel currently discharges a small flow (0 - 5 gpm) of partially diluted acid mine drainage. The flow is being captured and sent to the mine water collection system. The pH in 1995 ranged between 4.5 -4.6, with sulfate 3900 - 7200 ppm, and copper 2.7 - 15.8 ppm. Other samples in 1995 yield pH's of 4.2 - 4.4 with sulfate 6370 - 7740 ppm. The site was closed out by the OU 3, 6,7 ROD in Sept 2001.

BINGHAM TUNNEL (Lark) (facility #125)

The Bingham Tunnel was constructed to provide a second access adit to the Lark Mine in about 1950. Kennecott [1996] indicates that Kennecott constructed the tunnel between 1948 and 1952 to provide replacement access to USSRM's underground workings. It was used by USSRM to transport workers and haul ore from its operations in upper Bingham Canyon. It is now maintained by Kennecott to dewater the Bingham pit. Waste rock from the Bingham Tunnel and the most recent Lark Mine waste, was placed on the Round Dump (See Lark Waste Rock) [Kennecott, 1991]. Operations were active through the early 1970's. The tunnel discharges about 900 gpm with a pH of 7.4, sulfate 1230 mg/l, and TDS 2050 mg/l. [RI/FS Workplan, 1995]

Further details of the Bingham Tunnel discharge usage for irrigation was provided by Kennecott [1996]. To offset losses of water from the Butterfield Tunnel, the mining companies agreed to build a pipeline conveying Bingham Tunnel waters to the Herriman Irrigation Company's ditch. Later the flow was diverted from the pipeline to a settling pond on a bench north of the Butterfield Creek near Butterfield Ditch. Sediment settled or precipitated out from the tunnel in this pond was removed by Kennecott in 1995. The sediments contained lead up to 1610 ppm and arsenic up to 1270 ppm. The discharge from this tunnel to the pond ceased in 1988 and the Bingham Tunnel water was diverted to KUC facilities.

The Tunnel continues to discharge water, but Kennecott reports that this discharge is diverted to the East Side Collection System. Originally it discharged to Midas Creek and was used for irrigation. In 1986, the flow was estimated at 1250 gal/min [International Engineering, 1985] and 1800 gal/min [Bingham Engineering, 1986]. The state expressed concerns about the quality of the water in 1981, when it noted to Kennecott that the discharge was violating the irrigation standards for TDS and Arsenic. The lease of the water to the Herriman Irrigation Company was canceled in 1987. The lease (which began in 1952 with USSRM) indicated that with one year's notice Kennecott (USSRM's successor in interest) could cancel the lease if they planned to use the water for mining, milling and leaching operations. Kennecott collected samples of the Bingham Tunnel water in 1990 to determine the water quality of groundwater in

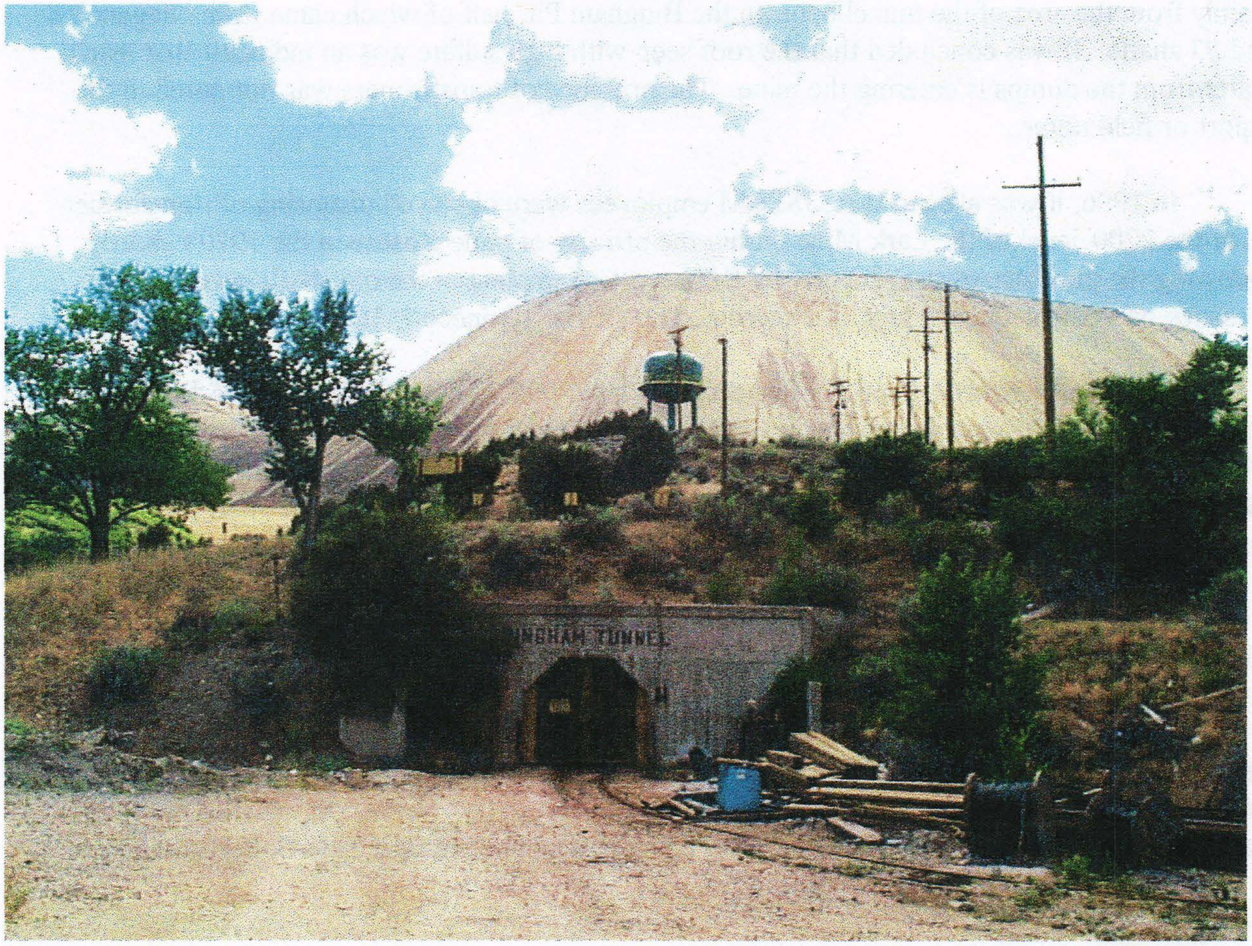

Figure 38: Portal of Bingham Tunnel

the bedrock beneath the East Side Dumps. In 1990, sulfate concentrations at the portal were 1851 ppm. In 1995, the discharge was 1370 ppm sulfate [Kennecott, 1996].

Kennecott [1996] reports that water from the tunnel was used at times in processing operations at the Bingham Canyon Mine and by USSRM for operations in Lark. Water was also discharged to Midas Creek and the Herriman irrigation ditch. Kennecott currently captures all the drainage from the tunnel (600 -1000 gallons per minute) for use in processing operations. There is evidence of acid seepage into the tunnel, but this is small relative to the total flow. An inspection in 1990 indicates that the tunnel is 21,000 ft long, the rear of which ends at the No. 3 shaft. The water is carried in a wooden flume 1 ft. x 1 ft. The tunnel intersects the St. Joe branch, Niagara #2 and #3.

In 1991, another inspection was conducted to determine the source of water entering the tunnel. At the time of inspection flow out the portal was 800 gpm. The sulfate was 1060 ppm at the portal. On roof seep inflow contained 43,800 ppm sulfate. The flow of the tunnel derived mainly from the area of the tunnel beneath the Bingham Pit, half of which came from Niagara #2 and #3 shafts. It was concluded that the roof seep with high sulfate was an indicator that leach water from the dumps is entering the mine. The presence of transformers was not noted in the report or field notes.

In 1996, it was alleged that USSRM employees were observed disposing of transformer oil at the 2200' level of the Lark Mine during the process of mine closure in the 1970's shortly following the purchase of the property by Kennecott. Sampling in the old shafts revealed the presence of a petroleum product; it it contained no PCBs [Kennecott, 1996].

Kennecott performed another inspection in late 1996. A layer of 2 inches of "oily rust" was found in the 12" pipe down the Lark shaft. Three abandoned transformers were found at the 19,500 foot mark in the tunnel. One of the transformers was sampled, but did not contain PCBs. [Kennecott, 1997]. Kennecott has recently (2005) begun dewatering the Lark Shaft and disposing the water in the East Side Collection System lower canal.

UNNAMED ADIT (facility #126)

In the process of waste rock removal near the East Side Collection System, Kennecott discovered an adit of a mine just north of the Lark townsite. According to Kennecott, the mine is about 700 feet in length. It does discharge water from its portal. Kennecott installed a cut off wall downstream of this discharge. Now it is being pumped to the East Side Collection System.

OLD BINGHAM TUNNEL (facility #127)

Boutwell [1905] reports that this tunnel "Bingham Tunnel" was 2150 feet long. The original purpose was to furnish a low level outlet for the large properties of Bingham. Dimensions were 7-8 ft high and 8-9 ft wide to allow space for a joint working and drainage/ventilation. It was projected to 4 miles into the mountain in original plans. Kennecott [1996] reports that the Bingham Tunnel Co built the tunnel in 1901 - 1907 to provide access and drainage to underground mines in Bingham Canyon. The project was reportedly abandoned before completion. USSRM records [1932] indicate that they purchased the "Bingham Prospect" and the company owning it (Lead Silver Mines Co) for $390K. The Lead Silver Mines Co was dissolved by USSRM later that year. The tunnel has some drainage and there is a cut-off wall downstream.

Billings [1952] reports that "during the Bingham Consolidated period of operations a wildcat promoter named Lamson appeared on the Lark scene." Lamson drove a tunnel with its portal of the south side of a small gulch northwest of the Mascotte Tunnel. "This tunnel was driven southwesterly about 4000 feet entirely in porphyry flow and failed to discover mineralization in sufficient quantities which would even classify the ground as mineral ground."

"Later Simon Bamberger (a governor of Utah) hired Jim Stark to homestead the property as agricultural ground. Mr. Stark and his wife established residence on the ground and lived there the required time to obtain title under the Homestead Act. However, his application was contested by a Mr. Evans who had acquired the Lamson interest. But after a hearing the Land Office decided the land to be in the category of agricultural and not mineral. Therefore, Mr. Bamberger obtained title to the ground which incidentally also carries the mineral rights. The tunnel developed a small stream of percolating water and was quite isolated, so during the Prohibition period a bootlegger found a profitable use of the tunnel where he erected a still for making whiskey." [Billings, 1952]

In 1992, Kennecott inspected the tunnel (Adrian Brown, 1992) inward for about 1675 feet from the portal to where the tunnel had caved in. They found at the portal a flow of 5.8 gpm with a pH of 4.1. Seeps from the ceiling had a pH of 3.53. At a fault 575 feet in, the seeps had a pH of 3.45. Other seeps had a pH of 3.62. The flow in the tunnel was 15.5 gpm at 1000 feet from the protal. The bottom of the tunnel had white gelatinous sludge at one point and ferric iron precipitates. The seeps into the tunnel has sulfate concentrations as high as 28,000 ppm. The flow in the channel of the tunnel contained 11,000 ppm - 400 ppm sulfate (lowest concentration at rear of tunnel), 4100 ppm sulfate near the portal. Copper concentrations of the water at the portal was 27 ppm. On an annual basis, Kennecott estimated that 149 tons of sulfate were discharged annually and about 1 ton of copper.

The tunnel was reinspected in 1994 following the installation of a cut off wall above the tunnel. The pH at the portal has risen to 6.6, and the flow was 11.3 gpm. Sulfate was 1600 ppm and copper 0.24 ppm, suggesting that the sources of the seeps had been reduced by the cutoff wall. The white gelatinous precipitate was identified as basaluminite ($Al_4SO_4(OH)_{10}$. $5H_20$). Although the leachwater source seems to have been eliminated, the water quality at the rear of the tunnel has increased in TDS especially Cl and SO_4. In 1995, the pH was 7.87 and sulfate 1310 ppm. Currently, the flow from the tunnel is collected in a HDPE pipe and sent to the lower concrete canal of the Eastside Collection System. 129.05 COPPER GULCH

Copper Creek is an ephemeral stream that originates in Copper Gulch on the east side of the Oquirrhs between Midas Creek and Butterfield Creek. Copper Creek begins from seeps and springs 1 mile north of Butterfield Creek and just south of the abandoned town of Lark. Copper Creek flows east on an alluvial outwash plain into the Jordan River where, after approximately

5.5 miles, it merges with Midas Creek.

Preliminary sampling in the Copper Creek drainage, just to the south of the townsite of Lark, revealed several spots of stream sediments containing high levels of lead and arsenic. In the Lark vicinity, this area was included in the Lark Removal Project completed in 1993. This action was limited to the stretch between Rt 111 and the first reservoir. Sampling of upstream and downstream sediments was conducted in the fall of 1994 by UDEQ with EPA funding. The only marginal elevated levels found by SAIC [1995] was about 1/2 mile east of Hwy 111.

MIDAS CREEK (facility #129.06)

Midas Creek originates in Midas Gulch on the east side of the Oquirrh Mountains. Midas Creek flows east and generally parallels 11800 S St. for approximately 9 miles until it discharges into the Jordan River. One section below the Bingham Tunnel has been filled with waste rock.

Historically, Keystone Gulch and the mines and tunnels near Lark may have discharged drainage waters to Midas Creek via the Mascotte Tunnel Ditch. Midas Creek flowed immediately north of the Lark Waste Rock and Tailings area, the site of historic mining and milling operations [The waste rock has now been relocated behind the Eastside Collection System; tailings with high concentrations of Pb and As have been relocated to the Blue Water repository and the remaining tailings capped.]

Visual sightings of tailings deposits have been noted some distance down Midas Creek which flows through the Lark Area into South Jordan. Some sampling of the creek sediments were conducted in 1990, but the sampling locations were not described. Other samples near Lark were collected during the Lark Project. Visual sightings of tailings have been observed in a rapidly growing development of South Jordan. One residential property was recently tested by Kennecott. Most of the samples were under EPA action levels.

Earlier studies of BERR [1990] found highest concentrations of Pb and As just south of the Jordan Utah Lake Distribution Canal. Under a cooperative agreement with EPA, SAIC was contracted by the state to conduct a survey down Midas Creek.

Of 62 soil samples, 16 contained As above the 50 ppm screening level and 4 contained Pb above the screening level of 500 ppm. The highest concentration was found from the drainage outfall that passes under Hwy 111. Most of the elevated As levels were found in a 2 mile stretch centered on 600 W st. Contamination was also found 60 ft. west of the Utah and Salt Lake Canal, which was reported to be a historic tailings pile. [SAIC]. Midas Creek passes through the rapidly growing town of Riverton (pop. 14,000).

CHAPTER 12
BUTTERFIELD CANYON AND CREEK

Mining activities began in Butterfield Canyon about 1875 and the nearby creek was a convenient dumping ground for the waste rock and tailings. The creek, named Butterfield Creek after an early settler, flows out of the canyon and has been used by the farmers in the valley since the days of early settlement. The community, called Herriman, once a small farming community of Mormon Pioneers, is now a growing city. The relations between the miners in Butterfield Canyon and the farmers and residents of Herriman have always been contentious, and became even more so when EPA discovered that the historic mining wastes had been spread all over town by irrigation practices of the early residents. This chapter details the historic mining and milling facilities upstream in Butterfield Canyon and the impacts the wastes had on the residents and farmers of Herriman.

REVERE MILL (facility #52)

The old Revere concentration works were built in 1875. It was located in Butterfield Canyon, 1 mile from the mouth and about 2 - 3 miles from the ore. It consisted of a 20 stamp mill, tie boxes, and tossing tubs. The old mill was bought, torn down and rebuilt by the Union Ore Concentrating Co of NYC. The new Revere concentration works were built in 1878-9. It included a Blake rock breaker, rotary drier, 3 sets of Cornish rolls, screens, 2 double water jigs, 2 single water jigs, 6 Paddocks pneumatic jigs, vanner, and tossing tub. The mill worked on waste dumps from neighboring mines. Ore containing 6 - 8% Pb was concentrated to 50% Pb. [Census, 1885]. The mill was later bought by the Yosemite Mining Co. in the mid 1880s, and may have been known as the Yosemite Mill after that time. In 1886, the Yosemite Company changed the mill to a wet concentrator with a capacity of 80 tons/day. The tailings were reported to have 3.2% lead (32,000 ppm Pb). The cost of the conversion was about $2500. Ores were transported to the mill via a Hallidie tram formerly used by the Chicago Co. in Dry Canyon [EMT, 1886]. One source reports that the mill also was equipped for ore roasting. It had a revolving horizontal hearth with domed roof and fixed rabbles. It was effective in desulfurizing the ore. By 1887, the works had been abandoned [AIME, Vol 16, 1887].

The farmers in Herriman were acquainted with this mill. According to testimony in a later lawsuit, George Miller recalled: "In '79 some parties put in a box which was put on trestles a little above the defendant's headgate [Keel], and turned our water into it. It was a foot square; we were acquainted with it, because it poisoned our water." [Miller, 1902]

In 1895, the mill was bought by the New Tintic Co. The mill was repaired and remodeled at a cost of $3000. It was designed for a capacity of 120 tons of ore/day to concentrate second class ores and the tens of thousands of tons of old dumps near the Yosemite mine [SLT, 1896]. The mill was destroyed by fire in 1896 [Intermountain Mining Review 1896].

Apparently in 1899 the mill was rebuilt yet again and equipped the machinery including a

200 ton concentrator and 100 ton cyanide plant [Mining and Scientific Press, 1899]. In 1900, plans were made to supply the mill with extra heavy rolls for fine crushing [USGS Prof. Pap. 38]. Kennecott [1996] reports that the mill was destroyed by fire around 1890. (Kennecott [1997] reports that the mill was destroyed by fire around 1900. Both may be correct - the mill may have burned down twice.)

According to Billings [1952], "The early day production of oxidized lead ores of the Yosemite Mining Company was hauled by six horse teams, first to a smelter in the Jordan Valley then later to a Revere Mill erected at the confluence of the gulch with Butterfield Canyon, where water was available. This mill was about three miles above Herriman, a farming community that used Butterfield Creek water for irrigation. In the milling operation, the Yosemite Mining Company was accused of allowing the mill tailings to flow into Butterfield Creek and thus foul up the water used for irrigation. Considerable bad feeling developed over this issue and eventually the mill was destroyed by fire. The mill was never rebuilt and the mine allowed to fill up with water which stood at approximately the 700 level when acquired by the Bingham Consolidated Company."

Figure 39: Tailings from the Revere Mill were found on both sides of Butterfield Creek. It is thought that the tailings on the far bank were part of a tailings pond built to prevent the tailings from going downstream. The presence of tailings in the creek downstream of the tailings pond indicates that the attempt was not very successful.

Kennecott studied wastes left at the site. Seven cores and surface samples near the location of the mill were collected in late 1996. The highest surface concentration was 36,800 ppm lead. Multiple layers of high lead material were found at depth with a maximum of 73,200 ppm lead. High concentrations of lead were found immediately downgradient, downstream, and across the stream from the site. Before cleanup in 1997, the site had remains of flumes and foundation walls.

Figure 40: Archaeology trench at the Revere Mill site next to the road. Bricks, plumbing, wooden flume fragments, and evidence of a fire were uncovered.

The Revere Mill is shown on a map in the Bingham Creek 104e request. Kennecott [1996] indicates that the location is on the north side of the creek near the confluence with Saints Rest Gulch. Kennecott [1996] suggests that the tailings probably washed down Butterfield Creek. The mill was implicated in a lawsuit filed by several Herriman farmers in 1877 shortly after the mill first started operations. The court told the mill operator to cease discharging tailings into the creek. Because wastes were found in a flat area across the creek from the mill site, it is suspected that the operator attempted to impound the tailings, but was clearly not too successful at this.

Removal of the waste from the mill site and from areas immediately downgradient, downstream, and across the stream was completed in the fall of 1997.

A preliminary investigation for cultural artifacts at the surface of the site was conducted in May, 1997 [Environet, 1997]. This survey found several glass fragments and square nails. When excavation of contaminated soils began at the site in July 1997, other artifacts were found including plumbing and flume remnants. The final archaeology report focused on non-mining artifacts including a cartridge casing (manufactured between 1867 and 1871), numerous white porcelain vessel fragments (some from England but most from the US, dates 1865 - 1891), and animal bones. After the mill burned a ranch house was constructed on the site. The residents were fond of different meats and threw their bones out back. Ham, mutton, and beef bones were found (mainly beef). The site was closed out by the OU 3, 6,7 ROD of Sept 2001.

YOSEMITE MILL (facility #52.01)

In about 1886, the Yosemite Mining Co. bought the Revere dry concentrator mill in Butterfield Canyon (see Revere Mill.) Reportedly, the Yosemite Company then had two mills, the old Revere Mill in Butterfield Canyon and another mill near the mine. It was apparently built in 1882 at a cost of $1000 with a capacity of 80 tons of ore per day [SLT, 1882]. Water for the mill came from the mine [SLT, 1894]. It was equipped with a concentrator and ore crusher. Another source indicated that the capacity was 40 tons/day [Mint, 1884]. There is no mention of this mill past 1886. In testimony associated with a later lawsuit, Joseph Bodell [a farmer in Herriman] recalled: "The Yosemite Mine, I guess, was running 5 or 6 years; don't remember it running within the past 12 years; it pumped water out into Butterfield Creek. We tried to keep the water away because it was poisoned." [Bodell, 1902]

Kennecott [1997] reports that tailings from this mill have been found in Yosemite Gulch as high as 90,700 ppm Pb. Kennecott cleaned up tailings deposited near the confluence of Yosemite Gulch and Butterfield Creek in 1997. The mill site itself is now covered by the Kennecott waste rock dumps. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

BROOKLYN MILL (facility #52.02)

Kennecott [1997] reports that the Brooklyn Mine in upper Yosemite Gulch (a tributary to Butterfield Creek) also had a mill. No details were given. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

HOLT MILL (facility #56)

The Holt Concentrating Works were erected in 1880 at the mouth of Butterfield Canyon. It had a revolving screen, 4 jigs, and 4 tie boxes. It worked approximately 2 months on waste rock from the Wasatch and Yosemite mines. The ore was 12 - 20% Pb which was concentrated to 55% Pb [US Census, 1885]. Kennecott [1996] suggests that the site of the mill was somewhere near the mouth of Butterfield Canyon producing concentrates containing lead, silver and gold. A 1994 Kennecott map indicates that the site has not been subsumed by the Bingham pit and dumps.

Kennecott [1996] collected 5 core and surface samples in the suspected location of the mill (a flat alfalfa field to the south of Butterfield Canyon Road at its juncture with SR 111). The maximum lead found was 1300 ppm lead. Local residents indicate that the flat area was created in 1950 using soils from nearby hillsides. Any evidence of a historic mill may have been buried. The site was closed out by the OU 3, 6, 7 ROD in Sept 2001.

BUTTERFIELD MINE WASTE ROCK (facility #58)

Butterfield Mine is south of, and adjoining the largest lead-zinc mine in Utah, the USS&R Mine. Its origin was back in early times when gold, silver, lead ore was mined from outcrops on the surface.

The mine has two main levels -- the Queen tunnel at 7000 foot elevation and the Butterfield Tunnel at 6000 foot elevation. These tunnels are connected by a vertical raise from which other levels were driven. A shaft was sunk 535 feet below the main tunnel level and some fissure and bedded ore mined from this area. Grade of the ore, heavy ground and low market forced discontinuance of this operation. This area in now flooded.

Ore was hauled from the mine bins to the railroad spur in Lark, three miles distant. [Craig, 1953]

One source indicates that the mine was originally started in 1892 by the Butterfield Mining Company, and expanded greatly by USSRM. [Boutwell reports in 1905 that the mine was being expanded to drain the upper works of the Queen vein and explore other veins. At 1905, it was 1.5 miles long.] The tunnel is now 3.5 miles long. This report also says that the Butterfield tunnel intersects with the Bingham Tunnel at the Niagara shaft. [International Engineering, 1985]. USSRM records [1922] indicate that USSRM, Niagara Mining and Lavagnino Consolidated began to extend the tunnel and later extended the Niagara shaft to intersect with the Butterfield Tunnel [USSRM, 1923]. The cost was apparently $215K [USSRM, 1925]. USSRM and Niagara gave water rights to the mine drainage from the tunnel to Lavignino Conglomerate. [USSRM, 1925]. According to an internal memo [Barber, 1959], the Butterfield Tunnel was connected to the Niagara #2 shaft in early 1925. The tunnel level was at the 600 feet level. Below the 600 feet level, water was pumped from the Niagara Tunnel out to the Butterfield Tunnel until 1952. After that the Niagara #2 water was discharged out the Bingham Tunnel (at the 1000 feet level).

Boutwell [1905] indicated that the Butterfield Mining Company was building an experimental mill. The location was not given. The company did have a mill, but it was not located in the district, but over at Bauer.

Figure 41: Waste rock from the Butterfield Mine in the channel of Butterfield Creek.

The site contained waste rock dumps produced during the construction of the Butterfield Drainage Tunnel and subsequent mining operations. The tunnel was originally driven by the Combined Metals Reduction Company in about 1912 to drain the Butterfield Mine workings in Galena Gulch, an upper tributary of Bingham Creek. This information is inconsistent with Boutwell who give a much earlier start date. The mine operated until about 1952 producing lead ores which were milled at Bauer Mill in Tooele County. [Kennecott (1996) indicates that mining operations occurred through the Butterfield Tunnel into the 1960s.] A contemporary newspaper account [SLT, 2-9-41] indicates that the Combined Metals Reduction Company mine in the Bingham District showed an increase of production of gold and zinc in 1940. The Snyders's owned about 25% of the company in 1941, and National Lead owned the rest of the stock. Some waste rock was removed from the Butterfield Dumps for construction ballast by Kennecott. The waste rock dumps contained approximately 1.4 million tons. They were constructed by end-dumping from the mine adit across Butterfield Creek, then along the side of the valley parallel to the Creek. The toe of the majority of the dump lays along the creek; the part of the dump that crossed the creek was eroded by the creek. The mine adit discharges water into Butterfield Creek. A side drainage emptied over the east end of the dump creating an active gully up the side of the dump during storm and melting events. Sediments have washed downstream. [Kennecott, 1991]

Figure 42: In 1997, a sudden cloudburst caused a wash out of waste rock dumps upstream of the mine portal. The sediment-laden stormwater overtopped upstream retention basins and created a mudflow which spilled down the gulch over the mine and into the creek. This flow buried the previous cleanup project there. (See Butterfield Canyon)

For design purposes, it was assumed that the Tunnel discharges 750 gpm, and the water is classified as "moderately contaminated" [International Engineering, 1985] In the 1890s, the Butterfield Mining Company claimed all the water from the tunnel and set up a head gate and diversion works near the mouth of the canyon to convey the water for irrigation of their property, consisting of 2800 acres located approximately 1 mile NW of Herriman. The claim of the Butterfield Tunnel water was challenged by the Herriman Irrigation Company, and the Utah Supreme Court awarded 1/2 of this water to Herriman [Kennecott, 1996].

Kennecott conducted a removal of this waste rock in 1992. In addition to the Butterfield Mine Waste Rock, other waste rock from slide off the main Bingham Mine Dumps was removed at the same time. The waste rock was hauled to a repository at the head of Castro Gulch. Cutoff walls were installed above and below the repository. A rock slide from the main dumps occurred during the winter of 1993 partially burying the repository. This waste rock has been cleared from the site. The OSC is Hays Griswold. The action has been completed under an AOC and the closeout letter was issued in June, 1994. Kennecott estimates the cost of this project was $5 million. Recent monitoring reports from the tunnel portal indicates that all parameters were within discharge limits except for zinc. A Toxicity Identification Evaluation for the outfall also indicated that zinc was the probably cause of biotoxicity. The drainage from the mine portal was included in Kennecott's UPDES permit in February 1995. The mine portal discharge is Outfall 010. The average flow is listed as 500 gpm. A summary of the water quality information presented in Kennecott's permit renewal application [1999] is given as follows:

Parameter	Maximum Daily Value	Average
TSS	11.4 mg/l	3.7 mg/l
Fe	1.35 mg/l	0.439 mg/l
As	0.55 mg/l*	0.042 mg/l
Cd	0.010 mg/l	<0.001 mg/l
Cu	0.09 mg/l	0.025 mg/l
Pb	<0.005 mg/l	<0.005 mg/l
Zn	2.5 mg/l*	0.40 mg/l

*exceeds UPDES permit limits

The Water Quality Classifications for Butterfield Creek are 3D (aquatic life) and 4 (agricultural).

In 2004, U. S. Department of Justice learned that Combined Metals Reduction Co (most recently operating in Nevada) had petitioned the Federal Court in Reno for bankruptcy, seeking to liquidate their mining properties (mainly in Nevada) to pay off their creditors. The Department of Justice filed several briefs indicating that the U. S. Government was also a creditor because it had about $12 Million in unreimbursed response costs for cleaning up Herriman. In 2005, the Department of Justice has also approached National Lead to help with the cleanup costs.

QUEENS ADIT AND OTHER BLACKJACK GULCH MINES (facility #128)

The Queens Adit is found high within the Queens Creek drainage, a tributary of Butterfield Creek. The water quality of water from this source is unknown, but may be similar to the Butterfield Tunnel. On the USGS map, there is an area labeled "Queens Mine" in the upper part of Blackjack Gulch, a tributary of Butterfield Creek. There is a mine dump on the map nearby the mine. Kennecott and EPA inspectors visited the site and found that the adit portal still exists (with bars on it). Outside the tunnel is a waste rock dump on one side of the gulch. There was a small flow coming out the portal. There was no visual evidence that the rock had migrated down the gulch toward Butterfield Creek. Later chemical analyses confirmed that the waste rock associated with the mine had stayed in place.

Queens Tunnel, as noted by Boutwell [1905] was located on the north side of Blackjack Gulch at the end of the main road from Bear Gulch. The tunnel was 2750 feet long. It is not known if Queens Adit, Queens Mine and Queens Tunnel are the same facility. Queen mine also had a mill which dumped tailings into Blackjack Gulch [Kennecott, 1997]. Samples from the waste rock and tailings in the Queen Gulch ranged from 1280 ppm - 31,500 ppm lead and 543 ppm - 3150 ppm arsenic. Kennecott reports that they installed a cutoff wall downgradient from the adit in 1994 which now directs the flow to the leach and stormwater collection system.

Other mines in the Blackjack Gulch included Eagle Bird (crest between Black jack and Bear Gulches, 787 feet long), Northern Chief (head of Porcupine Gulch), Bemis Tunnel (SW of Queen, 725 feet long), Lucky Boy Tunnel (SE of Queen), St. James Mine (located near the crest of the Butterfield Bingham Divide and was west of Blackjack Gulch) [Boutwell, 1905]. USSRM records indicate that USSRM granted Combined Metals Reduction the right to extend the El Dorado Tunnel northwesterly through USSRM claims of Osceola and Lucky Boy for joint use of the tunnel [USSRM, 1955].

According to a 1994 Kennecott map, the Northern Chief Tunnel has been subsumed by the Bingham Pit and dumps. The map also indicates that the following sites have not been subsumed by the pit and dumps: St. James Tunnel, Eagle Bird Tunnel, Bemis Tunnel, Queen Tunnel, and Lucky Boy Tunnel. Kennecott [1996] reports that the Bemis, Bunker Hill, Eagle Bird, Lucky Boy, Mobile, Osceola and Queens are behind the cutoff wall installed in October 1993. St. James mine is outside the system and is reportedly located in the drainage to the west of Blackjack Gulch.

ST. JOE'S TUNNEL and other Yosemite Gulch and Saints Rest Gulch Mines. (Facility #129)

St. Joe's Tunnel is shown near Saints Rest Gulch on a USGS map. Boutwell [1905] describes St. Joes Mine as on the south side of Yosemite Gulch and was 1200 ft. long. St. Joes Tunnel was also an access to the Lark shafts [USSRM, 1930]. Kennecott [1996] identified the St. Joes intersections with Bingham Tunnel. The water in the St. Joes branch in 1990 had a pH of 7.0, and 748 ppm sulfate. During the days of USSRM operations, the St. Joes Tunnel portal was located at the foot of the Kennecott waste rock dumps. Historically, water flowed from the tunnel portal into Saints Rest drainage, from whence it was piped to Lark for use as irrigation and domestic water.

The portal was buried with waste rock in the 1970s and the discharge then passed through the waste rock into Saints Rest drainage and ultimately to Butterfield Creek drainage as subsurface alluvial flow. The pH is above 7 and sulfate is about 2000 mg/l. A cutoff was was installed in 1995. A monitoring well in bedrock downgradient of the cutoff wall has a pH of 4.75 and sulfate of 1500 ppm. Kennecott speculates that the water may have come from historic discharges. Since the groundwater is 30 feet below Butterfield Creek, Kennecott suggests that the creek has not be affected. Note: According to a 1994 map of the dumps and personal inspections of EPA and Kennecott staff, the site has not been covered by the dumps. The portal is still there.

YOSEMITE MINE AND MILL (facility #129.01)

Other Yosemite Gulch mines include Yosemite mine (on the north fork of Yosemite Gulch) and Paradox mine (SW of Yosemite, 400 feet long). The Census Report [1885] indicates that the Yosemite Mine was located near the summit of the high steep ridge which separates Butterfield Canyon from Copper Gulch and Bingham Canyon. When observed in 1880, it had a large dump of second class ore (7 -22% lead). By 1932, USSRM apparently owned at least partial interest in the Yosemite works because they were paying for electrification of the works. Kennecott [1997] indicates that Yosemite mine had a mill which dumped its tailings into upper Yosemite Gulch. Characterization of Yosemite Gulch yielded lead values as high as 90,700 ppm. The deposits of high lead at the confluence of the gulch with Butterfield Creek were removed during 1997 as part of the Butterfield Canyon Removal Action. Note: a 1994 map of the dumps indicates that the site of the Yosemite mine and mill has not been covered by waste rock.

BROOKLYN MINE AND MILL (facility #129.02)

Kennecott [1996] also noted the Brooklyn Mine in the Yosemite Gulch drainage. The Brooklyn Mine also reportedly had a mill which dumped tailings into Yosemite Gulch. (See Yosemite Mine).

OTHER YOSEMITE GULCH MINES (facility #129.03)

Kennecott [1996] also noted these mines in the Yosemite Gulch drainage: Badger, Chicot, Gladstone, No You Don't, and Revere.

SAINTS REST GULCH MINES (facility #129.04)

Saints West Gulch mines include Daylight Extension Tunnel (east slope of Saints West Gulch, 2000 ft east of Bear Gulch road, 400 ft. long), Lenox Tunnel (SE of Daylight Extension, 250 ft long), and Yes you do Tunnel (SW of Daylight Extension, 75 feet long). USSRM purchased half interest in the Daylight and Daylight Extension claims in 1932 [USSRM, 1932] and the other half in 1940 [USSRM, 1940]. According to a 1994 Kennecott map, all of these mines have been subsumed by the Bingham pit and dumps. Lead in Saints Rest Gulch has been found as high as 73,200 ppm Pb. [Kennecott, 1997].

BUTTERFIELD CANYON (facility #58.01)

Butterfield Canyon is located on the eastern side of the Oquirrh Mountains at the extreme southwestern corner of Salt Lake County. The watershed begins at the crest of the Oquirrhs and the mouth of the canyon is near Herriman. Several gulches intersect the main canyon. The current canyon watershed (not counting the waste dumps that have filled the heads of several gulches) is 5802 acres [EPA, 1997]. Subdrainages include: Spring Gulch (443 acres); Tooele Fork (693 acres); Left Hand Fork (970 acres); St. James Gulch (274 acres), Stockings Fork (436 acres); Black Jack Gulch (432 acres); Olsen Gulch (196 acres); Castro Gulch (537 acres); Saints Rest Gulch (303 acres); and Yosemite Gulch (531 acres).

Butterfield Creek, a perennial stream in the canyon, flows at the bottom of the canyon. A county road follows the creek in its lower stretches, eventually going over the crest and down Middle Canyon on the western side of the Oquirrhs. Kennecott owns most of the property on the north side of the creek and private owners and the government own most of the south side. The Bingham Canyon mine dumps have encroached over the Bingham Creek/Butterfield Creek divide and now fill up the upper reaches of several Butterfield gulches.

Mineral resources, mainly lead and silver, were discovered in the canyon in the 1870s. Several mines and mills were located in the watershed [see Butterfield Mine, Yosemite Mine and Mill, Brooklyn Mine and Mill, Queen Mine and Mill, and Holt Mill.] Although rich lead carbonate ores had played out in Bingham, shoots of the carbonate ore were found in Butterfield Canyon until the late 1890s [Boutwell, 1905]. During normal flows, about half of the flow in Butterfield Creek originates from the Butterfield Mine Tunnel. [see Herriman water rights]. Today, all the water from Butterfield Creek is completely used by Herriman farmers for irrigation.

There have been several studies of Butterfield Canyon. The geology of the area was described by Boutwell [1905]. Summers of BLM [about 1982] evaluated the impacts of expanding the Bingham Mine dumps into portions of the Nevada tract prior to a land exchange. Kennecott [1990, 1992, and 1996] studied the various wastes and downstream migration of the wastes. ep&t [1997] studied the ecological risks posed by pockets of mining wastes in the watershed.

Vegetation at middle elevations is composed of 63.8% native species including western scouring rush, other rushes, redtop bent, American bulrush, burdock, northern willowherb and field mint. Trees include osier dogwood, yellow willow and box elder [ep&t, 1997]. Lower reaches have 100 year old scrub oaks [Kennecott, 1997].

Large animals include deer, elk, and cougar. There are three state sensitive bird species which migrate through the area (yellow throat, yellow breasted chat, and yellow billed cuckoo). Rough-winged swallows, marmots, red-tailed hawks, prairie falcons and other birds are found in the canyon [ep&t, 1997]. Butterfield Canyon presently has no fish [Parametrix, 1996], but old time Herriman residents report that fish were present at one time. There is a wide variety of aquatic macroinvertebrates living in the creek.

Upland vegetation includes Junipers, along with desert shrubs (sagebrush, rabbitbrush), serviceberry and chokecherry. Wildlife includes elk, deer, cougar, bobcat, white footed mice. Birds include robins, kinglets, mountain bluebird, vesper sparrows, golden eagles, red-tailed hawks. Crickets, ants and yellow jackets are also present.

Mining wastes are known to have washed down Butterfield Canyon below the Butterfield Mine. Kennecott conducted a sampling project down the canyon in 1990. Discolored, yellow soils mainly appeared in the vertical stream banks and lay in horizontal vanes 6 to 18 inches in depth. They appear to be deposited by past stream flows and are covered with 6 to 24 inches of topsoil. Later investigations in 1996 found that these deposits did not originate with the Butterfield Mine but was the site of an historic mill, Revere Mill.

Castro Gulch intersects Butterfield Canyon approximately 4,500 feet east of the Butterfield Tunnel Waste Dump. In 1967, this gulch carried a mine waste blow out from the Bingham Pit dumps into the Butterfield Creek Channel. The waste material apparently covered the road as well as filling the Butterfield Creek Channel. The material in the channel appears to have been washed downstream with the yearly runoff, but is not visibly deposited along the stream channel except at Castro Gulch. The material covering the road was apparently loaded up and dumped down stream on the north side of the road in 3 separate locations. Kennecott [1996] reports that 100,000 tons of this waste rock was cleaned up during the Butterfield Mine Waste Rock removal. Another Castro Gulch waste rock slide occurred in 1994 which partially buried the new repository for Butterfield Mine Waste Rock (placed there from the Butterfield Mine Removal Action). It was repaired.

Another Bingham Canyon Mine blowout occurred in 1979. The Yosemite blowout occurred in Saints Rest Gulch which was contained by emergency dams located 500 feet upstream of the confluence of Yosemite Gulch with Butterfield Creek [Kennecott, 1997]. According to a memo by R.K. Davey, the blowout occurred on the Yosemite truck dump on May 9, 1979. It occurred on a non-actively leached part of the dump and the slide involved 3 - 5 millions tons of rock and water. Although not on a portion of active leaching, there was an acid disposal area 600 feet to the north and leach ponds 100 - 300 feet to the NE. The Lark area water users were concerned because the slide affected Willow Springs. The mudflow topped the upper dam on the gulch and reached the emergency dam located 600 feet above Butterfield Creek.

Heavy storm water flows eroded mining wastes from several gulches. One incident occurred in the canyon on June 9, 1997. A heavy rain event, perhaps of cloudburst magnitude, was centered over Black Jack Gulch, Olsen Gulch, Butterfield Gulch, and Castro Gulch, all tributaries to Butterfield Creek in the canyon. Approximately 1.3 inches of rain fell over a 40 minute period, probably synonymous with a 10 to 25 year storm event.

The stormwater collection system built by Kennecott failed only in Olsen Gulch where the three sedimentation basins above the cutoff walls had been filled up, and water with abundant sediment topped the walls. Also the sedimentation basin between the cutoff wall in Olsen Gulch and Butterfield Creek had filled, and the mudflow crossed the road and entered Butterfield

Creek. The cutoff walls and sedimentation basins in Black Jack and Castro Gulches contained the mudflows, but were filled to near capacity and water flow began to seek new courses. The flows out of Butterfield Gulch above the Butterfield Mine adit resulted in a mudfall over a cliff behind the adit, and a new gully was formed across the Butterfield mine reclamation area. Kennecott had designed the sedimentation/cutoff wall system to contain a 10 year storm event. The company estimates that over a two day period, the runoff volume was 4 to 5 million gallons.

The muddy contaminated water flowed downstream in Butterfield Creek, and a portion of the flow entered the Herriman Irrigation System depositing lead and arsenic-bearing sediments in a number of residential yards. Analytical data of samples of suspended solids in the creek from near Butterfield Mine downstream to the intake of the irrigation system contained lead values averaging 1500 ppm Pb.

After the storm event, Kennecott dispatched backhoes and bulldozers to clean out the sediment-filled retention basins in all of the storm impacted gulches and to remediate erosion in previously-reclaimed areas in Butterfield Canyon. The contaminated sediments and soils were hauled to the Bluewater Repository. Kennecott cleaned up several yards at the same time. The yards most impacted were at the end of the irrigation system. Upstream users refused to turn out the water on their lands.

A similar mudflow was reported in July, 1998, but the mudflow apparently originated from several gravel roads in the area. The waste rock dumps in the Butterfield Canyon watershed were not involved.

The Butterfield Canyon Removal Action started in 1997 and cleaned up mill wastes from the Revere and Yosemite Mills at Saints Rest Gulch and Yosemite Gulch. [see individual entries]. The construction was completed in the spring of 1998. The stream is being monitored to ensure that the sediments carried by the creek do not exceed 500 ppm lead.

Kennecott adds that near the mouth of the canyon are several piles of mine waste material which appear to be waste from small glory hole excavations. Concentrations of lead were as high as 20,000 ppm and arsenic as high as 480 ppm. [Kennecott, 1991]. Some of these may have been cleaned up in the process of the later Butterfield Mine Waste Rock or Canyon Removals, but reports submitted to EPA do not address this.

UDEQ was given a Cooperative Agreement from EPA in 1994 to study the Butterfield Creek and its floodplain to determine the extent of the contamination, if present. The community of Herriman was included in this study. [See Butterfield Creek.]

BUTTERFIELD CREEK, HERRIMAN SOILS (facility #58.02)

Figure 43: Tailings from mining in Butterfield Canyon were carried downstream by the creek. Farmers and Herriman town residents used the creek water for irrigating their crops and lawns. In this photo, government agencies and contractors excavated the tailings from front yards and back yards of Herriman. The work required a delicate touch using heavy equipment.

Butterfield Creek drains the Butterfield Canyon at the southern end of the Oquirrh Mountains. The Butterfield Creek channel typically contains flowing water throughout the year. The water comes from runoff from melting snow, small springs, groundwater inflow and discharges from the adit of Butterfield Mine, perhaps others. Historically, discharges from the Bingham Tunnel were diverted to Butterfield Creek. Kennecott has a permitted outfall on Butterfield Creek (Outfall 010). The water quality classification is 2B, 3D and 4.

Butterfield Creek emerges from Butterfield Canyon and enters the Jordan River Valley approximately 2 miles southeast of the Bingham Mine. After entering the valley, it becomes a losing stream and eventually dries up. Water is also diverted from the creek into canals and ditches for irrigation use by local farmers near Herriman and by local residents for lawns.

Mine waste material in Butterfield Creek appears to have washed downstream with yearly runoff and was visible along the stream channel at Castro Gulch. Floods and irrigation are believed to have spread the contaminated sediments onto the floodplain near Herriman [SAIC, 1995].

The relationship between the farmers of Herriman and the miners upstream has always been a rocky one. In 1877, several farmers sued the operator of the Revere Mill for contaminating their irrigation waters in Butterfield Creek. The court ordered the miners to cease polluting the creek. The farmers later incorporated the Herriman Irrigation Company in 1893. Company records are filled with disputes between the irrigation water users and the mining company, usually involving water rights, but sometimes involving the impacts of polluted water.

A history of Herriman written in 1952 by school children from Herriman Elementary mentions irrigation in several contexts. Irrigation in the Herriman area started in 1852 and became a common practice of the early settlers. In 1895, a reservoir was completed at the mouth of Butterfield Canyon. Mining activities in Butterfield Canyon intercepted nearly all the flow from upgradient springs and diverted the water in tunnels and then mine owners used the water to irrigate their own land to the north of Herriman, later called the Bastian Ranch. Herriman farmers sued. Eventually, the courts ruled in 1908 that half of the water would stay with the mine owners, but the other half had to be provided to the Herriman farmers.

The booklet also states that at one time "people brought water from Bingham Canyon, but it was found to contain acids which killed the crops and farm animals. It has been stated that two children became ill and died as a result of drinking this water, but it has never been conclusively proven." The irrigation system in Herriman has been upgraded and improved over the years, first by lining the ditches with concrete, then by laying pipe. In 1952, the school children concluded that the surface water would be sufficient for only 80 families and Herriman already had 75 families. They said that a new source of water must be found in order for the town to grow. This was eventually done by use of groundwater resources.

Several studies of Butterfield Creek have be conducted (BSHW, 1986; BERR, 1990; Kennecott, 1990; SAIC, 1995). In the most recent study, through a cooperative agreement with EPA, the state contracted SAIC to complete a survey of lead and arsenic concentrations down Butterfield Creek and the floodplain near Herriman. These data indicate that lead and/or arsenic is present above screening levels from Hwy 111 on the west (start of the survey) to 1/2 mile east of Fassio Egg Farm on the east. The historic channel east of this point is not apparent but lead was found near Redwood Rd along the historic channel path. The highest Pb was 19,700 ppm with As at 357 (at depth). Of the 55 total samples, 22 contained lead above screening levels.

This study also confirmed the presence of Pb and As above screening levels in the farming community of Herriman. Using a 40 acre-size grid, 10 of the 46 surface samplings had Pb and/or As above screening levels. Six of the 10 higher samples were collected from irrigation ditches. The others were collected from residences and pastures. The highest concentrations in Herriman were 6750 ppm Pb and 140 ppm As. SAIC concluded that contamination is widespread occurring in ditches, fields, and residences irrigated by Butterfield Creek water. The highest concentrations were associated with early irrigation canals, now sometimes buried under fill. Further sampling on a lot-by-lot basis began during the winter 1995-6.

Beginning in March 1996, the BOR, under an Interagency Agreement with EPA began an intensive residential soil sampling program within the community of Herriman. As of December 1997, 194 residential lots have been sampled in soils to a depth of 24 inches. Elevated levels of lead and arsenic are associated spatially. About 194 town properties were characterized. Lead concentrations exceed 6000 mg/kg at 31 properties. A total of 83 properties were addressed in later removal actions.

On June 4, 1997, EPA signed the Herriman Residential Area Action Memorandum authorizing the soil removal action. The action is a Time Critical removal, fund lead. The community of Herriman was awarded a technical assistance Grant in June, 1997.

During the first year (1997), 37031 cy of contaminated soil and 2250 cy of Herriman ditch material had been removal. Twelve properties were remediated. In 1998, 66 yards were remediated with 67,670 cy removed. In 1999, 5 yards were remediated with 6180 cy removed. The total cost to EPA was $8,250,000. Repository and hauling services were provided by Kennecott. The contaminated soils are being hauled to Kennecott's Bluewater Repository under the provisions of an AOC.

At the request of the residents, EPA sampled surrounding agricultural lands in the fall of 1998. Based on these results, UDEQ (with funding from EPA) conducted a sampling program using 100 foot grids. The results were provided to the property owners, the city, and the county. Property owners whose property tested clean were provided with comfort letters which were also filed with the county.

In the summer of 1998, it was discovered that the Fassio Egg Farm chicken coop had been built on a foundation of Lark Waste Rock. Kennecott is removing this waste rock up to the main mine waste dump at Keystone Notch. Lark Waste Rock containing high levels of lead was also used as a road base for several streets in Herriman. EPA has sampled the shoulders of the road so that those areas can be paved to cap the contamination.

In the spring of 1998, Herriman voted to incorporate as a town. The application covered enough population (900) to meet the minimum requirements for incorporation. In 2001, Herriman became a 3rd class city. The 2000 census lists the city's population at 1500.

Herriman has a population of approximately 2500 as of 2005. Agricultural products include grain, grass, alfalfa, raspberries, cattle and sheep. Today, the City of Herriman is growing rapidly, particularly in the foothills south of downtown (areas never irrigated with Butterfield Creek). A commercial district is developing east of town. Herriman Residents for Responsible Reclamation (HRRR) in conjunction with the landowners of agricultural lands completed a land development plan which suggested that commercial and industrial development be the focus in the contaminated areas. The HRRR plan was later adopted by the City Council.

The City of Herriman is managing the development of contaminated farmlands through use of its building permit authority. The special conditions listed in the building permits depend on the proposed land use and layout of construction. Several farmers have expressed interest in developing their lands in the future.

HERRIMAN IRRIGATION COMPANY (facility #58.03)

The Herriman farmers and townsfolk began irrigating their crops soon after Fort Herriman was settled by the Pioneers. A ditch was dug to the fort to bring in water from Butterfield Creek in 1852. When mining and milling activities began upstream in Butterfield Canyon in 1872, it was not long before the farmers and the miners were in court. This rocky relationship continues until today. The following is a chronology of the problems and events. Unless noted, the source is the Herriman Irrigation Company board minutes.

1851 - Irrigation begins
1876 - Revere Mill built
1877 - Herriman Farmers sue owners of Revere Mill (lawsuit goes to Utah Supreme Court)
1893 -Start of Herriman Irrigation Co. (HIC)
1894 - HIC complains to Mr. Keel (Butterfield Mining and Milling Co.) for taking water out of the creek - stoping in mine dried up springs.
1897 - HIC loses their lawsuit against Mr. Keel in District Court. HIC appeals.
1902 - HIC wins against Mr. Keel, Keel offers to settle for $500.
1904 - Lavagano mill pollutes creek
1909 - HIC complains that a Bingham Canyon mining company diverted waters from Spring Gulch (headwaters of Butterfield Canyon) and sent it over land to the mining camp. The mining company later offers to buy the water. A rental arrangement was negotiated with the Independent Water Company - Bingham (IWC).
1914 - IWC files for a water right on the springs, HIC fights this
1917 - IWC refuses to pay water rent anymore, HIC votes to hold them to the rent.
1919 -Court finds for HIC, case is settled when IWC pays $1,233 to HIC
1922 - HIC protests U. S. Mines bringing poisoned water through Butterfield Mine into creek.
1922 - HIC leases water to Park-Bingham Mining Co.
1928 - No payment ever received from Park-Bingham Mining Co. for water lease.
1929 - Kuphalt made application for more water from the spring in St. Joes Gulch. HIC compromises - let him have the 8 gpm application of 1915.
1930 - HIC cancels lease with Park-Bingham Mining Co.
1930 - Pollution coming from St. Joes Gulch from U. S. Mine. Wants mine to pay for analysis of the water
1945 - U. S. Mine Co had been pumping mine waters into Herriman ditch, and in 1945 they stopped the practice.

1952 - HIC has contract with USSRM for mine waters from Bingham Tunnel
1966 - Lawsuit, HIC v. USSRM and KUC settled, regarding Lark and Butterfield Creek waters.
1969 - Complains about waste rock (Butterfield Mine WR) blocking creek.
1975 - Complains again about the Butterfield Mine waste rock blocking the creek.
1979 - Again
1986 - Concerned about water quality from Lark.
1986 - Told about Superfund by UDOH.

The construction of the cement ditch in 1912 was recalled in a biography of Albert Crane (May 13,1979). "Then in 1912 the Herriman Irrigation Company decided to cement the ditch from the Canyon to the last head gate at the bottom of town and I got the job hauling gravel for the cement with them. Piles of gravel was placed all along by the ditch bank and then the cement was shipped by train to Lark and we hauled the cement from there as it was needed. The hauling of the material was done mostly by local men and teams and wagons but the actual labor was done by a construction company from Salt Lake City who hire men from out of town. (This construction company advertised that the Herriman canal was being cemented and they were hiring help. But when a man was hired, he had to pay $1.00 for the job. They had two bosses – one who hired the men and collected the dollar and then in a day or two the other boss would fire him so it kept a continual flow of men coming and going on the job)." EPA investigators uncovered remnants of the cement ditch and found contamination on top and underneath it. This would suggest that contamination was coming into the irrigation system both before 1912 and after that as well.

Albert Crane also described the maintenance required for the irrigation system. "Several years I was the Water master over the irrigation ditch. That entailed preparing the ditch in the Spring to bring the water from the Canyon down to farms and town lots, and preparing the time schedule for turning the water. Then during the summer months in between farm crops I would go up into the canyon and clean out springs and straighten and clean the run-off ditches down to the main stream. This work was done by hand with a shovel and for this work, I was paid by the hour."

Operational difficulties were described in the records of the Herriman Irrigation Company:

1893: one resident was notified to repair the south ditch by his corral that he injured by plowing away the bank.
1895: a notification was sent to "all parties that cuts wood to see that the trimmings is put clear of the ditch."
1897: if the flow stopped, "it has been on account of the filling of his ditch with gravel as there has been a great deal coming down the Canyon this spring."
1897: the company is not responsible "for anyone that might tamper with the gate without our knowledge."
1899: a resident put in a box to raise the water. HIC told him to remove it and put water

in the bottom of the ditch.

1899: board wanted to keep the water properly divided and kept in the ditches so that it would not all freeze up and run all over the streets. Some folks at the lower end of town did not get water all winter.

1899: people that turn the stock in their fields and damage the ditches should be responsible for repairs.

1904: decided to clean out the ditches so that we will have water during the winter.

1905: one resident refused to pay his assessment until he saw the books for the past 4 years, eventually paid right before his rights were to be sold.

1907: cleaned the ditches

1910: Water master empowered to hire men to clean the ditches, HIC cleans the main ditches, the rest responsible for their own ditches.

1911: Objected to the practice of watering sheep on small streams; also did not like the practice of hauling water out of creeks in tanks or barrels; voted to prohibit stockwatering or hauling of water from ditches, asked county to take care of all loose stock in the streets of Herriman, and keep stock out of ditches.

1912: During construction of the ditch, the teams brought in were not satisfactory and boys were being hired that couldn't do the work. They voted to have the cement ditch in solid ground 3" below the level of the ground.

1915: Water master to clean the ditches.

1920: Some residents were accused of obstructing HIC right of way in Butterfield Creek.

1938: A resident was accused of interfering with the HIC reservoir above Dansie land. The resident had plowed and planted the land. The reservoir had been there for 45 years at that time.

1946: Tried to dig holes in the reservoir to find out how it was losing water - hit gravel layer 6 - 8 ft down.

1951: Current irrigated land is 365 acres, but could go to 500 acres if they could store the winter water.

1958: Cement ditch in very poor condition

1958: Proceeded to build a reservoir

1961: Applied to the government for help in repairing the ditch. "If we could not qualify we would not be out much for trying"

1983: Boy Scouts could help clean the ditches in the Canyon

1984: Some of the gate cylinders filled up with silt and had trouble keeping right amount of water for city users. Flooding in 1983 was noted.

1985: Flood cut a gully 15 feet deep. Salt Lake County filled it with rocks. HIC replaced the headgate that was washed away. (Note: the rocks were waste rocks from Kennecott)

A summary of events relating to the irrigation and culinary systems was provided by a history of Herriman water written in 1951 and updated in 1963 by Albert Crane:

1851: First ditch was constructed by Thomas Butterfield

1891: Reservoir built to store winter water. It was located just west of the city blocks.
1894: Reservoir was built in the mouth of Rose Canyon
1896: Cement pipeline was built from the dividing box for 2 1/8 miles down the ditch
1902: HIC awarded 2/3 of Butterfield Mine Tunnel water. 1/3 went to mining company.
1902: HIC sues mining company for $20,000 in damages (this case was lost)
1905: Herriman Pipeline Co. formed to provide drinking water. 2 miles of 3" pipe laid from springs to a storage tank and 4-6 miles of 4" pipe went from the tank down to and all through town. The tank was redwood and held 15,000 gallons of water.
1912: Cement ditch constructed for HIC
1916: HIC divided into three companies: Rose Creek Irrigation Co, Herriman Irrigation Co., and City Water
1945: Original 1905 drinking water system was replaced, with 6" cast iron pipe down to the highway, the 2 - 4" cast iron pipe to the houses. It included 9 fire hydrants. The wooden storage tank was replaced with a cement tank holding 110,000 gallons of water.
1949: Springs were piped in Arnold Hollow of Rose Canyon to cement boxes to protect water and prevent losses.
1950: Well drilled by HIC in mouth of Butterfield Canyon. It was 180 feet and did not hit groundwater before bedrock
1954: Land surrounding drinking water springs was fenced.
1955: Well was drilled by Pipeline Co (City water). It was 618 feet deep producing 450 gallons/min. It was west of town. Water was pumped from the well to a storage tank near the well and then to a storage reservoir 3/4 mile SW of town.

CHAPTER 13
MINING AND MILLING OF BINGHAM ORES IN TOOELE COUNTY

When space became limited in Bingham Canyon, several companies decided to access the Bingham ores by tunneling from the other side of the Oquirrh Mountains in Tooele County. These areas were at one time considered to be a part of the Kennecott site because a portion of the land is now owned by Kennecott and a portion by ARCO (which had also been involved in the Bingham Creek response actions in Salt Lake Valley). Because negotiations regarding potential cleanups on the Tooele side of the mountains lagged behind the rest of the Kennecott site, EPA decided to address the Tooele facilities separately. Although a part of the same operation, for convenience, EPA determined that all Kennecott-owned land would remain as a part of the Kennecott site, and ARCO lands (and areas downstream of ARCO land) would become a part of the new NPL site called International Smelting and Refining Site. This chapter describes the facilities mining Bingham ore from the Tooele side of the Oquirrhs. (Refer to EPA records of the International Smelting and Refining Site for cleanup actions occurring after 1996.)

ANACONDA CARR FORK (facility #62)

The Carr Fork Project began in 1947, when Anaconda acquired all the National Tunnel and Mines assets and lands, including the Carr Fork claims. Carr Fork is a tributary of Bingham Creek. A twenty year exploration program on the properties eventually prompted extensive core drilling and assaying. By 1973, drillers had delineated the Yampa and Highland Boy ore bodies that are the basis of the Carr Fork Mine.

In 1974, the Carr Fork Project began developing the mine and constructing the concentrator complex. It was decided to build the mill in the steepest part of Pine Canyon where the slope of the ground would allow gravity flow to be utilized. Access to the early mines in Carr Fork was in the area now occupied by the Bingham Pit. Access to this later mine was from the western side of the Oquirrh Mountains rather than on the pit side.

The drilling of four shafts, the underground development of the mine, the building of roads, and the construction of the concentrator entailed considerable labor and money ($216 million). Carr Fork was in full production by the fall of 1979. After the ore was mined and hoisted from the mine up the production shaft, it was fed into a powerful crushing complex. Next, the crushed ore was transferred to a 36 inch conveyor belt and advanced to the rod mill. Here a finer grind took place previous to an even finer grind in a ball mill followed by a regrind mill. By now the ore had been reduced to 100 mesh.

A 17 cell "rougher" flotation circuit was followed by a "cleaner" circuit and a "re-cleaner" circuit. "Cleaner" tailings flowed into six 300 cubic feet scavenger cells and eventually discharged to tailings disposal.

After ARCO purchased Anaconda in 1981, production was greatly decreased. In 1984, a massive mudslide at the top of the canyon killed one man and filled the service shaft. MSHA closed the mine. Kennecott bought the property in 1985. The mill in Pine Canyon (including offices and other buildings both in Pine Canyon and at the old International Smelting Company site,) together with air shafts, hoists, drys, railroads, much mining equipment, water lines, settling tanks, a large flotation mill, chemical laboratory, etc., was sold in 1986 and shipped out to other mining districts. [Dunlavy, 1986]

Tailings from the flotation mill were disposed of in the tailings pond below the old International Smelter site [ARCO, 1985].

There are also numerous mine dumps visible on the east side of the Oquirrhs at the head of Carr Fork which may have been associated with this project.

Kennecott now has completed a reclamation project at the site. Revegetation of the area was started in 1988. The project was damaged during a flood in May 1993. The flood loosened rubble and silt from the upper reaches of the canyon, and Pine Creek overflowed its channelized banks into the former channel. The area close to the creek and in the channel was filled with rubble, and the areas further away were buried by 1 - 2 inches of silt. The bigger shrubs survived the silting, but some of the grass was thinned out. The Pine Canyon Tunnel is located on site. There is one unreclaimed waste rock dump on the south side of the canyon near the tunnel portal. Kennecott [1997] reports that the dump is located 800 feet west from the tunnel entrance and contains less than 100 cubic yards of waste rock. The mineralogy is predominantly limestone with very minor amounts of sulfides. Analysis indicates the waste rock contains 69 ppm As and 63 ppm Pb. The dump is at the angle of repose and has not been revegetated [Kennecott, 1997].

The reclamation project was conducted under the supervision of the Utah Division of Oil, Gas and Mining. The wastes from this mill were deposited in the Anaconda Tailings Pond downstream of the mill.

Further investigations of this site have been conducted by UDEQ. [see also International Smelter #66 and Anaconda Tailings Pond #68] The site of the head shaft for this operation, now on Kennecott land, was closed out by the North End ROD of Sept 2002. The wastes associated with this operation are now part of the International Smelting and Refining NPL site.

STAR MILL (facility #63)

The Star Mill is shown on a map in the Bingham Creek 104e request. It was located on Pine Canyon in Tooele County near Baltimore Gulch. No other information was given.

Boutwell [1905] described the mill at Star Mine (west wall of Pine Canyon 300 feet up and to the west of the mouth of Baltimore Gulch. The mill was a cyanide mill with a capacity of 25 tons/day. This mill was located at the base of the slope beneath the tunnels.

Kennecott [1997] indicates the mill was located in upper Pine Canyon near the present abandoned Anaconda production shaft. It was a cyanide mill capable of handling 50 tons/day of gold-bearing ore (Mining and Scientific Press, Jul 30, 1898) Kennecott does not know where the extract was processed or when the facility ceased operations. Kennecott now owns the land. This site was closed out by the North End ROD of Sept 2002.

UTAH-DELAWARE MILL (INTERNATIONAL MILL) (facility #64)

The Utah-Delaware Mill is shown on a map in the Bingham Creek 104e request. It was located near the International Smelter in Tooele County. [Note that the Utah-Delaware Co, the Utah Apex, and the National Tunnel Co. merged in 1937.] No other information was given.

Kennecott [1997] indicates that the Utah Delaware Mill was situated adjacent to the International Smelter located in lower Pine Canyon. Its name was changed to Utah Delaware in 1924 after the mill was acquired through litigation from the Utah Consolidated Company (see International Mill #65). The mill had a operating capacity of 1000 - 1100 tons/day of low grade copper ore and in 1925, by use of different additional reagents, also extracted concentrates of iron, lead and zinc.

A Utah Consolidated report written in 1920 indicated that the mill was built in 1920 with an operating capacity of 1000 tons of ore/day. "The mill is located within a few hundred feet of the International Smelter at International, Utah, and along side the company's present aerial tramway which extends from the mine four miles distant to the smelter." According to the report, construction was to be completed by 1921.

References cited after 1924 commonly use the name of this mill as the International Mill. Originally, the ores concentrated at the mill were from the Utah Consolidated properties and from Highland Boy Mine. After the mill was acquired by Utah-Apex, ores from mines included the Park City, Utah-Delaware, Utah-Apex, Utah Metals and Tunnel, Bingham Mines, and general custom ores, were concentrated (Engineering and Mining Journal Aug 28, 1926). The majority of the ores were delivered by a 4-mile tramway. The mill operated from 1922 to 1972.

In 1924, the International Smelter added a lead-zinc flotation mill to concentrate and separate relatively complex lead-zinc-silver ores of Utah and adjoining states and provide feed stock for the International lead smelter. Tailings were disposed of on-site. The lead-zinc flotation mill ceased operations in 1968 and was razed in 1972. (ARCO, 1985). ISR agreed to close their mill in 1958 and send their ores to the USSRM Midvale mill. In return USSRM closed their smelter in Midvale in 1958 and sent their concentrates to the ISR Smelter in Tooele. Records regarding this cooperation are also included in USSRM records. The tailings pond area for this mill was later used again by later operations at Anaconda Carr Fork. This area has been reclaimed by ARCO, and is a part of the International Smelting and Refining NPL Site.

UTAH METAL CO (facility #64.01)

A 1909 publication of the Bingham Commercial Club indicates that the Utah Metal Company had a desire to build a mill near the new Tooele smelter and run a tunnel from Carr Fork. No further information was given. These plans were latter dropped (Kennecott, 2002). No mill existed and the site was closed out by the North End ROD of Sept 2002.

INTERNATIONAL MILL (facility #65)

The International Mill was a later name used for the Utah-Delaware Mill. (See details for Utah Delaware Mill.) The land is owned by ARCO and is a part of the International Smelting and Refining NPL site

INTERNATIONAL SMELTER (facility #66)

The International Smelting and Refining Company started construction of its smelter at the mouth of Pine Canyon in 1908 in response to the excess ore supplies and high demand for more smelting capacity following the closure of many older smelter in Salt Lake Valley as a result of the "smoke farmer" court case.

Two additional factors made the construction desirable. (1) The salvage possibilities at the shutdown smelters presented a source of cheap steel, building materials and smelter equipment. One third of the steel came from the Highland Boy smelter in Murray. (2) The site had sloping topography facilitating gravity flow for movement of materials and prevailing winds carried smoke up the canyon away from inhabited areas. [The owners took other precautions by purchasing all the ranches near the smelter, about 2000 acres, and an agricultural survey was conducted before the smelter was built.] The smelter became operational in 1911 principally using Highland Boy ores and other custom ores [Billings, 1952].

The first part of the smelter complex was a copper smelter with a capacity of 4000 tons/day. [However, typical smelting rates were 150 - 550 tons/day.] Ore came mainly from Bingham Canyon. The ore arrived at the smelter via the Tooele Valley Railroad or the private aerial tramway built by the Utah Consolidated Mining Co., or the Utah Metals Tunnel which could be used by any Bingham shipper.

Billings [1952] reported that the tramway line was constructed in 1912 and was divided in three sections. It was used to transport Highland Boy ores to the smelter. Later Utah Apex ores were transported via the Elton Tunnel to the smelter.

The copper smelting process included four steps which didn't change from 1910 to closure in 1972. The sampling building was 58 x 84 feet, corrugated steel 5 stories with a concrete floor. The ore was crushed, ground (<1/4"), sampled, and sent by conveyor belt to the roasting bins.

The Roaster two buildings were 64 x 162 feet each. The smelter had 32 MacDougall Roasters which forced out most of the sulfur and water vapor to produce a product called calcine. Roaster effluent went through two dust chambers 300 feet long and into a 210 foot flue leading to the smokestack (350 feet tall).

The calcine was discharged to dump cars, then into one of five reverberatory furnaces each 19 x 120 feet. The total capacity was 1250 tons/day. Heat produced molten material, the slag floating on the top, matte on the bottom. Slag was skimmed into slag cars and was dumped. The matte went to the converter. The fumes passed through a 1,200 foot flue to allow the dust to settle and then to the main stack.

The converter building was 117 x 402 feet and housed 5 converters. Two products were produced: slag which was sent back to the reverb furnaces and blister copper ready for shipment to a refinery. The fumes again went to a flue for particle removal.

Shortly after opening in 1910, the smelter's main customer, Utah Con, ran out of good ore and the smelter owners built a second smelting facility to produce lead. Construction of the lead smelter began in 1911 and was completed in 1912. Ores came from Bingham Canyon, Park City, Tintic, Idaho, and Nevada.

Milling and sampling machinery paralleled copper milling. The ore was roasted using 10 Dwight-Lloyd sintering machines, which drove off most of the sulfur. The sinter was charged to blast furnaces which produced slag, matte and bullion. Slag was taken by rail to the dump. Matte was put through converters. Bullion went to the drossing plant where more slag was removed. The product was shipped to a refinery in Chicago.

Fumes from the sintering plant were treated by traveling through a 446 foot baffled flue and then a Cottrell treater (one of the first electrostatic precipitators). The dust was recycled. Fumes from the blast furnaces went through a 600 foot flue to a bag house, 100 feet long, 34 feet wide with 1440 tubular cotton bags, then to a 200 foot stack. The dust was recycled.

The smelter was powered with an electric power generator, a brick building 240' x 52' producing AC and DC power and compressed air. Equipment included 2 triple expansion marine engines, 2 Nordberg-Corliss steam engines, Curtis turbine, 2 Roots blowers, 2 Corlis steam engines, a Nordberg steam engine, a Rarig steam engine, Westinghouse electric motor and Laidlaw-Dunn-Gordon steam engine.

The smelter facility was sold to Anaconda Copper in 1915. The lead smelter did add some new operations, a flotation mill for lead-zinc ores in 1924 and a slag treatment plant to recover lead and zinc in 1941. The copper smelter closed in 1946. There is a brief record in

USSRM records that Albert Hanford bought some USSRM flue dust from Coram Calif. which was to be shipped to the ISR Tooele smelter in 1947 [USSRM, 1947]. USSRM [1958] announced an agreement with ISR whereby USSRM concentrates would go the the ISR smelter (and close the USSRM smelter in Midvale). In return, ISR agreed to close its milling operations and use the USSRM Midvale mill for this. There is also evidence that USSRM paid for half of the cost of expanding the drossing plant building, 3 kettles and bag shaking equipment [USSRM]. The flotation mill closed in 1968. The lead smelter closed in 1971, and all were razed in 1972. [Most of this historical material was summarized from Comp, 1975.]

The wastes left on site were characterized by JBR Consultants for Anaconda in a 1986 report called "Reclamation/Stabilization Plan". The physical and chemical description of the wastes is given in the following table.

INTERNATIONAL SMELTER WASTES
[JBR Associates, 1986]

No.	Waste	Location	Nature	Volume or acreage	Analysis mean(max) in ppm	Planned fate
1	concentrator feed-stock	sulfide concentrator	crushed and ground Cu, Zn, and Pb ores	195 cy	As: 1828 (4200) Cd: 282 (12) [sic] Pb: 40233 (98800)	relocated to tailings trench
2	stockpiled ores and concentrates	south railroad yard	sulfide and oxide feedstocks of Pb, Zn, Cu ores in discrete piles	386 cy total	As: 2422 (6950) Cd: 275 (500) Pb: 54830 (96800)	see below
2a	pyrite-rich sulfide-carbonate concentrates		mixed with ored and partially concentrated ores	90 cy		covered with 1 ft. soil
2b	quartz-carbonate concentrates	west of yard	also crushed and partially concentrated ores	40 cy		covered with 1 ft. soil

No.	Waste	Location	Nature	Volume or acreage	Analysis mean(max) in ppm	Planned fate
2c	highly pyritic quartz-carbonate		also contains wood fibers of unknown origin	210 cy		covered with 1 ft. soil
2d	ore piles	NE of yard	three piles of copper stained and weakly pyritic volcanic rocks and iron-stained quartz	21 cy		covered with 1 ft. soil
2e	oxide concen-trator tailings	W of oxide concen-trator founda-tions	from demolition of oxide tailings thickener. Pink-brown, sand-sized, tailings, waste product of concentrating oxide ores of lead and zinc	25 cy		relocated to tailings trench
3	flue and stack dust	various	discrete piles and spread on ground	4820 cy total	As: 1704 (3650) Cd: 487 (2130) Pb 48278 (141000)	see below
3a	Lead blast furnace waste	N end of smelter site	black, fused flue dust mixed with coke from an adjacent stockpile. Some of this may be dross. This material was spread on the ground during smelter demolition	4700 cy		covered with 1 ft. soil

No.	Waste	Location	Nature	Volume or acreage	Analysis mean(max) in ppm	Planned fate
3b	Flue dust piles	South railroad yard	At least 4 piles			
3b1	Pile 1		may be an intermediate product, red-brown	80 cy		covered with 1 ft. soil
3b2	Pile 2		fused flue dust, red-brown, portions may have been recycled	170 cy		covered with 1 ft. soil
3b3	Pile 3		mixture of coke and alluvium with grey flue dust	140 cy		covered with 1 ft. soil
3b4	Pile 4		like Pile 2, in shallow depression	65 cy		relocated to tailings trench
3c	zinc furnace area	top of slag pile, north end of smelter site	at least 2 piles	40 cy		covered with 1 ft. soil
3c1	flue dust pile 1	former bag house	spread on surface, 6 inches deep	1 cy		covered with 1 ft. soil
3c2	flue dust pile 2	former zinc smoke-stack	on top of a foundation	10 cy		relocated to tailings trench
4	pyrite concen-trates	east side of smelter site	finely ground pyrite concentrates (maybe an unsold product of purchased feedstock	1250 cy	As: 815 (1000) Cd: 17 (20) Pb 16100 (20900)	not discussed

No.	Waste	Location	Nature	Volume or acreage	Analysis mean(max) in ppm	Planned fate
5	roaster building dust chamber waste	soil fill behind old roaster wall	yellow, grey, blue-white brown and effluorescence	3 cy	table is missing from EPA copy	covered with 3 ft. soil
6	reverber-atory furnace waste	individual furnace sites on top of copper roaster wall	crust-like copper and iron stained waste on foundations	2 cy	As; 3231 (6450) Cd: 155 (215) Pb: 60825 (99800)	waste on concrete flow and covered with 1 ft. soil
7	iron rich process waste	behind a small dike in a drainage area west of the gate house	process waste of unknown origin, black, red, grey (magnetite?)	Not given	As: 2383 (3450) Cd: 370 (370) Pb: 49700 (89100)	drainage rerouted around area, covered with 1 ft. soil
8	zinc furnace waste	zinc furnace area	greenish-gray, gritty, a copper or zinc product or by-product. Some was stored in rusted drums	10 cy	As: 34120 (64700) Cd: 372000 (398000) Pb 69850 (73500)	relocated to tailings trench
9	slag	north of smelter, and north edge of dry creek	slag plus fly ash, overlapping arcuate layers, hard glassy surfaces, interior intensely fractured	27.5 acres	As: 280 (380) Cd: 30 (40) Pb: 10883 (13100)	covered with 18 in. soil

No.	Waste	Location	Nature	Volume or acreage	Analysis mean(max) in ppm	Planned fate
10	IS&R tailings	below mouth of canyon	oxidized on the surface, quartz dominant, unoxidized parts are pyrite rich	278 acres	As: 2082 (10430) Cd: 21 (85) Pb: 8453 (33100)	100 cy relocated to tailings trench, (why just this amount was not explained). Rest terraced, limed and covered with soil.
11.	Carr Fork tails	below mouth of canyon on top of portion of IS&R tails	quartz and carbonate, slightly pyritic	52.6 acres	As: 82 (100) Cd: 5 (8) Pb: 127 (345)	covered with 1 ft. soil
12	Pine Canyon landfill	south bank of Pine canyon, west of slag pile	flue dust, scrap smelter components, flue pipe, precipitation wires, scrap iron, lab vessels, reagent containers	2770 cy on floodplain, at least 4600 cy on slopes	As: 3370 (10200) Cd: 651 (3250) Pb: 48550 (96800)	remove waste from toe of dump to higher up, remove waste from steep slope to middle, regrade, covere with 2 ft to 20 ft soil to relax the slope

No.	Waste	Location	Nature	Volume or acreage	Analysis mean(max) in ppm	Planned fate
13	Parking lot landfill	drainage channel west of former IS&R parking lot at west edge of former smelter site	ceramic crucibles from IS&R assay lab, fire bricks, ceramic upels, glass reagent bottles, scrap metal, flue dust	not reported	As: 1138 (1750) Cd: 101 (180) Pb 29043 (61800)	drainage rerouted around site, covered with 1 ft. topsoil
14	Other	see below				
14a	Carr Fork Tailings Dam	west side of Carr Fork, 1 mi west of smelter site	constructed with IS&R tailings	5900' long 300' wide 65' high	not reported	breached in middle for drainage
14b	settling ponds	mouth of Pine Canyon	settle suspended solids from Pine Creek, ponds and associated piles of sediments cleaned out of ponds	13.4 acres	not reported	diversion not operational
14c	Carr Fork Landfill	East of smelter site	permitted, non-toxic waste	50 acres, 8% currently used	not reported	not reported

JBR Consultants [1986] also conducted some environmental studies prior to reclamation of the area. Most of the groundwater samples collected downgradient of the site greatly exceed the drinking water standard for lead. For surface water samples, elevated lead levels were found in the Pine Canyon Tunnel discharge and at the foot of the Pine Canyon landfill. Elevated zinc was found in a spring at the slag heap and in Pine Creek downstream of the spring.

There were several transects of soil sampling done at various distances from the smelter site. Generally lead and arsenic concentrations decreased with increasing distances from the smelter. The transect to the east was the most impacted.

Reclamation of the site was done by Anaconda under the supervision and requirements of the Utah Division of Oil Gas and Mining. For most of the waste areas, the wastes were simply covered with top soil and revegetated. For those wastes which were found to be acid generating or flunked EP-Tox leach tests, a repository was constructed in the Carr Fork Tailings area in a spot where the tailings were 30 feet deep. Anaconda reasoned that the Carr Fork Tailings which were carbonates would be a suitable substrate in which to bury these wastes. About 215 cubic yards were buried in this repository (referred to in the table as the "tailings trench"). The tailings trench was built by excavating an area in the tailings 5 feet deep, 10 feet wide, and 71 feet long. The bottom was compacted. The wastes highest in Se were placed in the cell last. After the wastes were placed, the cell was covered with 3 - 4 feet of compacted tailings and 1 foot of topsoil, then revegetated. There were no provisions for monitoring this facility included in the plan.

There was apparently no action taken to revegetate or otherwise address soils in the mountains and canyons behind the smelter. Apparently, JBR felt that any soils eroded from this area would eventually end up in the Carr Fork Tailings Pond which would prevent off-site migration.

Following the reclamation, limited monitoring was required. Concentrations in Pine Creek were variable, but the slag heap spring continued to be high in zinc, and the tunnel discharge had some high hits of lead between 1986 - 1988. There was no further monitoring of groundwater.

The spring from the slag heap has not discharged for several years now. To prevent further development of the site, the current owner, ARCO, has completed a conservation easement for most of the property. It is being managed by the Utah Fish and Game.

Note: a former construction supervisor at JBR has reported to EPA that volume calculations were in error and water was encountered during the process of excavating the high hazard smelter waste repository. The actual dimensions of the repository are substantially different that originally planned. There are no "as built" plans. Further studies by UDEQ revealed that the actual placement of smelter wastes at the site is substantially different than proposed in the reclamation plan. The smelter/tailings pond area is now being evaluated as a separate site.

Sampling conducted by the state in the fall of 1995 confirmed the presence of water in both the tailings and the smelter waste repository. The state has recommended that ARCO, the current owner, take steps to prevent erosion of the tailings by placement of riprap.

This area was segregated from the Kennecott site in 1996 and now is being addressed separately. For convenience, the boundary between the International Smelting and Refining NPL site and the Kennecott site is the ARCO-Kennecott property boundary. Refer to the International Smelting and Refining site records for discoveries made after 1996.

WATER SUPPLY TUNNEL (facility #134)

A tunnel was used to carry waters back and forth through the Oquirrhs. Tooele was to give Utah Copper culinary water in exchange for irrigation grade water. The original purpose of the tunnel was to drain mines and aid in development of ore bodies. The tunnel is 11,494 feet long when completed in 1913 and connected several other mine tunnels. It daylights on the south margin of the Bingham Pit and in Middle Canyon. The tunnel drains northeast and southwest toward the Bingham Mine and Middle Canyon, respectively. In 1996, its flow rate was reportedly 750,000 gals per day.

About half the water drains to Middle Canyon and half to the Bingham Pit. The pit portal water is piped from within the tunnel, through the portal and to KUC operational facilities including the Visitors Center, Truck Shop and Dry Fork shops. [Kennecott, 1998]. There was a pump house and water tank on the Tooele side. The exchange is no longer in force. The tunnel's portal on the Tooele side continues to discharge water into Middle Canyon Creek. It spills over the mine dump adjacent to the road, under the road, and into the creek. Kennecott [1996] reports that the water flowing out the Bingham Pit portal of this tunnel is of drinking water quality. [see also Water Supply Tunnel Dump #39].

According to Kennecott [1997], the tunnel is now used to transport culinary drinking water for use at the Bingham Mine. It is of drinking water quality. The water discharge out of the Middle Canyon portal has a TDS of 314 mg/L, barium at 0.06 mg/L, zinc at 0.01 mg/L, and selenium at 0.003 mg/L. Most of the other metals were beneath the detection limit.

WATER SUPPLY TUNNEL DUMP (facility #67)

There is a mine dump associated with the western portal of the Water Supply Tunnel near the head of Middle Canyon in Tooele County. The Water Supply Tunnel, according to local sources, was built to facilitate a water exchange between Kennecott and Tooele. Tooele supplied Kennecott with culinary grade water in exchange for irrigation grade water from Kennecott. The tunnel, not visible from the road, discharges some water which spills into the creek below, but the exchange is not longer in effect.

According to a 12-10-10 article in the Salt Lake Mining Review, the tunnel was constructed by Utah-Metal Company primarily for the purposes of (1) affording cheap transportation of Bingham ores to the Tooele Plant, (2) development of that portion of Utah Metal claims, and (3) provide power from water. The tunnel was 11,000 feet long and 8 ft. x 9 ft. in cross section. The portal on the Bingham side was located on Utah Metal property in Carr

Fork, not far from Utah Consolidated.

Water was provided by two lines, one from Middle Creek proper and the other from a fork just above the power house. The water line from Middle Creek was 5,600 ft long. Water from the tunnel itself was estimated at 500 gal/min in 1910.

A letter by Utah Copper [1927] indicates UC was transporting 150,000 gal/day from Middle Canyon (through the tunnel?), most of which eventually found its way to Bingham Creek. Another UC memo [1929] indicates the diversion at that time was 650,000 gpd and 250,000 gpm was returned to Bingham Creek.

This article would suggest that the water exchange idea was a later development and not the original purpose of the tunnel. If all the waste rock which came from the driving of this tunnel were placed in the Middle Creek portal dump, the volume would be about 30,000 cu yds. Kennecott [1996] reports that the top of the dump has been used by the public as a baseball field.

A recent site inspection by Kennecott (1996) indicates that the tunnel is 11500 feet long with several connections underground with other mine tunnels. The portal on the Middle Canyon side is accessible and the water drains from the tunnel via an 8" pipeline to an open wood tank. The tank is 15 - 18" in diameter and 10' deep. Water enters the base and exits on the west top side. Sample results indicate the water to be of drinking water quality. The dump is flat on top about 250 feet in diameter. Samples were collected along the slopes, 5 - 10 feet below the top of the dump. Pb averaged 2110 ppm, and As 107 ppm. The flat surface has the remnants of a ball field. The back stop is on the SW side of the dump. Tooele is 7 - 8 miles downstream. The other end of the tunnel daylights in the Bingham Pit.

KUC has relaxed the sides of the dump by recontouring materials into erosional gullies and spreading the materials upward. Some riprap was added in the channel. Waste rock which migrated downstream during intermittent flow was excavated and the material used to create a protective berm. The old wooden tank about 600 feet downgradient of the dump receives water produced by the tunnel and is used for irrigation in Tooele Valley. [Kennecott, 2001]. The site was closed out by the North End ROD of Sept 2002.

ANACONDA TAILINGS POND (facility #68)

Just below the site of the International Smelter, there is a dike structure for the old tailings pond associated with the Anaconda Carr Fork project. The 7,700 ft long, 54 feet high dike enclosed a 550 acre tailings pond. Since the mill operated for only a short time (1979-1984), the tailings behind the dike are very shallow and may be located only in the northwest quadrant of the pond. This newer pond was built downstream on top of and adjacent to tailings from the International Smelter operations. The older pond covered a 278 acre area. The whole area is owned by ARCO and has been reclaimed with native grasses and vegetation. ARCO has recently reached an agreement for the area to be a Wildlife Preserve managed by the Utah Fish and Game. The plan is to attract elk and deer to the area during the winter, to keep them out of nearby farms. The dike has been breached in the middle to allow for natural drainage. Some sediment has washed out of the breach to the land below the dike.

There is a repository for IS&R smelter wastes placed in this tailings pond. [see International Smelter]

ARCO conducted surficial reclamation of the entire mine, mill and smelter subsites in the Tooele area in 1986 and 1987. Most of the subsites were covered with a veneer of 6 - 18 inches of locally derived soils. Subsequent erosions has exposed hazardous materials, and the entire site has been investigated further under CERCLA authority.

UDEQ conducted an investigation under agreement with EPA as set forth in the August 3, 1995 workplan (amended Feb 13, 1996). A report, finalized on June 2, 1997 describes the results of sampling conducted on the site as part of an Expanded Site Investigation and limited Remedial Investigation. The majority of the sampling and field activities was conduced by UDEQ personnel with assistance provided by EPA's Technical Assistance Team (TAT).

The sampling program results show widespread elevated concentrations of arsenic and lead and other metals in exposed soils around the site, including the tailings impoundment, that have either no soil cover or the cover has eroded away. Exposed tailings areas are either actively eroding and providing contaminants to surface water runoff and ground water percolation, or contain concentrations of metals too high to support plant growth. Concentrated hazardous wastes in the tailings waste pit, as well as throughout the tailings themselves, were saturated with water and may be contributing metal constituents to groundwater. This area is now a part of the International Smelting and Refining NPL site. See the ISR site records for post-1996 events and cleanup activities.

ELTON TUNNEL (facility #130)

Elton Tunnel, built by the National Tunnels and Mines Company, was started in 1938 and completed in 1940. It was 23,000 feet long and connected the mines in Carr Fork with the Tooele smelter. It contained both a railroad and a drainage conduit. It drained the lower flooded workings of the Apex mine permitting additional exploration. The mine water irrigated 2000 acres of farm land on the other side of the mountain. [Bailey, 1988].

A contemporary newspaper account indicates that the tunnel was completed in August 1941 [SLT, 8-23-41] taking 4 years to build. The dimensions were 11 ft. x 12 ft. The objectives of the tunnel according to several newspaper accounts between 1940 and 1941 were (1) to drain both the Utah Apex and Utah Delaware Mines owned by the National Tunnel and Mines Company; (2) to provide irrigation water (3500 gals/min) to Tooele Valley; (3) haul ore from Bingham to the Tooele smelter and (4) transfer workmen from the Tooele workings at Bingham. The cost was $1.5M. It was named after J. O. Elton, the general manager of ISR. Water gushing out of fissures and gravels caused construction difficulties and one fatality. The National Tunnel and Mines company, a subsidiary of Anaconda Copper Mining Company, constructed the tunnel.

ARCO reports that the flow from the tunnel was about 4000-5000 gal/min in 1939. Flows during the 1940's ranged between 400 - 3000 gal/min. Former Anaconda employees said the flow under normal conditions was 1200 - 1800 gal/min, but increased during spring runoff to 3000 - 5000 gal/min. [ARCO, 1994]. The water was used primarily for irrigation, but also by Utah Copper, by the Tunnel Company, and the International Smelting and Refining Company.

Caving in the Elton Tunnel began in 1948, the first cave-in was repaired. A former employee indicates that the water had stopped flowing in approximately 1952 due to caving. Although the Anaconda Company considered the Elton Tunnel for dewatering old workings in the development of its Carr Fork Mine in the 1970's, the idea was abandoned when the tunnel was determined to be completely blocked by caving within 250' of the portal. Anaconda installed a concrete bulkhead to seal the tunnel in the late 1970's.

The portal of the Elton tunnel was buried during reclamation of the area. There is no surface water expression of any drainage. The tunnel portal is in an area still owned by ARCO, but Kennecott owns the water rights. The water rights for the Elton Tunnel (WUC # 15-296) is for process water at 5802.98 gpm [KUC Water Rights, 1990]

In 1999, Anderson Engineering (a consultant to ARCO) discovered that the south branch of Pine Creek had eroded a channel through a breach in the lower water holding pond and was flowing through the original Elton Tunnel portal structure. Anderson repaired this by constructing a overflow channel and spillway from the holding pond to the natural drainage channel below the ponds. Excavations revealed no further subterranean voids between the plug and the former portal, and there was no evidence of mine drainage in the fill. The tunnel portal structure was demolished and 300 cy of fill was added to fill the sinkholes and the voids.

PINE CANYON (facility #131)

Pine Canyon, just to the east of Tooele was selected as the site of the International Smelter largely because the local prevailing winds blew up the canyon and would therefore carry smoke and gas emissions with them away from neighboring farms. Problems at other local smelters with "smoke farmers" had resulted in the closing of nearly all of them. To prevent his possibility, purchases and long-term options on most of the land within a 2 mile radius from the smelter were made. The foresight of smelter owners saved them from what could have been considerable damage claims when, soon after production began, the foliage of the canyon hills disappeared and local livestock were poisoned.

Pine Canyon is drained by the intermittent and rather small Pine Creek. Precipitation at the head of the Canyon averages 40 inches per year and spring runoffs can be quite heavy. Pine

Creek has been rechanneled by Anaconda to the western side of the canyon and small embankments have been built to route the water around the installations. In 1984, a massive mudslide occurred at the head of the canyon. The lack of vegetation combined with rechanneling may have been the cause. In any case, erosion is evident throughout the area and most topsoil appears to have long ago disappeared. The PA/SI report indicates that the soil contamination due to fallout is 1950 ppm As and 8700 ppm Pb.

Another slide occurred in May 1993, also originating at the head of the canyon. Local sources say the slopes at the head of the canyon are very unstable, and slides may be recur at any time. There are two permitted outfalls on the creek - Pine Canyon Tunnel and a truck maintenance facility. Kennecott's Stormwater SW4 outfall also reports to Pine Creek.

According to ARCO, Pine Creek water is currently used for irrigation and does not reach any flowing streams [ARCO, 1994]. Pine Canyon Creek has not been classified by the state.

PINE CANYON TUNNEL (facility #132)

Near the main shaft of the Anaconda Carr Fork site is the western portal of the Pine Canyon Tunnel. The Pine Canyon Tunnel has standard gauge railroad tracks and currently discharges water. The tunnel was built to provide ventilation and water drainage. It is about 4300 feet long and connects with a fresh air shaft serving the workings below. Water from the tunnel travels in a precast concrete ditch which formerly led to settling ponds and then used for agricultural purposes. Some of the water was used for process water in the mill. Kennecott was issued an UPDES permit for this discharge in Feb. 1995 (Outfall 009).Kennecott uses the portal of this tunnel to access underground pumps etc.

Kennecott [1996] reports that the tunnel was operational between 1972 and 1985. Samples collected in September 1995 contained 430 TDS, 0.006 ppm total lead, 0.07 ppm Cu with a 7.91 pH. The current flow is 35 gpm.

ERDA AIRSHED (facility #133)

Erda, Lake Point and Stansbury Park are small communities in the Tooele Valley close to the Great Salt Lake and Kennecott's Garfield smelter. The main agricultural crops in the area are alfalfa and hay, but there are numerous gardens also. UDEQ collected soil samples in this area in late 1994. Although places were found with Pb and As concentrations above background, no samples (with the exception of sites very close to ISR) were found with concentrations exceeding typical EPA action levels.

135. MISCELLANEOUS TUNNELS (facility #135)

There are several tunnels which, according to the USGS maps, and local information cross from the Bingham Canyon area to the western slope of the Oquirrhs. In addition to the Pine Canyon Tunnel, the Elton Tunnel, and the Water Supply Tunnel, there are other portals shown on various maps including: Apex Tunnel, Armstrong Tunnel, Highland Tunnel, Bingham West Dip Tunnel, and Parvenu Tunnel. It is not known how many of these were plugged during reclamation, nor what the water quality is. Tooele economic development personnel are interested in this water for irrigation purposes.

Apex Tunnel (Parvenu Tunnel) (facility 135.01)

The Apex and Parvenu are reportedly two names for the same tunnel. It is located in Township 3 South, Range 3 West, near the Section line between Sections 27 and 34 on the Parvenu mining claim. The tunnel was probably constructed between 1905 and 1907. It was used for haulage and drainage from the Apex workings above the 1000 level. The Apex (or Parvenu) Tunnel interconnects with the Pine Canyon Tunnel and are at the same level. ARCO reports that the Kennecott Bingham Canyon pit has now intersected the tunnel [ARCO, 1994]. The Parvenu Tunnel was mentioned in the Magna Tailings Pond Expansion Project as a method by which tailings could be transported to Tooele in one of the rejected tailings expansion alternatives. [EIS. 1995] Kennecott [1996] indicates that the tunnel was operational from 1905 to 1932. Kennecott reports that any water draining from the tunnel would be captured in the pit and be used as process water. The old portal area along with any waste rock on the pit side has been subsumed by the pit.

Kennecott[1997] reports that the tunnel can be located and confirms that the easterly end of the tunnel has been mined away. The tunnel also connects with the Pine Canyon Tunnel. Kennecott may refurbish the portal to facilitate draining the water from the interconnected tunnels.

Armstrong Tunnel (facility 135.02)

There are two Armstrong Tunnels: upper and lower. The lower was the main tunnel. ARCO reports that the Armstrong Tunnel is now owned by Kennecott and has no interconnection with the Anaconda underground workings. The Armstrong Tunnel was located on the south side of the canyon about 1/4 mile above the Apex (Parvenu) Tunnel in Township 3 South, Range 3 West, Section 34 apparently on the Mercer No. 2 mining claim. ARCO reports that both tunnels as well as all related workings no longer exist but are now part of the Kennecott Bingham Canyon pit. Kennecott [1996] indicates that the tunnel was operational between 1914 and 1978 and is almost completely mined away by the pit. Kennecott reports that any water draining from the tunnel would be captured in the pit and be used as process water. The old portal area only with any waste rock on the pit side has been subsumed by the pit.

Kennecott [1997] estimates that 30-50% of the tunnels still exist although both portals have been mined away.

Highland Boy Tunnel (facility 135.03)

The Highland Boy 700 level is commonly referred to as the Highland Tunnel. The tunnel was used for mine haulage and drainage and was interconnnected with all the other tunnels on the west side of the valley. The Highland Tunnel is located on the Lorena mining claim, Section 34, Township 3 South, Range 3 West. ARCO reports that Kennecott may be maintaining the tunnel [ARCO, 1994].

Bingham West Dip Tunnel (Levine Tunnel) (facility #135.04)

The property map shows the Bingham West Dip Tunnel as the Levine Tunnel located on the Angell Tunnel site, which was acquired by Utah Apex in 1926. The tunnel was originally built by promoters seeking to interest outside funding for exploration. No ore was discovered or produced. Water from the tunnel was used by IS&R for culinary and industrial purposes beginning in 1927 through rental agreements first with Utah Apex and later with National Tunnel and Mines. The Angell Mining Claim, the Angell Tunnel Claim No. 1, the Angell Tunnel Claim No 2, and the Sherrif claim are unpatented lode mining claims in Section 17 and 21, T3S, R3W, which cover the line of the Bingham West Dip Tunnel and the intake and pipeline from the tunnel to the old IS&R property. [ARCO, 1994].

The Bingham West Dip Tunnel appears on a 1990 list of Water Rights (WUC 15-1654) for 516 gpm. The Tooele side terminus is shown along the walls of Pole Canyon, a northern tributary of Pine Canyon. Kennecott [1996] indicates that this tunnel may predate 1900, but was operated as a water supply tunnel from 1927 -1985. Kennecott performed a site inspection in 1996. They indicated that the tunnel portal was caved in but a steel pipe transects the tunnel and discharges to a 4' x 5' cement sump near the portal. Water in the sump is discharged to a 30' x 30' storage tank about 1/8 to 1/4 mi SW of the portal. Some of the flow escapes before it reaches the tank directly into the drainage. The total flow is 150 - 200 gpm. The analyses indicated the water was drinking water quality.

The Bingham West Dip Tunnel also has a dump about 80' x 80' in area, averaging 15 - 20' deep. It contains 236 ppm Pb and 29.3 ppm As.

Adamson Tunnel (facility #135.05)

The Anaconda Carr Fork Reclamation Plan refers to an Adamson Tunnel contributing water to Pine Creek. Other than one water quality analysis, no further information was given. Adamson Tunnel is on a 1990 list of KUC water rights [WUC

15-1652] for 413 gpm. The location appears to be close to the Pine Canyon Tunnel. Since there was no listing for the Pine Canyon Tunnel on the water rights lists, the Adamson Tunnel and the Pine Canyon Tunnel may be different names for the same facility. Kennecott [1996] reports that this tunnel is believed to supply water to a pipe which empties into a tank located in Pine Canyon. The location of the portal is unknown but the pipe and water tank still exist. The tank overflows into Pine Canyon Creek.

Kennecott [1997] reported that the portal of the tunnel could not be found. International Smelting and Refining Company drove the tunnel in 1925 to collect water for its processing. The tunnel was 319 feet long transecting the bottom of Pine Canyon. Later the water was used by the Anaconda Carr Fork mill. Excess waters were used for irrigation.

One water right application [1971] indicates the water was diverted from the portal to an electric pump which pumped the water 150 feet to the Pine Canyon reservoir. The reservoir is formed behind an earthen dam. From the dam it entered the smelter industrial water system.

A later change is given in a water right change application [Anaconda, 1976]. At that time the water was carried by 6" pipe to another pipe originating from Big Spring reservoir. Both waters were carried by 12" pipe to a 250,000 gallon "water gathering" tank. The water was used to supply the concentrator. The water was recycled. Overflows were carried by ditch to settling ponds, after which it was used for irrigation of approximately 1888.71 acres. The locations are of the irrigated acres are given in the water right change application.

Copper Boy Tunnel (facility 135.06)

Copper Boy Tunnel. According to a 1990 KUC list of water rights, Kennecott owns the water rights to Copper Boy Tunnel shown on the topo sheet provided by KUC in Baltimore Gulch around 7700' elevation. The water right is for 200 gpm for both process and culinary purposes.

Spring Canyon Tunnels (facility #135.07)

Spring Canyon Tunnels. According to a 1990 KUC list of water rights, Kennecott owns the water rights to 3 tunnels in Spring Canyon between Pine Canyon and Middle Canyon. All are plotted on the map at Spring canyon near the base of the Oquirrhs at the 5800' elevation: Hardrock Tunnel (WUC # 15-1419), 80.26 gpm for process water; McBride Tunnel (WUC # 15-1420), 165 gpm for process water; and Main Tunnel (WUC # 15-1421), 80 gpm for process water.

Upper Bruneau Tunnel (facility #135.08)

Upper Bruneau Tunnel. According to a 1990 KUC list of water rights, Kennecott owns the water rights to the Upper Bruneau Tunnel located up Pass Canyon (north of Pine Canyon) at the 6300' elevation. The water right (WUC#15-1653) is for 54.8 gpm.

Helen B Tunnel (facility #135.09)

Helen B Tunnel. According to a 1990 KUC list of water rights, Kennecott owns the water rights to the Helen B Tunnel located up the south fork of Swenson's Canyon (just north of Pine Canyon). The water right (WUC # 15-1652) is for 20 gpm.

CHAPTER 14
ORE MILLS NEAR MAGNA

When two mining companies in Bingham Canyon, Boston Consolidated and Utah Copper, began to exploit the low grade copper ores in the canyon, both companies realized that they would have to mine at a much larger scale in order to make a profit. The mills would have to be large to have the high capacity needed. Since space in the canyon was limited for the land requirements of the mills and tailings disposal areas, both companies built their mills on the slopes of the north end of the Oquirrh Mountains near ranch lands and wetlands suitable (by the standards then) for disposal of the tailings. Shortly after the two mills went into operation, Utah Copper bought Boston Consolidated, its mining claims and mill. Therefore, Utah Copper owned both mills after 1910. Later, Kennecott Utah Copper (the successor to Utah Copper) built a more modern crushing and grinding facility, retired the older Boston Consolidated Mill and expanded the Utah Copper Mill's flotation facilities. The town of Pleasant Green near the two original mills, formerly a farming community, started to grow with immigrants who came to work in the mills. The diversity of the town, now called Magna, persists even today. Today, all the milling activities near Magna have ceased and this is now being done near Copperton. This chapter describes the two historic mills, the newer (but now surplus) crushing facility, and the associated nearby facilities and cleanups.

BOSTON CONSOLIDATED MILL (ARTHUR CONCENTRATOR) (facility #71)

Located on property adjacent to the ASARCO smelter, Boston Consolidated began construction of its mill in 1906 and was in operation in 1909. Utah Copper bought the company and its facilities in 1910. One source says the property was 810 acres [Bailey, 1988]; another says 910 acres [Arrington, 1963].

The Boston Consolidated Mill, a giant concentrator, handled ore at a rate of 3000 tons/day. The mill building was 370 by 555 feet in size and was built of steel and concrete. Erected at a cost of $1.5 million, the mill was designed in 6 units, each capable of handling 600 tons. Equipment consisted of 18,000 ton main ore bins, four Gate's crushers, 312 Nissen individual stamps, 284 Wilfrey tables, 256 Johnson tables, and 312 Callow settling tanks. All material was handled by gravity [Bailey, 1988, also Bingham Commercial Club, 1909]. Between 1910 - 1912, the Nissen stamps were replaced by Garfield rolls and later expanded to include Chilean mills for regrinding. [Hulse, 1964]. Boston Consolidated owners also considered building a smelter with the mill but the contract with the ASR smelter was so favorable that smelter plans were dropped.

An early task facing Utah Copper after the absorption of Boston Consolidated in 1910 was the remodeling of the Boston Mill (now renamed the Arthur Mill after President Chester A. Arthur). Allen H. Rogers was hired to make comparative tests on the Magna and Arthur Mills. Rogers' report showed that the Magna Mill had a better recovery of copper at lower costs than did the Arthur Mill. With this information, the Arthur mill was remodeled along improved lines and increased in capacity from 3000 to 8000 tons/day. According to Billings [1952], the Arthur mill differed from the Magna mill next door only in that at the Arthur plant the fine crushing was done by Nissan stamps each with individual mortars whereas in the Magna plant 7 foot Chilean mills were used. For the crushing and the concentrating of the freed minerals, there was practically no difference in the kind of equipment used. According to Billings [1952], in this period, the ore concentrated by the Arthur mill had too much iron pyrite for easy smelting, so the mill piled up these concentrates until the Garfield smelter could figure out how to deal with them.

According to Billings [1952], experiments with flotation began in 1914 and partial replacements of the gravity method continued at both the Magna and Arthur mills until by 1926 both mills had been completely converted over to flotation. The concentrate had a substantially higher copper content with an excess of iron over silica. This changed the nature of flux ores required for smelting. There was a demand for siliceous ores preferably containing copper, gold and silver to flux off the excess iron in the flotation concentrate. This demand resulted in revival of operation by the US and Bingham Mines companies including outcrops, near surface ores, as well as low grade ores left as unprofitable in the early days. Even old mine dumps and mill tailings were used especially carried on by lessees.

According to the Utah Copper's History of Milling Developments [1939], the following reagents were tested at the Arthur Mill beginning in 1913 (both the Magna and Arthur mills had flotation circuits by 1918): coal tar creosote, petroleum, petroleum residuum, petroleum stove oil, pine oil, reco pine oil, reco turpentine, calura (lime, sulfur and sodium hydroxide), rosin, lime, soap solution, sodium sulphide, sodium hydroxide, light oil, coal tar, phenols, sulphuric acid, alpha naphthylamine, xylidine, thiocarbanilid, ortho toluidine, potassium ethyl zanthate. In 1924 a typical charge consisted of creosote oil, steam distilled pine oil, sodium hydroxide, and sulphur. New reagents were introduced in 1925 including reco cresylic acid (a reaction product of cresylic acid and phosphorus pentasulfide) and reco alcohol (a reaction product of alcohol and phosphorus pentasulphide). In 1927 the Arthur mill used reco cresylic acid, lime and cyanide while the Magna mill used sodium xanthate. The reco cresylic acid proved more cost effective and both mills switched to this reagent along with reco ethyl alcohol but this was corrosive. By 1933, neutralized reco cresylic acid was being used and was in use at the time the milling history was written in 1939.

Following WWI, copper prices slumped and the mill was closed in April 1921 and resumed operations in 1922 when prices rose due to post war demands. During the period of closure, both the Arthur Mill and Magna Mill were extensively remodeled, froth flotation units were installed and the recovery of copper from the porphyry ores was greatly improved. Froth flotation was added to the Arthur Mill in 1918. In 1917, to produce finer grinds for flotation, 26 ball mills were added. Vanners were eliminated in 1918, and Chilean mills in 1923. The first flotation mills were Janney mechanical-air flotation machines, which was replaced by Fagergren 56-inch machines. By 1926, the capacity of the mills had been increased to 50,000 tons/day.

The depression of the 1930s and the accompanying decline in the market for copper resulted in the curtailment of the Bingham operations of the Utah Copper Co. The Arthur plant was closed in 1930. From 1935 to 1938, both the Magna and Arthur mills were reconditioned to improve their recovery. In 1936, the Arthur mill was reopened, after 6 years of inactivity. The flotation units installed in 1936 were Fagergren machines. Operations were continued at a modest rate until June 1938 when the economic downturn and an oversupply of copper resulted in a discontinuance of production from Utah properties for 2 1/2 months. By 1963, they had a combined capacity of 90,000 tons/day. [Arrington, 1963] Wastes from this facility went to the Magna Tailings Pond.

Gold recovery launders were installed in the Arthur plant in 1938. The installation included 54 launders, 37.5" wide by 100 ft long and handled 21,000 tons of tailings per day [Utah Copper, 1939]. An interesting feature of the Arthur plant shut down was the recovery of gold from the idle mill. Lucrative places were launder bottoms, launder junction boxes, classifier bottoms, elevator pits, etc. The gold was generally recovered by reaching into the inaccessible spots with small picks and chisels and sweeping up with hand brushes and brooms. $700K worth was recovered between 1934 - 1938 in this fashion. In 1952, the Arthur Mill was converted to new 62 inch Fagergren flotation machines. The chemicals used in flotation were lime (as a conditioner to get the feed into an alkaline state); cyanide (acts as a pyrite depressor and helps clean the metal for better collecting), surfactants (to create froth) and "others" to coat the desired mineral particles and give them an affinity for the bubbles (clearly reco, but too secret for Kennescope readers (employees)).

At the end of the grinding process, the ground ore was sent to thickener tanks to reduce the water content prior to flotation. The thickener tanks separated out the coarsely ground material which was sent back to the ball mills and allowed some settling to thicken the product. The excess supernatant water was recycled back to the mills.

The Arthur Mill was closed with the construction of the Bonneville Crusher in 1966.

Ancillary facilities included a steel and brass foundry, boiler shop, machine shop, paint shop, and a reagent still. In 1975 a tailings re-treatment plant was added. Most operations ceased in 1985 and most of the buildings were demolished in1988-9. The tailings retreatment plant was demolished in 1992. The only remaining buildings are the administration building (which is close to the new laboratory facility) and maintenance shops. The new laboratory at the site opened in 1995. The site was closed out by the North End ROD of Sept 2002.

REAGENT STILLS (facility #71.01)

The reagents used in the foam flotation process were manufactured on site with a still. The location of the still was not specified but may have been associated with the Arthur mill. The still in operation by 1924 was described in Utah Copper's History of Milling Developments [1939].

In a typical recipe, 532 gallons of creosote oil, 16 gallons of steam distilled pine oil, 2 3/4 gallons of 40% sodium hydroxide solution and 249 pounds of sulfur were charged to a 1000 gallon horizontal cylinder approximately 10 feet long and 4 feet in diameter. The top of the still was provided with 3 3" condensing pipes 300 feet long inclining upward at a slight angle. About 80 feet of the condensive pipes passed through a wooden launder in which cooling water was circulated. The lower part of the still was enclosed with brick work with a firing chamber underneath and at front. The chemicals were gradually heated with a wood or coal fire to 300 - 375°F for two hours. The product was discharged to storage tanks ready for flotation use.

In 1927, Utah Copper also attempted the manufacture of reco alcohol. The product formed by the reaction of alcohol and phosphorus pentasulphide proved to be corrosive to iron and stainless steel and glass lined kettles corroded the outer kettle through pin holes. Stoneware was then used successfully but easily broke. The stoneware kettles were 600 gallon capacity. This process was retired when other reagents proved more effective.

In 1933, a change was made from sodium reco alcohol to neutralized reco cresylic acid which was also manufactured on site. The stoneware kettles were retired and two chrome nickel stills were installed, each with a capacity of 291 gallons, heated with electricity. The starting reagents were cresylic acid (a mixture of phenolic substances including phenol, cresols, xylenols, etc.) phosphorus pentasulfide and sodium hydroxide (H_2S and H_2O are by products of this reaction, forming sodium dicresyldithiophosphate.) The nickel-chrome stills were charged with 530 lbs of crushed phosphorus pentasulfide. After closing the still, 144 gallons of cresylic acid was added through a charging pipe. The vessel was heated electrically. The heating coils and the vessel was surrounded by magnesite insulation. Temperatures in the vessel reached 300 - 310°F in four hours. After cooling, a 10% solution of NaOH was added. After dilution, 600 gallons of sodium reco cresylic acid was produced. The use of one still was sufficient to supply the flotation reagent needs of both mills.

In a 1956 article in Kennescope, the still was described as located on a hillside above the Arthur mill. Storage tanks were located above the Arthur mill and the reco product was delivered to Arthur via a gravity flow pipeline and to Magna via railcar. Three stills were in operation in 1956.

The stills site is located approximately 800 feet south of the Arthur Central Shops and covers an area of approximately 6.5 acres. It is located on a moderately steep, broken topography comprised of lacustrine beach deposits overlying bedrock at shallow depths. Before demolition, the site contained nine above ground storage tanks, stills, support buildings, and a 1,000,000 gallon reservoir. Chemicals stored at the site included the following: burner oil, cresylic acid, methyl alcohol, sodium hydroxide, RCO, and #2 burner oil. Approximately one third of the site had been recontoured. The remaining area showed signs locally of impacted (stained or discolored) soils and the odor of RCO can be detected on the west side of the reservoir. Slag and bricks were visible locally.

The reservoir is located in the approximate center of the site. It is circular in shape, 60 feet in diameter, and 10 feet deep. Sludge has been deposited in the bottom to a depth of 7 feet. Below the sludge is sandy gravel which appears to be natural ground. Elevated arsenic was found from the southeast sidebank of the reservoir. If the reservoir area is contaminated down to one foot, the estimated contaminated volume would be 570 cy.

An area approximately 100 feet by 150 feet located directly west of the reservoir displayed discolored soils. The odor of RECO can be detected. A small debris pile (30 x 50 feet) containing bricks, slag, and metal debris is located within this area also. Elevated lead was found in the debris pile about 150 feet west of the reservoir. The estimated volume of this pile was 208 cy (75 x 30 feet with a depth of 2.5 feet).

Nine storage tanks were located along the southern boundary of the site prior to demolition. These sites can still be identified by the remnants of rock retaining walls. The tanks were known to store one of the following: cresylic acid, methyl alcohol, sodium hydroxide, and RECO. Most of the tank locations are discolored with iron oxide. In addition, one of the tank locations was found to contain a sludge-like material to a depth of 1 foot with a strong alcohol odor. Locally tailings, that appear to have been water deposited, were observed in the near vicinity of the tanks. No elevated metals were found in this location. [Kennecott, 1996].

As of 1998, Kennecott reports that the contaminated soils were removed to the Arthur Stepback Repository. [Kennecott, 1998]. The site was closed out by the North End ROD of Sept 2002.

IRON FOUNDRY (facility #71.04)

Located at Arthur, the Utah Copper Iron Foundry was established to cast roll frames, ball mill sections, and crusher parts [see Utah Copper, 1939]. The original foundry building was 61 x 62 ft but was expanded until it was 80 x 315 ft [Anderson, 1930]. Production reached 1,800,000 lbs/mo in 1917.

The principal item of production were chilled semisteel balls used in ball mill grinding. The foundry had 8 sections with 96 water cooled iron molds each with a capacity of 40 balls. the molds were coated with oil and graphite and silica flour, hytempite and water. Production reached 50 tons of balls per day. A smaller unit casted aluminum and brass parts as needed. The brass foundry had a separate building with 3 oil fired blast furnaces and a capacity of 9000 lbs/day.

The iron foundry had 2 No. 9 Whiting cupolas. The furnace was fired with coke and was charged with steel scrap, soft iron scrap, coke and lime rock. After melting, 3 ton ladles were used for transfer and pouring.

The Foundry Slag site is located approximately 600 feet east of the Arthur Central Shops.

The site covers an area of approximately 150 feet x 750 feet and is situated on a steep slope bounded on the north and south by railroad lines. The top of the pile is flat and slopes at the angle of repose toward the north. Bedrock outcrops locally to the south of the site, but is mostly covered with sandy, gravelly beach deposits that likely underlie the site. A sampling of the area in 1993 found arsenic as high as 499 ppm, chromium to 10,130 ppm, lead to 193,600 ppm. At that time it was recommended that the area be capped. Ruins of the foundation and a portion of the walls still exist at the site.

Figure 44: Foundations of the iron foundry near Arthur Mill.

The Foundry Slag site consists of predominately slag and metal debris from the now demolished Arthur Foundry [Kennecott, 1996]. The area was sampled again in 1996. Again, elevated arsenic concentrations were found at the site (up to 393 ppm) and elevated lead concentrations (up to 8100 ppm) were also found. In addition, some of the wastes flunked TCLP leach tests for lead.

The contaminants were found above action levels in the top three feet. The contaminated soils/slag were removed to the Arthur Step Back Repository in 1996.

The site was closed out by the North End ROD of Sept 2002.

WEST DEBRIS SITE (facility #71.05)

The West Debris Site is located approximately 2000 feet west of the Arthur Administration Building and 800 feet south of State Route 201. The site covers an area of approximately 1.1 acres (50 x 1000 feet) and located immediately north of an access road, on a moderate to gently sloping historic beach terrace. Sandy limestone and quartzitic bedrock outcrop locally at the site. Debris piles up to 8 feet tall and 100 foot long are scattered throughout the site. [Kennecott, 1996].

The West Debris Site consists of irregularly shaped piles containing predominately soil, wood, slag, laboratory glassware, crucibles, metal shavings, concrete, bricks and other building material. Characterization indicated that 4 of the 11 samples were elevated in arsenic and/or lead. TCLP indicated that the materials did not leach. The highest concentrations were 360 ppm As, 4 ppm Cd, 65000 ppm Pb and <14 ppm Se. The site was included in the North Facilities Soils Removal. [Kennecott, 1996]. Removal of asbestos contaminated soil started in October 1996 and was completed in November 1996. Total removal of the material was completed in October 1997. The metal and asbestos contaminated soil was placed in the Arthur Step Back Repository. Surface grading of the site was completed in late November 1997.

Approximately 3100 cy of materials were removed and placed in the Arthur Step Back Repository. The site was closed out by the North End ROD of Sept 2002

RAILROAD DEBRIS SITE (facility #71.06)

The Railroad Debris Site is a pile that was used as an end-of-line barrier for the railroad. It is located approximately 1200 feet northeast of the Arthur Administration Building. The pile is 30 feet wide by 75 feet long and is located immediately south of a dirt road which parallels the Ore Haulage Railroad. The pile consists of oxidized metallic debris, soil and concrete debris. One sample was collected in 1994. It has 877 ppm lead. [Kennecott, 1996] More sampling was proposed. No cleanup action was taken. The site was closed out by the North End ROD of Sept 2002.

CRUCIBLE SITE (facility #71.07)

The Crucible Site is located 300 feet south of State Highway 201 and 800 feet northwest of the Arthur Administration Building. The site covers an area of 75 feet by 280 feet and is dissected lengthwise by a dirt road. The land to the north of the site has been reclaimed.

The Crucible Site consists of predominately fire assay debris and other waste from the old Arthur Assay Laboratory. Characterization sampling in 1994 indicated 6 of 16 samples to be elevated in total As and/or lead. The maximum concentrations were 210 ppm As, 4.1 ppm Cd, 37000 ppm Pb and <30 ppm Se. The site was included in the North Facilities Soils Removal [Kennecott, 1996]. Based on the results of the sampling and the analytical results, there is an estimated 650 cubic yards of contaminated material at the site covering an area of approximately 7,100 square feet. The contaminated material was disposed of at an off-site facility. Post removal samples were collected, none of which contained elevated concentrations of any of the analytes. The site was completed in Dec. 1997. The site was closed out by the North End ROD of Sept 2002.

ARTHUR SECOND LINE DITCH (facility #71.08)

Prior to digging a drainage ditch along the second line tracks located 800 feet northwest of the Arthur Administration Building, the soils were sampled. The soils contained elevated copper but no metals above the EPA action levels. The site was closed out by the North End ROD of Sept 2002.

LEAK IN PIPELINE SOILS (facility #71.09)

Yellow tailings-like material near the Arthur Central Shops pipeline corridor was sampled and found to contain low concentrations of metals. There was no cleanup needed. The site was closed out by the North End ROD of Sept 2002.

MAGNA CONCENTRATOR (MAGNA MILL, NORTH CONCENTRATOR) (facility #94)

Concurrent with the construction of the Garfield smelter, the Magna concentrator was built on a sloping hillside at Mill Stone Point (or Point of West Mountain) at the northern extremity of the Oquirrh range. Construction was started in June, 1907. It was located 4 miles east of the ASARCO smelter. When completed in Nov. 1908, it had a 6000 ton capacity. [Bailey, 1988]. Billings [1952] reported that the mill was "ready for operation" in June 1907, and had reached a capacity of 6000 tons/day by the summer of 1908. Utah Copper was the primary customer who shipped their ores to the mill via the "Highline" built by the Denver and Rio Grande Railroad. About 3000 tons/day came from underground operations and 3000 tons/day from the pit. It treated primarily Utah Copper ores but also some custom ores [Billings, 1952].

The area of the mill had numerous springs, marshes and sloughs and was the home of numerous flocks of water fowl. The mill site consisted of 2,400 acres of ground. The water for the mill was to come from several very large springs located at Pleasant Green near Magna. The springs when developed produced about 12,500 gal/min with constant pumping.

The original design was for a 3000 ton/day capacity but plans expanded to a 6000 ton/day capacity in 12 sections. The entire 12 sections were completed in Nov 1908. The mill building, located 115 feet above the valley floor, was 509 feet by 600 feet in dimensions. The framework was of steel set in concrete with corrugated iron sidings and roof. The cost of the original plant together with accessory facilities was $4,005,000. The original mill contained vanners, Wilfrey tables, and Chilean mills.

According to Billings [1952], the Arthur mill differed from the Magna mill next door only in that at the Arthur plant the fine crushing was done by Nissan stamps each with individual mortars whereas in the Magna plant 7 foot Chilean mills were used. For the crushing and the concentrating of the freed minerals, there was practically no difference in the kind of equipment used.

At the same time the Arthur mill was remodeled in 1911, the Magna mill facilities were improved and expanded raising its capacity to 10,000 tons/day. Following WWI, copper prices slumped and the mill was closed in Feb, 1919 and resumed operations in 1922, when prices rose due to post war demand.

During the period of closure, both plants were extensively remodeled, froth flotation units were installed and the recovery of copper from the porphyry ores was greatly improved. Froth flotation was added to the Magna mill in 1923. By 1926, the capacity of the mills had been increased to 50,000 tons/day. [Arrington, 1963]. Experimental foam flotation was begun at Magna in 1918. By 1923, identical processes were used at the Magna and Arthur mills. [UC, 1939]

According to Billings [1952], experiments with flotation began in 1914 and partial replacements of the gravity method continued at both the Arthur and Magna mills until by 1926, both mills had been completely converted over to flotation. The concentrate had substantially higher copper content with an excess of iron over silica. This changed the nature of the flux ores required for smelting. There was a demand for siliceous ore, preferably containing copper, gold and silver to flux off the excess iron in the flotation concentrate. This demand resulted in revival of operation by the US and Bingham Mines companies including outcrops, near surface ores, as well as low grade ores left as unprofitable in the early days. Even old mine dumps and mill tailings were used especially carried on by lessees.

Froth flotation requires addition of reagents to the slurry, and blowing air through the mixture. This creates a froth which rises to the top of the mixture. Some of the materials which have been used as flotation reagents are sulfuric acid and coal tar creosote, lime, xanthate, cresylic acid, and cyanide. [SAIC, 1991]. In 1927, the Arthur mill used reco cresylic acid, lime and cyanide while the Magna mill used sodium zanthate. (A xanthate plant was installed in 1926 at the Magna mill to produce this frothing reagent. The reco cresylic acid proved more cost effective and both mills switched to this reagent along with reco ethyl alcohol, but this was corrosive. By 1933, neutralized reco cresylic acid was being used and was in use at the time the milling history was written in 1939 [UC, 1939].

In 1933, the Magna plant experimented with gold recovery from the tailings by using a 2600 ft tailings launder with burlap strips. A new 1000 ft launder was constructed in 1934. By 1938, gold recovery launders had increased to 26 launders each 500 ft long with capacity of 30,000 tons of tails/day. The concrete at the bottom of the launders also contained gold and was chipped out periodically. In addition, during the time when a portion of the Magna mill was idle in the 1930's, gold was recovered by picks and chisels from cracks and crevices in the launders and tailings circuit [History of Milling Developments, Utah Copper, 1939].

During the depression of the 1930's the Magna mill remained open but the production declined to about one-fifth capacity. From 1935 to 1938, both the Magna and Arthur mills were reconditioned to improve their recovery. Operations were continued at a modest rate until June 1938, when both mills were shut down for about 2 1/2 months. [Arrington, 1963] In the late 1950s, the normal capacity was 40,000 tons/day. [SAIC, 1991].
The flotation portion was upgraded in 1975.

When the Bonneville Crusher was opened, the Magna mill's grinding facilities were no longer needed and this part of the facility was demolished in 1991-2. Until recently, the flotation circuit was in operation fed by ground ore from the Bonneville Crusher. The concentrate produced by the Magna mill was flumed to rail cars and sent to the smelter. Tailings were sent via a flume to the Magna Tailings Pond. In July, 1993, a rail car backed into this flume spilling tailings all over the adjacent highway (2100W). The road was closed about 12 hours, partly because the flume fell on a gas line. Until recently, the facility was operating with the original filter plant. The capacity of the Magna Concentrator at the time of closure was 30,000 tons of ore per day. It produced copper concentrate. The molybdenite circuit was shut down in 1988, but could have been reopened.

According to Kennecott [1997], the land occupied by the grinding portion of the mill has been reclaimed. The site surface was graded and recontoured. Chemicals used by the currrent flotation circuit include sodium dicresyl dithiophosphate, methyl isobutyl carbinol, sodium cyanide, and a anionic surfactant (in storage tanks, but not currently used).

After the WWTP was built,"Adverse" water from the North Concentrator was directed there for treatment. The sludges produced were sent to a "new lagoon" for floc treatment and settling. The "new lagoon" was the beginning of Sludge Pond D. Prior to the WWTP construction, sediments from water treatment was excavated and placed on the former slag pile on the north side of the highway for recycling.

The active portion of the facility is covered under a DOGM operating permit. Surface contamination (where present) is being addressed as a part of the North Facilities Soils Removal Project. Demolition debris was disposed as follows: clean debris to the tailings pond landfill; scrap steel was cleaned and sent to Hugo Nue. The RCRA facilities ID is UTD000826420.

On May 26, 2001, Kennecott announced that it would be laying off 235 workers and closing the Magna mill, at least temporarily, until copper prices improved. The shutdown affected the Magna mill, the Bonneville crusher, and railroad operations. The mill has now been permanently closed and is slated for demolition under DOGM and cleanup as part of the CERCLA project.

MAGNA LEACHING FACILITY (facility #69)

Since the beginning of the opencut operations in 1906, a great deal of oxidized copper ore was uncovered as part of the capping of the main ore body. This was considered an uneconomic waste material until 1916 when a 2,000 ton leaching plant was constructed south of the Magna mill to treat the ore with a sulfuric acid leach, and then precipitate the copper out using scrap iron. The plant operated until the decline in the price of copper in 1919. It was reopened for a short period in 1920, but was closed permanently in December of that year. [Arrington, 1963]

According to Utah Copper's history of milling developments [1939], leaching was done with sulphuric acid in a cyclic process. The solution was advanced from one vat to another to build up the copper content to 1.75 - 2.5% copper. The leach solution was maintained at 15% free acid. The pregnant copper solution was drawn off through a wood stave pipeline to a series of precipitating launders using scrap iron. The first precipitating units consisted of 4 rows of 4 vats in series each 9.5 x 62.5 x 6 ft deep made of reinforced concrete and mastic lined. The first vat of the first row was equipped with 5 wooden precipitating barrels 7'4" by 8' long. The second precipitating unit consisted of wooden vats 9' x 64' x 3'7" deep. Periodically, the vats were emptied of their copper content by removing a plug in the bottom and washing the copper to settling bins.

The leached ore was removed from the tanks by means of a Mead-Morrison excavator provided with a 10 ton grab bucket. This waste was discharged into Clark-Air dump cars "whence it was disposed of on a nearby hillside".

Kennecott reports that the facility had 12 leaching vats each 100 feet long, 50 feet wide, and 17 1/2 feet deep made of concrete with filter bottoms. Each vat had a capacity of 4000 tons. [Kennecott 104e, 1991] See also lime kilns and lime slacking plant descriptions.

Kennecott [1997] indicates that the leach vats are now used for water storage for the power plant at the smelter. The area around the tanks is used for storage of miscellaneous items like shipping pallets, scrap metal and electrical transformers. The site is currently part of the North Zone operational area which includes some reclaimed and revegetated land, the railroad corridor, and water storage. It is located close to the Utah Copper Power Plant. The electrical transformers stored there do not contain PCBs. The North Concentrator facilities are scheduled for demolition in 2004 as part of the North End ROD of Sept 2002

LIME KILNS (facility #71.02)

Various lime kilns were installed at various times at various locations. Utah Copper's first lime kiln was installed in 1926 at the ASARCO Garfield smelter. The first plant consisted of a 6 x 125 ft rotary kiln, a burned lime storage bin and a chain elevator to raise the lime to the bin. The kilns were fired with pulverized coal. An 8 ft. rotary kiln was added in 1927.

The lime burning equipment was moved in 1929 to the main crusher building of the old leaching plant at Magna. The process was changed so that the two kilns operated in series, the 6 ft kiln used to preheat the limestone rock and the 8 ft kiln to produce the burned lime. The capacity was 120 tons/day. Each kiln had a steel stack partially lined with firebrick. The kilns were heated electrically. The kilns were again rearranged in 1936 to operate each independently, blowers were added, and capacity was increased to 200 tons/day [History of Milling Developments, Utah Copper, 1939]. The leaching bays remain in use as process water storage areas for the smelter. An asphalt pad covers the remainder of the site. The site was closed out by the North End ROD of Sept 2002.

LIME SLACKING PLANT (facility #71.03)

The lime slacking plant was constructed in 1925 in the main crusher building of the leaching plant in Magna. It consisted of 2 8 ft x 22" Hardinge ball mills and 66" pan feeders. The milk of lime (25% solids) was originally pumped to the Magna plant storage tanks and from thence a portion sent by rail to Arthur. In 1929, a 4" pipeline was laid to Arthur. [Utah Copper, 1939] The site was closed out by the North End ROD of Sept 2002.

CONCENTRATE LOADING SITE (facility #94.02)

The Concentrate Loading Site is an active operations area consisting of a rail line and a overhead concentrate chute that loads the rail cars. This site was cleaned up in 1999. [Kennecott, 1996, and Kennecott, 1998]. The rails have now been removed.

RAILROAD SLOPE SITE (facility #94.01)

The Railroad Slope Site is an area consisting of steep slag and metal debris slopes. Characterization indicated 6 of the 14 samples were elevated in arsenic and/or lead. A composite flunked the TCLP leach test for lead. The maximum concentrations were 270 ppm As, 6.3 ppm Cd, 11000 ppm Pb, and 30 ppm Se. The site was included in the North Facilities Soils removal. [Kennecott, 1996]. Kennecott [July, 1997] indicates two separate areas of arsenic and lead soil contamination; one covering 43,400 square feet and one of 21,000 square feet within a 3.3 acre area. The estimated quantity of contaminated material was 3,500 cubic yards, all of which have been removed. This material was taken to WWTP Pond C for temporary storage, mixed with sludge and then disposed of in the Arthur Step-Back Repository.

Reclamation of the site included covering the areas where contaminated soil was left in place with at least 18 inches of clean soil as well as other disturbed areas where soil stabilization was required. All post reclamation sampling (13 samples) of the contaminated footprint and the peripheral areas showed very low levels of the constituents of concern. Field inspection made in May 1998 indicates that vegetation has been successfully reestablished. Kennecott [Dec, 1997] indicated that all work on this site was completed.

THE EAST DEBRIS SITE (facility #94.03)

The East Debris Site consists of predominately waste ore and metal debris. Characterization sampling in 1995 indicated 6 of 18 samples were elevated in arsenic and/or lead. The maximum concentrations were 990 ppm As, 14 ppm Cd, 9900 ppm Pb, and 41 ppm Se. The area of lead and arsenic contamination covered an area of 20 feet by 350 feet. The site was included in the North Facilities Soils removal. [Kennecott, 1996].

A total of 3,200 cubic yards of contaminated soil were removed from the site during the fall of 1995. The soil was taken to WWTP Pond C for temporary storage, then mixed with sludge, and disposed of in the Arthur Step-Back Repository. Two post removal samples were collected in December, 1995. No elevated levels of arsenic, lead, cadmium, and zinc were found. The site was regraded and 10,800 cubic yards of topsoil were hauled in during the winter of 1996. Seven post reclamation samples were collected none of which contained elevated concentrations of any of the analytes. The site was reseeded during the spring of 1996. The work has been completed.

TRUCK AND RAIL MAINTENANCE YARDS (facility #146)

There are several truck and rail maintenance yards on site. Such facilities have been known to be involved in spills of petroleum products and cleaning solvents.

Kennecott [1997] indicates there are several building located a few hundred feet south of the Magna Concentrator which are used to support the facility. Those buildings include truck and rail maintenance shops, utility shops (electrical and piping) and emergency response equipment. Some of the buildings appear to have been renovated. However, early 20th century architecture is evident at most buildings.

Although Kennecott [1997] asserts that spills there do not be a significant threat to the environment, they did find one well with <6" of diesel sitting on top of the water table. This is being addressed through a Corrective Action under a State Groundwater Permit.

Currently, all tanks have a secondary containment and are inspected. Waste oil generated at the facility is collected for off-site recycling. Waste part cleaning solutions are burned as fuels at off-site incinerators (D001 Hazardous Wastes).

BONNEVILLE CONCENTRATOR (BONNEVILLE CRUSHER) (facility #95)

The Bonneville Concentrator was built in 1965-6 in an area just south of the Magna Concentrator, locally referred to as Little Valley. The declining grade of ore coming from the mine required a finer grind that the older milling sections at the Magna and Arthur Concentrators. Designed to increase the ore processing capacity of the other two plants, the Bonneville Concentrator incorporated the latest developments in ore crushing and grinding machinery. Start-up of the first four units occurred in September of 1966, with the feed from the Bonneville mill divided between the Magna and Arthur flotation circuits. This ultimately increased Kennecott total processing capacity from 90,000 tons of ore per pay to 108,000 tons of ore per day by the spring of 1967. [SAIC, 1991] Since 1985, the Bonneville Crusher feeds only the Magna Concentrator.

The Bonneville Crusher is a rod mill which is more effective with harder ores than the facility in Copperton. Ores with higher molybdenum concentrations are sent to the Bonneville Crusher. These ores are segregated in the pit and loaded into rail cars for shipment to Bonneville.

According to Kennecott [1997], the ore slurry is now sent to the Magna Concentrator. Waste oil and greases are containerized and sent to an oil processing center. Some soils contaminated with hydrocarbons was hauled to USPCI in May, 1997.

On May 26, 2001, Kennecott announced that it would be laying off 235 workers and temporarily shutting down the Bonneville Crusher, the Magna flotation circuit and the railroad operations. The shutdown would last for 18 months or until copper prices improved. Shortly thereafter, KUCC permanently closed the facility and began to sell the railcars, grinding equipment, materials handling equipment and conveyors. Demolition of the buildings and cleanups (if necessary) is scheduled for 2005. The site was covered in the North End ROD of Sept 2002.

BONNEVILLE GATE HILLSIDE SITE (facility #95.02)

The Bonneville Gate Hillside Site is located southwest of Magna and immediately west of the Bonneville Gate. The site covers an area of approximately 8 acres (600 feet x 600 feet).

The Bonneville Gate Hillside Site is the former location of a precious metals recovery operation that stockpiled ore on the hillside. "The site is defined by strongly discolored copper oxide rich soils. The soils are a result of an in-situ precious metals process that produced a waste product at the site. The waste has since been removed but residual copper oxide remains.

Characterization indicated that none of the 6 samples had elevated metals. (Copper concentrations were as high as 91,264 ppm. Kennecott attempted to recycle the copper at the Copperton Concentrator. Because the copper was in the oxide form (not sulfide) the copper would not float and could not be recycled. [Kennecott, 1996]. The copper material was consolidated in place, recontoured, and revegetated. All work has been completed [Kennecott, May, 1998]. The site was closed out by the North End ROD of Sept 2002.

THE NORTH SLOPE SITE (facility #95.04)

The Bonneville North Slope Site is located just north of the Bonneville Crusher. The North Slope Site consists of three distinct piles of ore, fill soil and metal debris piles from the routine cleaning of the Bonneville Crusher and Grinder. In addition there are three small piles of ore located in a parking area immediately southeast of the Bonneville Crusher.

Pile A, located 200 feet northeast of the Bonneville Crusher serves as a level pad for the waste oil disposal bays. The pile consists of medium brown, silty sand and contains approximately 20% debris, including metal, wood, and cement. The pile is approximately 25 feet high, 50 feet wide, and 200 feet long.

Pile B, located 400 feet northeast of the Bonneville Crusher is fill material for the Main Bonneville Substation and contains yellow and green, copper and iron oxidized, sand-sized ore. The pile is approximately 15 feet high, 120 feet wide, and 200 feet long.

Pile C, located 250 feet south east of the Bonneville Crusher, is fill material for a laydown yard built to the north of the entrance road to the grinder. The pile consists of debris contaminated ore including metal, wood, and cement. The pile is approximately 20 feet high, 100 feet wide, and 200 feet long.

The smaller piles, located in the parking area southeast of the grinder, contain ore and are approximately 20 feet wide, 40 feet long, and 12 feet high.

Characterization samples indicates that none of the 5 samples had elevated metals [Kennecott, 1996]. The site was reclaimed in 1996. All work is complete [Kennecott, May, 1998). The site was closed out by the North End ROD of Sept 2002.

LITTLE VALLEY SETTLEMENT PONDS (facility #95.03)

The Little Valley Settlement Ponds Site is located 4300 feet west of the Bonneville Security Gate and 2000 feet south of the Bonneville Crusher. The site consists of four sediment ponds connected by a drainage. The ponds were created by construction of dikes across the drainages. The ponds and connecting drainage are filled with ore eroded from stockpiles located immediately upgradient from the site near the Bonneville Crusher. The eroded ore is water deposited in the ponds and drainages as a grey, well sorted, silt. A 2 to 4 inch thick layer of hydrocarbon stained sediment was observed interbedded in the ore deposition in one of the ponds. This unit is located approximately 1 foot below the surface. The hydrocarbon unit was observed in only one pond and the hydrocarbon source is suspected to be the former Bonneville Soils Petroleum Contaminated Soils Stockpiles that are located adjacent to and upgradient from the site. The depth of ore deposition is not known.

The Little Valley Settlement Ponds Site consists of a series of ponds that collect sediment from the upgradient Bonneville Crushing and Grinding facility's ore stockpiles. None of the 4 samples had elevated metals [Kennecott, 1996]. There is no record of any hydrocarbon determinations. All work has been completed according to Kennecott [Kennecott, May, 1998]. This area was cleaned up as a part of Clean Water Act, stormwater control project. The site was closed out by the North End ROD of Sept 2002.

THE SCRAP YARD (facility #95.01)

The Bonneville Railroad Scrap Yard site is located approximately 800 feet west of the Bonneville Security Gate and 2500 feet east of the Bonneville Crusher. The site covers an area of approximately 1.25 acres (50 ft x 1000 ft.).

The Scrap Yard Site was used as a coal storage and concentrate stockpile area. Sampling revealed several piles of concentrate which were removed to the smelter for recycling. A layer of coal 2 - 10 feet deep remains at the west portion of the site which is now being used as a railroad laydown yard. The laydown yard consists of two railroad tracks that hold several out of service rail cars and support equipment. The area immediately around the tracks has surplus rails and ties. The east part of the site (approximately 4.5 acres) was used as a borrow area for Magna reclamation projects. It has been reclaimed with waste rock and native soils. In 1995, the site was further characterized. None of the 4 samples had elevated metals. [Kennecott, 1996] There was, however, a failure of the vegetation to grow on the east part reclamation area. This was due to excess acidity in the soils for the kinds of vegetation planted. A new mix of vegetation was planted in 1997. The site was closed out by the North End ROD of Sept 2002.

CHAPTER 15
MAGNA TAILINGS IMPOUNDMENTS

The tailings from the two mills near Magna were sluiced to a grassy area between the mills and the Great Salt Lake. When the Copperton Concentrator near Bingham was opened, the tailings from that facility were also piped to the tailings ponds in a slurry. As time went on, dikes were added were contain the tailings. When the tailings pond had reached a height that engineers thought might be unstable into the future, the tailings pond was expanded toward the north. An emergency catchment area for tailings also developed over the years in an area just to the south of the main tailings ponds. Historic research has documented that a number of facilities were buried by the growing tailings ponds. This chapter details the history and reclamation activities for the tailings areas and describes the facilities now buried underneath the tailings.

MAGNA TAILINGS POND (SOUTH TAILINGS IMPOUNDMENT)(facility #101)

The sloping hillside at Magna provided sufficient elevation not only for gravity flow through the mill, but for the disposal of the wastes on the large flat farming area below. Hulse [1964] describes the area as a "meadow - lush, green, and fine for pasture cattle." A history of Utah Copper Mills [1939] described the area as "an irregular mass of marshes and sloughs, the home of large flocks of waterfowl. Nearer the mountain were several ranch houses." The original tailings pond in 1907 covered an area of 1315 acres, or more than 2 square miles, which was expanded another 1460 acres shortly afterwards [SAIC, 1991]. The pond, into which was discharged from 95 to 97 percent of all the tonnage milled, was also used by the neighboring Boston Consolidated for the disposal of tailings from its Garfield concentrating plant. To retain the water and protect the railroad tracks to the north, a dike was constructed on the north and east sides of the pond, out of mine waste. The water for conveying the tailings varied in amount from 10,000 to 15,000 gallons/minute, depending upon the tonnage being milled and the percentage of solids in the tailings pulp. [One Utah Copper reference says up to 25,000 gallons/minute were discharged, 1939]. Once the tailings were dispersed in the pond, the water was collected in concrete dewatering boxes in the north and east sides of the dike. They served to discharge the clear water from the tailing pond after the solids had been settled [Arrington, 1963].

During the early days of the pond, Rickard [1919], a mining reporter whose writings were often punctuated by flowery prose said "the sun shimmered across the vast stretch of tailing [sic] estimated at 65,000,000 tons, averaging 0.5% copper, as dead metallurgically as the salt waste that it blankets." [obviously before the days of wetland appreciation].

By 1915, the pond area below the mills had been filled to such an extent that dikes averaging 20 feet high had been constructed. Further expansion of the tailings pond, occurring shortly thereafter necessitated both the relocation of 9 miles of railroad track, and construction of a new dike 7 miles long. This allowed an additional 2933 acres to be engulfed by tailings. The other option for expansion was to raise the dikes to a height of 80'. This option was rejected because it was more expensive and the railroads feared that a dike that high could "prove a continuous menace to the operation of the railways". [Rickard, 1919]. The land onto which the expansion occurred was obviously a wetland at the time. Rickard [1919] reports that "because of the wet condition of the ground," drainage ditches to the Great Salt Lake were built. The new dikes were made of tailings, lined on the inside with rip rap of slag. At a later date, 268 acres appear to have been added to the eastern side of the impoundment. [SAIC, 1991] The relocation of the tracks during the 1918 expansion is further discussed by Jones (1993), See also Riter and Ragtown.

During the early years of operations, when the grinding was coarser, it was necessary to provide flumes to carry the tailings a mile or more north and west of the Arthur mills to cause the tailings to flow toward the north dike. At the Magna plant in 1916, considerable difficulty was experienced because the coarse tailing backed up to higher ground. Greek and Japanese worker housing and the highway had to be relocated to higher ground. Later, with finer tails, these flumes were no longer necessary. [UC, 1939].

In 1939, Utah Copper's History of Milling Developments indicated that a rail track surrounded the pond along the dike and as the dikes were raised, the tracks were shifted inward. The width of the dikes were described as 20 - 35 ft, and the dikes are at the natural angle of repose. As that time, the overflow water was discharged into the Great Salt Lake unless sufficient water was unavailable. Then it was recycled to the mill reservoir.

In 1950, the dikes were raised again about 150 feet inside the edge of the pond using a displacement method. Gravel was dumped from trucks causing the soft tailings to yield until penetration was sufficient to develop resistance again sliding. Then the dike was raised about 25 feet above the crest of the original level [Trexler, et al., 1982]. Yet another dike was constructed in 1952 about 150 feet inside the 1950 dike. Between 1957 and 1970 dikes were raised by placement of sand and gravel hauled from off-site. Each raise was placed inside the previous one at a height of about 3 feet. This resulted in a slope of about 4:1. In 1957 water was removed from the pond using two concrete dewatering boxes, one of which was moved in 1964. A siphon decant system was installed in 1965. [Trexler, et al, 1982]

In 1970, Kennecott began a new method of dike raises which included a flat surface 12 to 15 ft wide to a road around the dike and greater protection from overtopping. [Trexler, et al., 1982]

Breaks in the dikes enclosing the tailings have occurred, and at least twice have caused work stoppages. Breaks occurred on October 16, 1941 and February 11, 1942. In August 1944, a break in the dike, which had reached a considerable height, caused a complete suspension of operations for 4 days. Inner protecting dikes, roughly 150 feet inside the pond, described above, were constructed to alleviate this problem [SAIC, 1991]. There was another break in January 29, 1951 shortly after completion of the 1950 dike. A recent 104e response indicated that there had been 7 failures of the dikes, mostly from erosion problems along the north and northeast sides. The most significant spill occurred in 1964. Morton Salt, railroad tracks, the Great Salt Lake and utilities were impacted. [Salt Lake Tribune, 1964] The failure occurred near the south dewatering box. Although the exact cause of the failure was not determined, it was clear that the dewatering boxes were involved. This system was retired and the siphon decant system installed. Additional tailings were added between the decant system and the dikes to produce a more significant sandy beach in the area. Two more failures occurred in 1969 caused by erosion of a gap caused by water leaks from the perimeter tailings discharge pipes. It was recommended that there be more freeboard and more frequent inspections. [Trexler, et al., 1982]. In 1982, Kennecott's insurance carrier required the dike to have at least 4 feet of freeboard.

In 1982, the decant pond siphon system was two 48" siphons which could remove water at a maximum rate of 90,000 gpm. The south siphon was used routinely because it withdrew water to the clarification canal leading to the pump station. The north siphon was used only in emergencies. It went directly to the C-7 ditch. Twelve feet of water was maintained between the siphon intake and pool bottom to minimize TSS in the water. [Trexler, et al., 1982]

The stability of the dikes particularly in a earthquake scenario has been cited as a reason why the expansion of the facility toward the north is warranted. New dikes toward the north would stabilize the existing dikes. Some of the existing dikes were built with less than ideal construction materials (finer grained tailings), particularly the lower levels [EIS, 1995]. Kennecott [1997] reports that, in the past, it was noted from aerial observations that minor seepage may have occurred.

By 1958, the impoundment covered 6,259 acres. The continuous use by the Magna and Arthur concentrators, with additional use by the Bonneville Concentrator in 1965 and the Copperton Concentrator in 1988, has necessitated an increase in the height of the dikes around the impoundment. By 1969, the dikes on the north side of the impoundment averaged 100 feet in height, with the eastern side averaging 80 feet, and then ranging down to 20 feet in height on the southern side. The ever-heightening dike walls compelled the construction of a pumping plant in 1969 by Kennecott to boost tailing slurry from the Magna Plant over the top of the dike [SAIC, 1991].

Early milling and concentrating methods had a metal recovery efficiency of only approximately 60 percent. This allowed for a substantial volume of metals to be lost in concentrator waste streams and deposited in the tailings pond. Possible re-treatment of the tailings for their metal content has been mentioned as far back as 1933. While re-treatment of the tailings before their disposal in the tailings pond appears to have begun in 1971, there no evidence of any reprocessing of tailings previously deposited. [SAIC, 1991]

Kennecott publications indicate that dust storms and erosion of dike slopes have been an ongoing problem. Water sprays, snow fences, plowing, and chemical additives have been used in attempts to stabilize the tailings. In 1971, Kennecott began to spray a petroleum emulsion on the tailings pond that combined with moisture in the tailings to form a soil-crusting film. In the spring of 1972, Kennecott began transplanting trees from the old Garfield townsite to further address the problem. Experimental plantings of various grasses and tree seeds also appear to have been tried. None of these efforts appear to have been entirely successful. [SAIC, 1991]. In a recent effort to keep down blowing dust, the State required Kennecott to keep 90% of the tailings pond wet at all times. This was accomplished by construction of a manifold system whereby tailings can be slurried to different parts of the pond. Kennecott [1997] reports that in an effort to further stabilize the tailings pond, wicks have been installed to aid in dewatering.

Tailings from the Copperton Concentrator are sent via a 48" pipeline to a splitter box on the hillside south of Hwy 201. At the splitter box, the tailings flow is divided between two 28" pipelines that feed the existing impoundment peripheral discharge system and a 48" pipeline known as the Copperton single-point discharge. These three pipelines cross the highway on a steel trestle bridge located at the intersection of 9600 West and Hwy 201.

Tailings from the North Concentrator (when it was still in operation) crossed Hwy 201 via a pair of concrete flumes and flow into a pump house. These tailings are then pumped to the top of the embankment and deposited directly into the impoundment through a single-point discharge located approximately 2000 feet to the east of the Copperton single-point discharge. One of these flumes from the former North Concentrator which cross the highway has been removed and the other is in current use as foot access and carried active utilities.

Two-thirds of Copperton tailings are sent to the peripheral discharge system which consists of 39 pipe sections, approximately 1500 feet in length, that distribute sequentially along the entire perimeter of the impoundment and provide dust control. The remaining Copperton tailings enter the impoundment through the Copperton single-point discharge. This system was installed in 1988. During periods of extreme cold or operational upset in the peripheral discharge system, the entire Copperton Tailings can be routed through the Copperton single-point discharge.

After deposition in the impoundment, the solids within the slurry settle out and the resulting supernatant water flows to a decant pond in the northeast corner of the impoundment. Three siphons installed in the decant pond transfer the water to the clarification canal, which flows around the southeast corner of the impoundment. This canal provides secondary clarification and returns the water to Pump Station #1. Here the water is pumped to a holding reservoir where it is returned to the concentrators for reuse in the process water circuit.

According to a 1982 report, Kennecott was having trouble meeting its NPDES permit discharge limits for the tailings pond during storm conditions. Problems included: 1. If excess water beyond process needs accumulates, then it needed to discharge "to protect the physical structure of the dike". 2. During storms, the runoff in the pond has too high a suspended solid load to be usable in the concentrator without "adverse economic impact". 3. Winds during storms resuspend solids into the decant water.

The embankment of the existing impoundment is raised on a continuing basis to accommodate ongoing tailings deposition. This is accomplished by excavating previously deposited tailings along the embankment and placing the material in a dike along the perimeter. The dike is 8 feet high, 22 feet wide. This operation takes place year-round, curtailed only by severe weather. As the perimeter of the impoundment is raised, the peripheral discharge system and the decant siphons are relocated to the new embankment crest.

The Reclaim Water Canal is part of a partially closed-loop recycling system. The Reclaim water canal receives water decanted from the tailings impoundment and returns it to the ore-processing operations. Kennecott has the option of discharging excess water from the

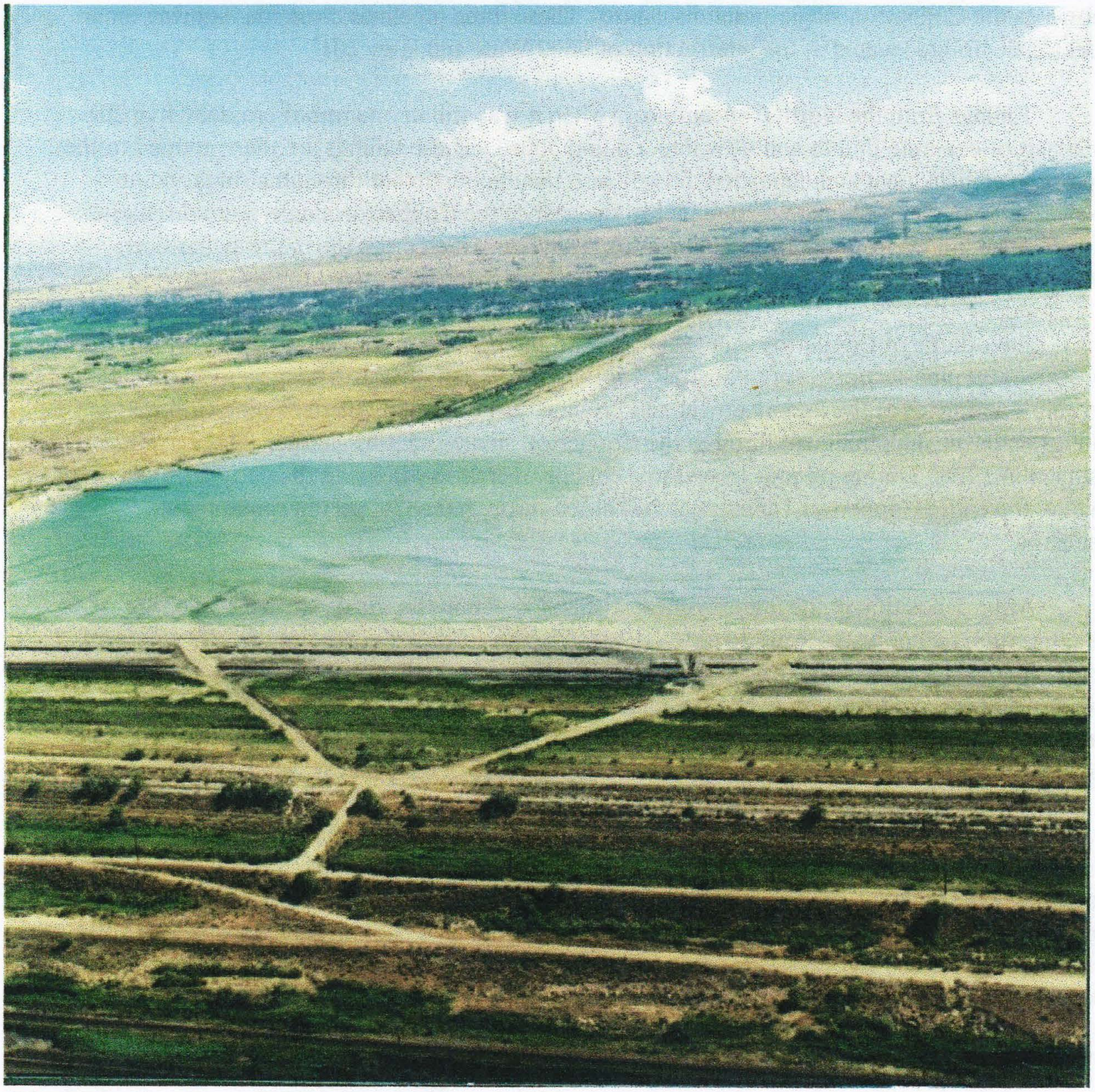

Figure 45: The Magna Tailings Impoundment before expansion. Magna is in the background.

Reclaim water canal into the C-7 ditch via UPDES permit outfall #001, or reusing it for reprocessing. [Kennecott 404 permit application, 1994].

Kennecott Utah Copper currently places tails in the impoundment at the average rate of 112,000 tons/day. It is anticipated that this quantity will increase to an annual average of 145,000 tons per day upon completion of the current facilities expansion. [Kennecott, 1991]. [The EIS reports that production of tailings is 122,000 tons per day from the Copperton Concentrator and 30,000 tons per day from the North Concentrator, (EIS, 1995).]

Tailings and wastes from four primary sources are currently consolidated and disposed of within the Magna tailings impoundment: 79,000 tons/day from the Copperton Concentrator; 30,000 tons/day from the Magna Concentrator; 3000 tons/day from the slag concentrator; and 55 tons/day of fly ash from the power plant. Water ponded on the tailings is siphoned off to the clarification channel for recycling, or discharged to the C-7 Ditch. [Kennecott, 1991] SAIC reports that tailings pond receives 27.4 million tons annually, which amounts to a growth at a rate of an additional 4 feet of waste per year. [SAIC, 1991]

The tailings impoundment contains about 2.1 billion tons of material. [Kennecott, 1991]

A recent test boring indicates that the composition of the tailings varied little over time [Kennecott, 1994]. Water quality testing of water from the pond indicated average values of As and Se close to the Utah Groundwater Water Quality Standards. Some values exceeded the standards for these elements.

On the average, the tailings contain the following metals:

Metal	Surface (ppm)	Subsurface (ppm)	underlying soils
As	6.2	14	14
Ba	-	170	130
Cd	0.5	0.47	0.55
Cr	43	47	34
Cu	147.6	270	16
Pb	10.8	13	11
Se	-	0.65	0.2
Zn	29.2	46	54

This part of the tailings pond is undergoing closure under the supervision of DOGM. The surface is being covered with grass. It is now known as the South Tailings Impoundment

NORTH TAILINGS POND EXPANSION (NORTH TAILINGS IMPOUNDMENT)(facility #101.01)

In June 1994, Kennecott submitted an application to the Army Corps of Engineers for a 404 wetlands permit needed to expand the tailings pond toward the north and west of the current facility. After the expansion project is completed, the current facility will be closed. This is projected to occur 1997 - 2004. Kennecott proposes to reclaim the site by planting of rapid growing grass seed by range drill seeders, hydromulching, dust control, and planting of trees and shrubs. Test plots for this process have already been laid out in the southeast corner of the impoundment.

Kennecott evaluated six other locations for their expansion needs: Coon Canyon, Barneys Canyon, Dry Fork, Carr Fork, Tooele, and Stockton. The North expansion site was chosen, using land formerly owned by Morton Salt. In order to build this facility, approximately 14 federal, state and local permits will be required. In the entire application to the Corps for the Wetlands permit, Superfund status was not mentioned, but was mentioned several times in the permit itself [Army Corps of Engineers, 1996]. The additional 3200 acres contains 1055 acres of jurisdictional wetlands (391 acres of saline playas, 226 acres of emergent wetlands, 294 acres of evaporation ponds, 63 acres of open waters, and 81 acres of overflow basins) [Army, 1996]

The design of the new portion of the facility appears to be similar to the existing facility except that it will have a layer of slag at the bottom of the dikes to provide drainage. As part of the permit, Kennecott proposes to use recently purchased property on the north side of I-80 to replace wetlands subsumed by this project..

The new tailings pond and the remaining capacity of the old tailings pond will accommodate an additional 2.0 billion tons of tailings. The existing height is now about 190 feet. The final height will be 250 feet and cover an additional 3200 acres, for a total acreage of both ponds at 8,900 acres.

Two geotechnical studies indicated that during and following an earthquake, significant runout could occur along the southeast corner of the tailings pond. This runout occurs when shaking of wet sandy soils such as tailings or beach sand undergo "liquefaction". The soils/tailings would simply flow out and spread over the landscape. Potentially impacted by such an event could be the Norcross residence and the northwest section of Meadow Green Estates (a subdivision in Magna).

Kennecott began three projects in 1998 designed to prevent earthquake damage to neighbors. (1) The southeast corner of the tailings pond will be dewatered as quickly as possible. Kennecott previously installed 31 dewatering wells, but plans to install 15 additional wells. The drier the tailings, the more stable the tailings would be. (2) Two barrier berms to contain any flow are nearing completion. One an "L" shaped tapered berm, is 10 - 15 feet tall and located on 80th St just north of Meadow Green Estates. The other, a similar berm, is located on 80th St between the Norcross residence and the tailings pond. They have been called the South 80th West Berm and the North 80th West Berm. (3) A roadway warning system was installed with several signs which would activate in the event of an earthquake to warn motorists to avoid hazardous areas. (The signs indicate that motorists should not pass the signs when the lights are blinking - they do not say why.)

With the opening of the north expansion project, Kennecott began to have significant difficulties in meeting the requirements of their UPDES water quality discharge permit. Most of the exceedances of their permit involved high TDS content and the inability of the WET test organism (Ceriodaphnia dubia) to survive the high TDS in the discharge. The test organism does not survive salinities greater than about 5000 mg/l. Kennecott's discharge varies between 4000 mg/l in the winter to greater than 10,000 mg/l in the summer. Part of this is because the evaporation rate in the winter is about 2000 gpm while the evaporation rate in the summer is much higher, about 20,000 gpm.

Another problem with salinity is the fact that the North Tailings Expansion area was built on salt ponds of the former Morton Salt operation. Because the salt originated from the Great Salt Lake and Kennecott inherited the UPDES permit from Morton Salt, Kennecott flushed at least some of the salt from the footprint between March and May, 1999. Even so, Kennecott expected that it would be some weeks before the tailings would completely bury the salt ponds and eliminate this source of salinity in their tailings pond waters. Deposition of tailings in the new tailings pond began in June, 1999. In another case, the toxicity in the WET experiments originated from Cu and Zn, probably from the new settling pond. Cu and Zn had accumulated in the settling pond before it was used for the North Expansion Pond.

To address the salinity problem in the discharge, Kennecott proposed to change the location of their main outfall from 001 and 002 on the C-7 Ditch (freshwater) to a new outfall (012) directly to the Great Salt Lake (salt water). Kennecott also proposed to change the test organism from a freshwater species to a salt water species (brine shrimp). Outfall 001 would be eliminated and outfall 002 would remain in place for discharge to the C-7 Ditch if needed. To make the WET more appropriate for discharge to saline waters, Kennecott got permission to change the test species to a more salt-tolerant organism.

In addition to flows from the Copperton Concentrator, the tailings impoundment include approximately 15,000 gpm from the North Concentrator, 1,500 gpm from the slag concentrator, 250 gpm from the hydrometallurigical plant, and 1,000 gpm of water contained in ash sluice and cooling tower blowdown from the power plant.

Water from the new tailings pond is pumped from the North Expansion decant pond via the floating decant barge pumps. The intake to these pumps has been designed to skim water from just below the surface in order to reduce the potential to suspend solids from the bottom of the pond. A sediment pond upstream of outfall 002 will also be used to settle suspended solids on an as needed basis.

Two cyclone plants have been placed on the top of the new tailings pond to separate coarser tailings from the rest. The coarser tailings are used for the dikes and exterior parts of the tailings pond to create further stability. The finer tailings are discharged to the interior of the pond. When a new lift is added, a drainage blanket of slag is laid down to allow water to drain into the toe ditches.

A toe ditch has been constructed along the outer perimeter of the North Expansion embankment with a central toe ditch retention pond. Outfall 007 is used to discharge water from the toe ditch retention pond to the C-7 ditch when the water is not needed for recycling.

Kennecott has a storm exemption for the tailings pond when stormwater exceeds the volume of water in the decant pond. On Feb 3, 1998, "movement" occurred on the starter dike on the NE corner of the new impoundment. Excess water was discharged so that the integrity of the dike could be restored. During this effort to reduce pond height because of these initial dike stability problems, there was an excess of TSS discharged due to high algae and decomposing organics from the former salt ponds.

A fuel oil and lubricant station for the new tailings pond was designed to have secondary containment for capture 100% of any spill.

ARTHUR STEP-BACK REPOSITORY (facility #101.02)

As part of the Kennecott North Facilities Soil and Wastewater Treatment Plant Ponds Site Removal Action, Kennecott Utah Copper constructed on existing company property a Subtitle C type repository known as the Arthur Step-Back Repository.

The Repository was designed to receive and hold soil, sludge and other solid wastes removed from the smelter, refinery, Arthur Concentrator, Magna Concentrator, Bonneville Crusher, and Wastewater Treatment Plant areas of the North Facilities which are potentially contaminated with inorganic materials, primarily metals. These materials will be removed over a period of two to four years, process, compacted into the Repository, and finally covered with a cap meeting Subtitle C requirements.

Design of the repository began in 1994 and construction began in the spring of 1995. Construction was completed by the end of 1996. Filling of the repository began in the spring of 1997. Since the initial cleanup activities did not fill the repository to its capacity, the eastern part was closed in 2002, but the western part has a temporary closure which can be re-opened to accept future cleanup wastes.

The repository is situated on the southwest corner of the Kennecott Tailings Impoundment in a depression known as the Arthur Step-Back. The impoundment is located between the souther shore of the Great Salt Lake and the northern end of the Oquirrh Mountains on an alluvial bench above the floor of the valley. The alluvial bench is composed mainly of clayey to sandy gravels eroded from the northern end of the Oquirrh Mountains.

A geological engineering study report covered site conditions, geotechnical concerns, earthwork requirements, and meteoric runoff control. In includes seven field borings for 27.25 feet to 121.5 feet in depth, two of which contacted the natural alluvial soils. The study concluded that there were no significant geotechnical constraints at the Repository which would prevent construction of the cell.

The repository covers an area of about 30 acres on the southwest corner of the Kennecott Tailings Impoundment and is approximately 3060 feet long and 420 feet wide at the top. It contains 3:1 horizontal:vertical slopes with 6:1 horizontal:vertical slopes ramps on the east and west ends. It is approximately 100 feet deep with a bottom elevation of 4286 feet above sea level and a top elevation of 4387 feet above sea level. It has been designed to hold up to 2.5 million cubic yards of material with a maximum cap slope of 15%. About 1.34 million cubic yards were excavated and hauled 3/4 mile to a disposal area on the southwest corner of the Kennecott Tailings Impoundment.

The repository is lined with 3 feet of clay meeting a minimum permeability of 1E-7 cm/sec and compacted to 95% standard proctor density at a moisture of 0 - 4% of optimum. Clay capable of meeting these requirements was hauled to the repository from a source located on the northwest bench of Oquirrh Mountains in Tooele County, Utah, about 10 miles away.

The synthetic liner system consists of a 60 millimeter conductive HDPE line, a HDPE geonet and an 80 mil conductive HDPE liner. The ramps on the east and west ends of the repository consist of 50 and 80 mil textured liner encasing a fabric covered geonet.

There are five sumps located in the bottom of the repository, each consisting of a primary and secondary system. Each depression contains a double chambered 36 inch stainless steel fabricated sump with a 12 inch primary withdrawal pipe, a 10 inch secondary withdrawal pipe and two 6 inch instrumentation pipes. The primary system allows removal of leachate that collects on top of the primary liner. The secondary system allows leachate that may leak through the primary liner to collection of the secondary liner for removal. The five sumps are equipped with permanent stainless steel pumps in both the primary and secondary systems. The primary sumps contain 1.5 inch pumps capable of pumping 17 gpm at a head of 120 feet. The secondary sumps contain 1 inch pumps capable of pumping 7 gpm at a head of 120 feet.

A drainage system has been incorporated into the bottom of the repository to facilitate movement of leachate materials on the primary liner toward the five sumps. This system consists of one to three layers of high capacity HDPE drainage net separated by 60 mil HDPE liner and covered with non-woven filter fabric. The system is then covered by 2 feet of clean sand which promtes drainage and protects the liner system from hauling and placing equipment. [Kennecott, May, 1997].

On October 7, 1996, approximately 7000 cubic yards of tailings slurry was accidentally released during a re-energizing of a tailings pipeline north of the Arthur Step Bact Repository.

The release occurred when the line was re-energized with a valve open and the tailings slurry breached a valve waste pond and flowed south to the Repository drainage ditch. The tailings slurry flowed down the liner to the repository bottom over the protective sand layer area of sump 3 and 4. The tailings were not geotechnically suitable to leave in the repository and were therefore removed.

Following removal of the tailings, meteoric water started reporting to the secondary sumps 3 and 4. At least one penetration of the primary liner was found and repaired, but water continues to flow into the secondary system. A second leak is suspected. Once the repository is filled and meteoritic water can no longer enter the repository, Kennecott hopes this secondary flow will cease. [Kennecott, June, 1998].

As of 2003, the Arthur Stepback Repository is temporarily closed, since the initial removals of soils and wastes have been completed. The eastern half of the repository is filled to capacity and is permanently closed with an impermeable liner and soil cover. The western half was temporarily closed with an impermeable liner which can be peeled back and additional materials added as additional facilities are closed and demolished. The current volume of waste included in the repository is 2,165,065 cy.

Associated with the Arthur Stepback Repository is a Drying Pad located just to the north of the repository also on the Magna Tailings Pond. This area was used to spread out wet sludges so that they could be mixed with soils and dried to obtain the optimum moisture for proper compaction in the repository. The drying pad has been cleaned up (as of 2003), and is inactive at this time. The drying pad covered an area of about 35 acres (1700 feet x 850 feet). The surface now is the original tailings surface.

KENNECOTT TAILINGS POND LANDFILL (facility #106)

Kennecott reports that various demolition debris was placed in the Kennecott Tailings Pond Landfill which is located on the western side of the Magna Tailings pond. The demolition debris includes: anode building, reverb building, and the convertor building. Other wastes are also placed here. The nature of these wastes is unknown. [Kennecott, 1997, indicates construction debris, lunchroom and office trash.]

The location now is on the southwest portion of the Magna Tailings Pond, previously on the southeast corner. Actually the location of the Tailings Pond landfill has been moved from time to time. Over the past 30 years, there have been a few different landfills within the tailings impoundment. Typically these landfills would be used for a number of years until such time that the tailings rose high enough to cover the site. Then the landfill would be relocated to a newer portion of the impoundment. These landfills were not officially closed as they were not regulated at the time. No records exist regarding types and quantities of waste. With the exception of the current landfill, all of the previous landfills have been buried under several feet of tailings. Other than "old timers" memories, no records exist of the exact location of the previous landfills. The landfill prior to the existing landfill was located on the southern embankment of the impoundment across from the highway from the Arthur Concentrator and was buried approximately 12-14 years ago [Kennecott, 1998].

In 1992, Kennecott placed 2800 tons of "waste rock" in the landfill as a cover [Kennecott, 1991]. Later it was revealed this material had come from the slag pile and had high concentrations of lead. Originally, Kennecott stated that it planned to excavate the material and haul it to USPCI. A later letter revealed that Kennecott instead covered the waste in place in Sept, 1992.

Kennecott [1997] indicates that the 2800 tons of "waste rock" was actually material that was originally supposed to be used for flux at the smelter. The material originated from the Tintic Mine and was intended to be used as a precious metals bearing flux. At first it was stored on top of the slag pile until it was subsequently determined that the contained metal value was not economically recoverable at 1992 silver prices. For this reason, it was decided not to use the flux material. At this point, according to Kennecott, it became a Bevill exempt waste, and was disposed of in the tailings pond landfill. It contained 29 mg/kg silver, 1100 mg/kg arsenic, 34 mg/kg cadmium, 3900 mg/kg lead, and 8 mg/kg selenium. Of the RCRA metals, only Pb exceeded the TCLP limit of 5.0 mg/L. [Kennecott, 1998].

The landfill is permitted by the Salt Lake City-County Health Department to receive non-hazardous solid waste from KUC facilities. The solid waste material consists of construction debris and general office and lunchroom trash. The wastes are covered immediately upon disposal eliminating the air pathway, according to a Kennecott fact sheet [Kennecott, 1997].

DIVING BOARD TAILINGS (facility #104)

The Diving Board Area Tailings is a 21 acre impoundment facility located near the northwest corner of Magna, Utah. It is adjacent to the south side of State Highway 201 and 1.2 miles west of the southeast corner of the Magna Tailings Pond and about 2500 feet east of the Magna Concentrator. The facility consists of an eight-acre northern impoundment and a thirteen-acre southern impoundment. The primary functions of this facility are to impound tailings and mill water overflow during scheduled shutdowns and temporary upsets of the Magna concentrator. Approximately 1,500 tons/month may be diverted to this area. Process water from the two Dorr tanks and from timber tanks at the filter plant are also diverted to the Diving Board Area. The area also acts as a retention basin and captures local stormwater runoff. Fly ash and miscellaneous construction debris may be incorporated in the tailings. An earthen berm was added in 1977 to better contain the tailings [Kennecott, 1997]. The area has been in use since the Magna Mill was first constructed.

The Diving Board Cyclone System was built in the mid 1970s to separate coarse tailings from the main tailings stream to produce road base. This system was used only periodically, primarily for roadbase used by the State of Utah during construction of Interstates 80 and 215 (see Road construction description) [Kennecott, 1991]. The cyclone was dismantled in 1991.

The system removed the sand fraction of the tailings from the Magna Mill. It operated for about one year in 1973 and 1974. Approximately 5,000,000 tons of sand was removed, resulting in an estimated 25% reduction in the total tailings volume discharged from the Magna pump station. [Trexler, et al., 1982]. The cyclone was dismantled in 1991.

The facility contained approximately 400,000 cubic yards of tailings and materials. The nearest population is in Magna about 1/4 to 1/2 mile away.

Kennecott began to rehabilitate this area in 1993. They planned to relocate the tailings and other materials to the Magna Tailings pond. According to a letter to UDEQ [1992] approximately 150,000 - 200,000 cubic yards of the tailings were to be used as a stepback dike at the Magna Tailings Pond. The north and south ponds was excavated completely and the area will be regraded to provide retention for localized stormwater runoff. In addition, a concrete retention basin with the ability to retain anticipated tailings discharge resulting from scheduled and emergency shutdowns of the Magna tailings pump was constructed at the southeast end of the Diving Board Area. Accumulated material would then be periodically pumped from the retention basin to the Magna Tailings Pond. The new retention basin was constructed with concrete to facilitate material removal. The concrete impoundment provided controlled retention of tailings and minimize any potential impacts resulting from future percolation and wind dispersal. [Kennecott, 1991]. About 363,000 tons were removed in this project (21 acres).

In Nov. 1997, a small overflow of tailings from the Magna Concentrator spilled into the Diving Board Tailings area. The spill was cleaned up.

Another spill of tailings occurred on March 1, 2000, when the Magna Pump Station failed. Most of the tailings ended up in the wetlands between the old tailings area and SH 201. By March 3, the tailings had been cleaned up. This wetland was created in a former quarry. In the Spill Report, the area was described as a "dry wetland". According to a BOR inspection, the spill originally occurred at the Magna Tailings Lift Station location just to the north of SH201 underneath the tailings pipeline overpass. The tailings spilled out into the Lift Station and then ran downhill to the east in a ditch on the north side of the road. At the bottom of the hill, there is an underpass and the tailings ran through this underpass to the south side of the road, then through a culvert into wetland area adjacent to the Diving Board Tailings site. There, the tailings spread out over about an acre to a depth of about 2 inches. The spill lasted about 45 minutes and the tailings, originating from the Magna Concentrator, were flowing at a rate of 15,000 gpm. Some tailings got on the road, but most ended in the ditches and wetlands. The volume of the tailings was about 1000 cy, but excavation amounted to 2000 cy. The tailings were stored to dry on the north side of the road. A vac truck was used to clean the tailings out of the ditches and culverts.

RAGTOWN AND SNAKETOWN (Historic camps buried by tailings)(facility 101.03)

According to Schroedl [1993], a small community of tents, dugouts, and shanties known as Ragtown developed near the construction sites of the Magna Mill in 1905 and 1906. Ragtown was located on the flat area below the Magna Mill and north of the present location of the Webster School. The town may have stretched from 2100 to 2700 South and included approximately 60 houses arranged in five rows. The community included a district called Snaketown known for its saloons. Snaketown was north of 2100 South, now buried by the Magna Tailings Pond. According to an old timer [quoted in Jones, 1995], "There were several saloons there that served both beer and whiskey. Of course a lot of men would get down there and have a little too much liquor to drink and get snakes in their boots as they used to call it. I guess that was the reason it was called Snake Town." Snaketown was the first of the tent towns to go since it was located in the area that began to be covered by tailings. Ragtown was later absorbed by Magna.

A small barrack community of Japanese smelter workers was formed east of the Magna Mill, near the old site of Ragtown in the 1920s. The fortunes of these towns were closely tied to the industries that fostered them. Ragtown was abandoned in 1917 as a result of the construction of the tailings pond. Some structures from Ragtown remained intact until the 1960s. The Japanese community was abandoned in the 1930s. Many of the structures in Ragtown were moved to Magna.

The site of Ragtown reportedly has been extensively disturbed by past mining activities and is now a current operations area of Kennecott. No archaeological remains of this community exists.

The Schroedl cultural survey indicates that some of the original structures from Ragtown were moved to Magna. A known address of one Ragtown structure is: 2365 South 8000 West, Magna.

HISTORIC ROADS (Historic roads buried by tailings)(facility #101.04)

Two historic roads are known to transverse the Magna Tailings Pond Area. The most famous is the Lincoln Highway, the first paved transcontinental highway. Most of the highway has been buried by newer construction of SH201 and railroad infrastructure. A section of the Lincoln Highway still exists on Kennecott property just west of the Magna Tailings Impoundment near SH201 and Sludge Pond C. It is in good condition and is currently in use by trucks hauling sludges to the new repository.

Another road through the area is the old Salt Lake to Tooele Highway. It consists of a raised roadbed. Portions of the road were abandoned in 1917 when the tailings pond was expanded. It currently originates at the pumphouse for the Tailings Impoundment (SW1/4 of Section 17) and traverses eastward crossing the Kersey Creek Canal and bisects S1/2 of Section 16 (T1S,R2W). In the SW1/4 of Section 15, the road becomes an unimproved two track and continues eastward to Section 13. This track of road is marked on maps as far back as 1902. The

1902 map indicates that the roadbed was part of the Salt Lake to Tooele Highway. It is also possible that this represents the Stage Route from Salt Lake City, the Hasting's Cutoff, and the route of Fremont's second expedition to the Great Salt Lake in 1845. No physical remains of the early trails remain intact. This feature is in deteriorating condition but portions of the road can still be seen visually and some portions are still in use. [Schroedl, 1993]

RITER (Historic town/train station buried by tailings)(facility #101.05)

When the Oregon Short Line narrow gauge RR tracks through the area were standardized and then incorporated into the San Pedro, Los Angeles and Salt Lake RR, the flag stop at Riter was upgraded into an actual passenger station. Riter was the closest stop to the Magna construction sites (3 miles away) in 1905. A horse drawn stage service transported workers from Riter to the construction sites. Given the concentration of so much passenger traffic through the old flag stop at Riter, a small, ephemeral town grew around the station that included a half dozen saloons, a bakery, two stores, a restaurant, a poll hall, and a few private dwellings. The station and the town was apparently later buried beneath the tailings impoundment with the latter was expanded in 1918 [Jones, 1995].

There is evidence to suggest that Riter had been abandoned as a town long before the tailings pond was expanded and the tracks relocated to the north. This was because with the new passenger stop at Garfield, the workers could disembark closer to their work and the usefulness of Riter had passed. No buildings in Riter were shown in the drawings for the relocation, just the railroad siding.

The name Riter Station appears after the relocation for a siding. Later Western Pacific maps indicate that there was a collection of railroad structures at Riter (the new site) including a frame bunkhouse, concrete cistern, ice house, coal shed, and station building. In 1995, there were foundation remains of the bunkhouse, cistern, and station, along with several depressions and the decomposing remains of concrete fenceposts. The new Riter must have also been shortlived. By 1928, there were no facilities at the site only a private railroad telephone. [Jones, 1995]. This site was buried by the most recent expansion (1996-1998) of the tailings pond when the railroad was once again realigned further to the north.

101.06 HISTORIC RAIL ROUTES (Historic rail beds buried by tailings)(facility #101.06)

Three different railroads had tracks through the Magna Tailings Pond area. The first grade was built by the Salt Lake, Sevier Valley and Pioche Railroad in 1873. Utah Western RR gained control of the grade and then laid narrow gauge tracks in 1875. The Utah Western RR originally went only as far as Lake Point where Jeter Clinton had built a resort complete with pavilion and bathhouses. Lake Point also became the homeport of steamship with "General Garfield", formerly the "City of Corinne". After reorganization into the Utah and Nevada RR, the Union Pacific gained control of the company and consolidated it into the Oregon Short Line subsidiary in 1889. In 1903, UP standardized the tracks. Also in 1903 the tracks became part of the San Pedro, Los Angeles, and Salt Lake RR and was the Salt Lake route of this transcontinental line. The name was changed to Los Angeles and Salt Lake RR in 1916.

In 1915, the tailings pond had reached 20 feet and needed to be expanded to the north. After lengthy negotiations with the Los Angeles and Salt Lake Railroad, the railroad gave its consent to relocate their tracks to the north so that the tailings pond could be doubled in size. The original size was 3000 acres. The realignment of the railroad occurred in 1918 and expansion of the tailings pond was completed in 1919. There were two stations which were affected by the realignment: Riter and Garfield. (See also Riter). The new tailings pond expansion required relocating the Garfield station which was located on the westernmost extent of the two railroad segments that were realigned. A new station was built. The original trackbed angled WSW through the center of the pre-1997 tailings pond. Although the tracks have been long removed, the bed of these tracks serve as a road base for the road adjacent to the Smelter Return Canal. The realigned tracks (1918 - 1997) were just to the north of pre-1997 tailings pond

The tracks were again realigned in 1996-8 when the tailings pond was expanded again. A portion of the 1918-1997 tracks and railbed still exists through the Garfield wetlands and serves as a dam preventing water from flowing via surface routes from south to north. The new tracks, now owned by Union Pacific, were constructed on a new railbed constructed of slag from the historic slag piles left by earlier smelter operations. There are double tracks through this area now and a rail yard operation near SH 202 as well. A new overpass for SH 202 was built at the same time.

The second grade near the tailings pond is the Saltair Line built by the Salt Lake and Los Angeles Railway in 1892. The railway changed its name to the Salt Lake, Garfield and Western Railroad in 1916. This railroad was first built to service the new Saltair Resort which was completed in 1893. The railroad also constructed a branch from Saltair to the south to service the Inland Salt Crystal Co. The trains also went down the 4000 ft. jetty to the pavilion. In 1923, the line was extended from Saltair to Garfield. The line specialized in passenger service and salt. It did not service the smelter. The Garfield extension was not used much after 1932. During the 1950's, the salt business was the only customer. By 1976, the tracks went only as far as the Morton Salt Plant. Today, the tracks extend westward only to 7200 W. Its main business is coal delivery to the Gadsby UP&L power plant. The original grade was not relocated in either the 1918 or 1997 tailings pond expansion. It roughly follows I-80 to Saltair.

The third grade was constructed in 1903 by the Western Pacific RR, roughly paralleling the San Pedro, Los Angeles and Salt Lake RR through the Magna area, but the Western Pacific went to San Francisco rather than Los Angeles. This line was completed in 1910. The Western Pacific grade was also relocated along with the adjacent Los Angeles and Salt Lake Railroad when the tailings pond was expanded in 1918. UP gained control of the Western Pacific in 1982. The double trackage through the area were both moved to the north to accommodate the new tailings pond expansion project in 1997.

A minor relocation of a short stretch of the tracks of the Bingham and Garfield Railroad was also required in the tailings pond expansion of 1918.

CHEVRON FERTILIZER PLANT (GARFIELD PLANT)(pond and plant site partially buried by tailings) (facility #77.01)

The Chevron phosphate fertilizer plant was created as a joint venture between Stauffer Chemical Company, American Smelting and Refining Company, and Kennecott Copper Corporation. The project began in 1952 with partners incorporating under the name of Western Phosphates, Inc. Kennecott supplied the land (749 acres), which was deeded to Western Phosphates; ASARCO supplied the sulfuric acid; and Stauffer was designated as plant operator.

The property is located immediately northwest of the former Magna Tailings Pond. Ownership of the property was transferred to Stauffer in 1966 when Stauffer purchased the holdings from Kennecott. Chevron Chemical company acquired the facility from Stauffer in February 1981. Chevron operated the facility from 1981 to 1986 at which time the phosphate fertilizer production operations were terminated. Prior to acquisition of the property by Kennecott in August, 1994, Chevron leased the property to FCI Agri-chem, formerly called Four Court, Inc. The firm intermittently mined and sold the phosphogypsum stack tailing raw material as a soil additive. Kennecott bought out FCI's lease at the time Kennecoutt bought the land from Chevron. Only a small portion of the 385 acre gypsum tailings stack was mined by FCI.

Beginning in 1952, raw materials consisting of phosphate rock concentrate, sulfuric acid and anhydrous ammonia were imported to the site to produce phosphoric acid and dry phosphate fertilizers. Phosphate rock containing calcium phosphate was dissolved in sulfuric acid to form phosphoric acid and gypsum (calcium sulfate). The gypsum was filtered from the phosphoric acid and slurried to the gypsum tailings impoundment (phosphogypsum stack) and the phosphoric acid was concentrated and sold. Original plans included recovery of uranium and vanadium concentrates as a by-product. Original production rates of phosphates were projected at 90,000 tons per year [DN 2-15-53]. The original cost of the plant was about $5M. A later article indicated that actual production varied between 10,000 tons to 70,000 tons [SLT, 7-8-56] Byproducts included about 300,000 tons/year of gypsum.

Because of the "unfirm surface of the ground" construction of the plant required workers to build a haul road from the ASARCO slag pile so that thousands of yards of slag could be used for fill. The slag was then covered with sand "to stabilize it" [SLT, 5-17-53].

At the time production ceased in 1986, phosphoric acid and dry phosphate were being produced at rates of 150 tons per day and 200 tons per day, respectively. Since 1986, a portion of the gypsum from the gypsum stack was mined, processed for sale, and sold as a soil additive for off-site applications. From 1987 - 1994, Four Court Inc pelletized the phosphogypsum tailings material with potassium chloride, potassium sulfate and molasses and sold the material as a soil additive. The footprint of the phosphogypsum stack covers about 385 acres. It is believed to contain approximately 6 million cubic yards of material. The plant was dismantled in June - Oct 1995. The non recycleable materials were disposed of on the phosphogypsum stack. Only the Administration building remains.

Environmental investigations prior to the sale of the property to Kennecott identified the following issues:

(1) Groundwater in the shallow aquifer may have been affected by gypsum stack and plant processes resulting in slightly reduced pH and increased phosphate and fluoride concentrations.

(2) Process plant soils show some impacts including: total petroleum hydrocarbons at concentrations up to 6,400 mg/kg (Utah reference concentration is 500 mg/kg); naphthalene at 28.4 mg/kg (Utah reference concentration is 10 mg/kg); radium - 226 at 16.9 pCi/g (Utah standard 10 pCi/g).

(3) Capacitors and transformers that potentially contained polychlorinated biphenyls.

(4) Asbestos containing materials were identified on site.

(5) Gypsum stack materials were found to contain silicon, phosphate, and fluoride and radionuclides including radium-226 have been detected (above Utah reference level), and radon flux is in excess of background.

(6) Process water settling basins and ditches where radium-226 was detected.

(7) An unpermitted landfill area where 13,800 cubic yards of solid waste was found (no hazardous substances were detected).

(8) In addition to the wastes listed above, a source indicates that several tons of unsold fertilizer were buried on site still in bags. This fertilizer was tainted with a herbicide that killed potatoes when applied to fields. The product was recalled and buried on site. This has not been confirmed yet. [Dames and Moore, COE draft Environmental Impact Study for 404 permit]

Kennecott [1996] reports correspondence indicating that Stauffers' Pasadena facility produced some fertilizer contaminated with the herbicide Tordon. Old-time employees told Kennecott that 100 tons of the fertilizer was buried by digging large trenches placing the bags of fertilizers in the trenches and covering it with 2 feet of soil. Investigations in 1993 and 1995 failed to find the Tordon.

Kennecott agreed to clean up the PCBs, asbestos, soils contaminated with petroleum hydrocarbons, soils contaminated with herbicide, containerized wastes, and materials in the solid waste landfill. [Dames and Moore, 1994]. Action on the gypsum waste will depend on the leachability of associated radionuclides.

This whole area will be buried in the process of expansion of Kennecott's tailings pond.

Kennecott has determined that several of the trace metals and radionuclides will migrate from the gypstack in the presence of tailings water after burial. Shepherd Miller [1995] reported that several constituents would leach rapidly as tailings water interacted with acidic waters in the gypstack. Increases would be expected in SO_4, F, SiO_2, As, Cd, Cu, Fe, Pb, and Zn. The resultant waters will end up in the toe drain of the new tailings pond, and from then (except in emergencies) be recycled for industrial uses. A mass balance calculation indicated that, with the possible exception of Cd, the resultant waters (tailings water plus leachate from the gypstack) will not violate CWA standards if discharged into Lee Creek. [SMI, 1995b]. The Army Corp of Engineers Permit requires annual monitoring of nearby wells for radionuclides. Some of the administration buildings at the plant were not buried and are still in use by Kennecott contractors. This site has been closed out by the North End ROD of Sept 2002.

MORTON SALT PONDS (ponds buried by tailings) (facility #77.02)

The former Morton Salt Plant and Ponds is located directly north of Kennecott's Magna Tailings Pond between the pond and the Interstate Highway 80. Operations began during the late 1800s. The property was originally owned by Royal Crystal Salt Company and was purchased by Morton Salt in the mid 1930s. The original processing plant was destroyed by fire in the late 1920s and rebuilt in 1929. In 1991, the plant consisted of 1650 acres, most of which are shallow evaporation cells, and a processing plant which washed, dried, and processed the product. In addition to the plant acreage, the property contained 1,500 acres of non-operational undeveloped land north of I - 80 running east-west adjacent to the freeway. The property was sold to Kennecott in 1992.

To produce salt, water was pumped from the Great Salt Lake into a series of evaporation cells. Water was evaporated and the concentrate was pumped to crystallizer ponds for salt crystallization. After crystallization, the remaining fluid, called bittern, was discharged to the Great Salt Lake. Salt crystals were scraped from the pond floor, and placed in a storage pile near the processing plant. Salt was washed, dewatered, dried, packaged, and shipped.

In addition to gathering in salt which had precipitated along the shore (the most common method), some early pioneers produced salt as early as 1847 by boiling the Lake water. The first salt boiler appears to have been erected near Black Rock. The only refining in early days was removal of dirt (Miller, 1947). The Carrington lake crossing in 1848 noted salt boilers along the southern shore of the Lake. [Morgan, 1947].

Development of solar evaporation ponds began in the 1870s. Dikes were built across the entrance to small coves. Dams were opened to allow entrance of salt water to the ponds or winds blew the waters over the dike. This method was unpredictable. Dikes had to be reinforced with planking to prevent erosion by waves. By the 1880's serious businessmen had installed steam pumps to obtain salt water. Fractional crystallization was introduced by 1888 to remove bitter impurities. A series of ponds were constructed using terraces to allow the water to flow from one pond to the next. The first pond removed suspended material. The next pond removed $CaSO_4$ and $CaCO_3$. The next pond removed the NaCl. The remainder called the bittern was discharged back to the lake. This process was used April - September producing 1 - 6" of salt on the floor of the pond. At the end of the season, the salt was harvested first by loosening the salt with a plow then shoveling the salt into large wheelbarrows. Refining did not begin until the late 1880's.

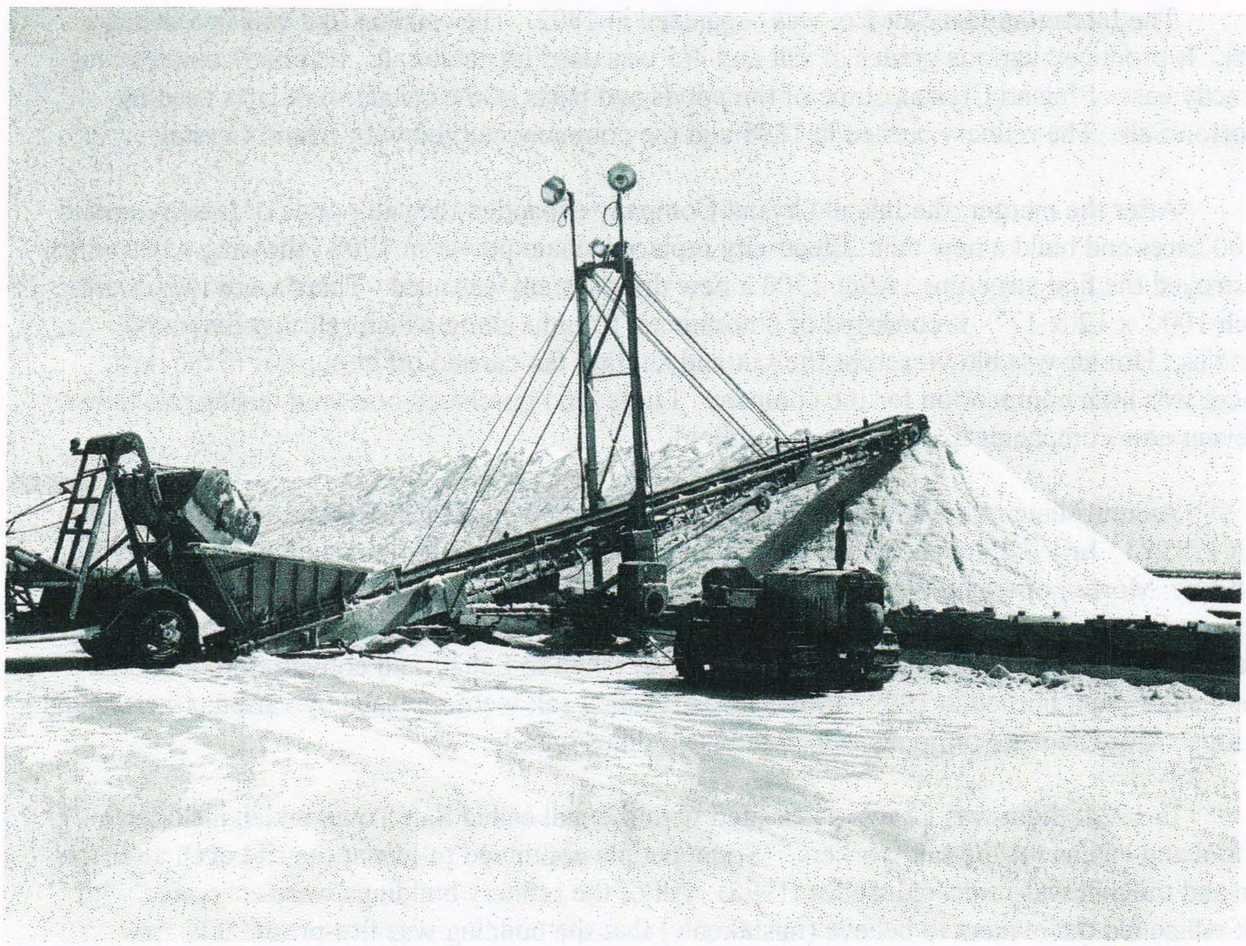

Figure 46: Harvesting salt from evaporation ponds.

The Inland Salt Company, probably owned indirectly by the LDS Church, was organized in 1887 and was the predecessor of the Intermountain Salt Company, Inland Crystal Salt Company, Royal Crystal Salt Company, and Morton Salt Company's Utah Branch. The Inland Salt Company eventually had 900 acres of ponds and a mill. The mill crushed and sacked the salt. Later a rotary drier was installed. Mill capacity was 50 tons per day, later increased to 100 tons per day. Montana silver mills were the largest customers. Production was 40,000 tons/yr.

The Inland Salt Co. was sold to Kansas City buyers in 1891 and renamed Inland Crystal Salt Co [money from the sale was used to build Saltair Resort, Saltair Railway, and Intermountain Salt Co.]. Inland Crystal installed one of the world's largest rotary kiln driers (42x 9 x 5 ft diameter). A suction fan drew off dust containing $CaSO_4$, $MgSO_4$ and Na_2SO_4. Production reached a high of 180,000 tons/year in 1892. Silver mining crashed in 1893 and production dropped to 42,000 tons/year.

The Intermountain Salt Co. was organized in 1892. The refining mill was in Salt Lake City. It produced various grades of salt and 4/5 was used for table salt. Its pond complex was directly east of Inland Crystal; some of the ponds and parts of the canals were later used by Morton Salt. The refinery burned in 1898 and the company merged with Inland Crystal.

After the merger, the Inland Crystal Company expanded the salt ponds of Intermountain 1100 acres and build a new mill. Electricity replaced steam power in 1908 following a fire which destroyed the first structure. After 1908 a new drier system was used. There were two driers, each 1000' x 12' x 17". It consisted of 6 horizontal troughs along which salt was drawn by paddles. Hot air was blown across the salt and another fan carried off impurities in the dust. There was little competition for the company. Large land purchases occurred during this time to prevent new companies from getting a foothold.

A controlling interest in the Inland Crystal Co was bought from the church by Morton Salt in 1923. In 1927, it was made a wholly owned subsidiary under the name of Royal Crystal Salt Co. Morton operated two salt plants next to the Great Salt Lake; one in Burmeister, the other at Saltair. In 1933, the works at Burmester were dismantled and taken to Saltair. The oil burning drier was moved. The coke drier was also taken to Saltair and converted to a cooler. The Saltair plant burned in 1949. Plows for harvesting salt were replaced by various tractors and scoops. More acreage of ponds were added and dikes raised.

In 1924, there was a town associated with the mill called Salt Town which included a school and cabins for the salt workers. (Some people continued to live at the site even after the fire and the mill was relocated, Jones, 1995). All of the refinery buildings were encrusted with salt which led the owners to believe (mistakenly) that the building was fire-proof. The new refinery building burned in 1927, but the town was spared.

After the original Inland mill burned in 1926, the site was changed from the west side of the ponds to the east side about 3 miles away. The process included a rotary kiln heated to 300 decrees by an oil burner. The salt was then cooled in an older kiln drier from Burmester. New sacking and packaging equipment was installed. The plant rebuilt after the 1949 fire had a 100,000 tons/season capacity and had 68,608 ft2 of floor space. The ground floor housed the loading dock, block press, warehouse, kiln driers, and cooler. The packaging and bagging facility and the printing shop were located on the second floor. The upper floors had the crushers, screens, and bins for sizing the salt. In 1965, a new addition on the south side of the building for more warehouse space became necessary. A salt washing machine was also installed to increase the purity of the salt. Another 300 acres of ponds were constructed in 1969.

Plant processing began with a washing and drying step in which the salt was washed in a special classifier and discharged into a centrifuge where it was dewatered. The salt was conveyed to a storage silo. From the storage silo, the salt was conveyed to the mill building for screening and processing followed by sorting by size, loading into trucks or railcars and shipped off-site.

An environmental investigation identified the following issues associated with the Salt Ponds:

(1) Asbestos containing material were identified on site.

(2) Miscellaneous laboratory chemicals and a solvent were identified on site in various documents.

(3) Solvents have been used on site.

(4) PCB containing transformers have been identified on site

(5) A small spill of PCB oil occurred on June 27, 1990 due to an overload on a transformer. Kennecott reports that the PCB spill occurred on the third floor of the mill. Aptus cleaned up the spill on June 29, 1990.

(6) An underground storage tank was abandoned in place prior to UST regulation - releases unknown. Kennecott reports that the this tank, reported closed in place by Morton was found in 1995 to be severely corroded and surrounding soils were contaminated with petroleum. The tank was 12 feet long, 4 feet in diameter and buried 3 feet under. The soils were remediated by landfarming under the supervision of the UDEQ UST program.

(7) All fuel was stored in above ground storage tanks located in a concrete containment area

(8) An unpermitted landfill exists on site. [Dames and Moore, 1994]

The 10 acre landfill existed to the east of the former main plant and south of the railroad loading area. The landfill is not permitted and has been in operation for 40 years. Morton reported that the landfill contained only waste salt, packaging material, and construction debris. A Kennecott study found the presence of an oily black material which was water soluble. Kennecott suspected it was decomposing sewage sludge.

In addition to the above problems, salt ponds sometimes concentrate As and Se at the bottom of the ponds. It is unknown whether this is a problem at this particular facility. Kennecott reports finding a black muck under the crystallizer ponds which was perhaps decomposing organic materials associated with the salt.

Kennecott agreed to remove the following wastes: PCB-containing materials, asbestos-containing wastes, containerized waste; and materials in the landfill. Kennecott [1996] reports that the processing plant was demolished in 1993 and the salt evaporator ponds and crystallizer ponds were buried under tailings beginning in late 1997. The contents of the former landfill were moved to the center of the new tailings pond footprint in 1996. Residues of salt remaining in the ponds have begun to dissolve entering the canals at the toe of the new tailings pond dikes. This has been partially blamed for exceedances of Kennecott's Water Quality Permit during 1998. The site was closed out by the North End ROD of Sept 2002.

The demolition of the Morton Salt plant received some attention by the news media. An initial attempt at demolition caused the building to lean but did not fall. Because the plant was near I-80, highway travelers were curious. At the time, Kennecott told the media that they were demolishing the old plant because it was structurally unsafe. (The fact that the building was hanging together despite all the efforts to demolish it was testimony that the building was rather sturdy! Kennecott was just not ready to tell the public about their plans to expand their tailings pond in that direction.) The ponds were later buried by tailings, but salt leaching out of the former salt evaporation ponds increased the salinity of the tailings slurry water. This was short-lived. The plant site was not buried.

TAILINGS SLURRY PIPELINE (facility #108)

From 1987 to 1996, tailings from the flotation circuit at Copperton flowed by gravity through a 48 inch pipeline to the Magna Tailings Pond. The pipeline was constructed of heavy wall concrete pipe, with bridge crossings and drop box entries being rubberlined steel pipe. The pipeline has a total length of 70,000 feet and is installed on a continuous 0.8% downslope with 33 drop boxes. The total drop in the pipeline system is approximately 1,200 feet. Pipeline flow level measurement at three locations, with data cable connection to the concentrator central control room, is provided. The normal operating condition for the pipeline is transporting approximately 41,000 gpm of tailings at 28% solids. The pipeline capacity ranges from 8,000 to 60,000 gpm of tailings [BPMA, 1988]. Tailings production at the Copperton Concentrator is about 122,000 tons per day. [EIS, 1995] Under normal conditions, the pipeline carried 41,000 gpm of tailings at 28% solids [Kennecott, 1997].

There have been four ruptures of the older tailings slurry pipeline. Two of these ruptures were due to corrosion, both near the terminus of the pipeline at Magna where the pipeline drops in elevation through a series of ells. Corrosion (rather than abrasion) aided by bacteria was blamed for these ruptures. To solve this problem, Kennecott is in the process of lining the entire pipeline with rubber (Kennecott, 1993). Kennecott [1997] reports that the tailings were allowed to dry and then were excavated and placed into the Magna Tailings Impoundment.

Another rupture occurred in 1995 at the trestle crossing Barney's Wash, close to the Gold Mine. The break occurred sometime during the night and was discovered by security the next morning. Before the line was taken off-line, an unknown volume of tailings slurry had escaped. Fortunately, the tailings proceeded down the wash only to the Barneys Canyon Gold Mine access road where the road embankment over the wash impounded the tailings. At the time of this incident, Kennecott planned to let the tailings dry out and excavate them from the wash and the new impoundment. The ERNS spill report indicated that 500,000 gallons of slurry was released. Kennecott [1997] reports that this spill was cleaned up by October 1995. Kennecott attributes these failures to increased wear caused by a coarser grind of tailings. They decided to replace this line with a new line with a better design. The path of the new slurry line follows the path of the old one. The new slurry line was completed in 1996. The tailings line was constructed on a trench that roughly follows the old railroad railbed.

Another spill of tailings occurred in July 1993 when a railcar backed into flume supports. Tailings spilled out all over State Hwy 201 resulting in closure of the road for 12 hours while all the tailings were recovered and placed in the tailings pond. According to Kennecott [1997], this spill did not involve the tailings pipeline from Copperton, but the pipeline from the Magna Concentrator. [The Magna Concentrator tailings pipeline has no separate facility listing.]

The new pipeline, located 50 feet west of the older pipeline, was commissioned in October, 1996. It is 60 inches in diameter constructed of concrete. The older 48" pipeline was left in place to serve as a backup for repairs and to contain any leaks from the new 60" pipeline.

The older smaller pipeline was involved in yet another spill at Barneys Wash on Sept 22, 1999. The original report indicated that 100 tons of tailings had escaped out of an air vent in the older 48" pipeline. The final removal report indicated that 1730 cubic yards were removed from the wash and 11,000 gallons pumped from the low spot just upgradient from the Barneys Canyon access road. Two improvements were made: the air vent was extended to vent four feet above the tailings line to prevent the surge or bubbling of tailings out the vent. Also Kennecott constructed a small retention basin immediately downgradient of the tailings line. The new detention basin has a capacity of about 300 cubic yards.

Originally the 1999 spill was blamed on operator error (too high a flow for the smaller pipeline). Later it was learned that there was a deposit of gypsum scale inside the pipe that was so thick the capacity of the pipe had been reduced by at least 50%, maybe more. The Kennecott environmental staff had been conducting an experiment regarding how much acid leachate could be neutralized by the tailings. The pipeline was being used as a 13 mile long treatment plant. As it turned out, the acids were already neutralized in the first half mile of the pipeline. Scale of calcium sulfate precipitated out in the tailings pipeline forming a scale deposit. When the acid additions ceased, the scale was scoured out of the line by the tailings. The scale did not need cleaning.

An earlier experiment conducted by Dames and Moore in the mid-80's had determined that scaling did not begin until concentrations exceeded 5000 - 6000 mg/L. When the acid leachate solutions were blended with cleaner water, scaling did not recur.

Another spill into Barney's Wash occurred on October 18, 2000 (6.5 cubic yards), again out of the air vent pipe. This incident was blamed on a maintenance crew adding extra tailings to the line. A similar accident occurred on January 19, 2001. Again, tailings spilled out the air vent. This accident spilled about 2900 cubic yards of tailings down Barney's Wash. The spill went 3000 feet down the wash. This happened during a test of the 48 inch pipeline. Kennecott planned to use it exclusively during routine maintenance of the 54" line in the summer of 2001. A routine maintenance schedule has been adopted for removal of scale deposits in the Copperton end of the slurry line. While one pipeline is being cleaned, the other one is used for operations.

USE OF TAILINGS FOR ROAD CONSTRUCTION AND PIERS (facility #142)

Enos Wall agreed to furnish waste material from dumps on his property to the local road superintendent for road construction [Bailey, 1988; Arrington, 1963]. Also in a cooperative venture with the State of Utah in 1972, Kennecott installed a tailings classification and stockpile facility east of the Magna plant to promote the use of tailings material by highway contractors. Tailings were used in the construction of the roadbeds in the region, and for the Interstate Highway I-215 beltloop around Salt Lake City. Tailings have also been experimentally used in the control of beach erosion and in the construction of piers out into the Great Salt Lake [SAIC, 1991]

CHAPTER 16
SMELTER NEAR MAGNA

Partly as a result of the smoke farmers lawsuit, smelting companies evaluated sites for smelters that were remote from cities and farm land. ASARCO built a smelter near the Great Salt Lake adjacent to lands which Boston Consolidated and Utah Copper were planning to build their ore mills. A continual supply of concentrate was guaranteed to the new smelter when both companies received favorable smelting contracts. Eventually, ASARCO sold the smelter to Kennecott in 1959. Kennecott built a new smelter using the Noranda Process in 1978. The new smelter was adjacent to the older one. The old one was retired. Yet another new smelter was erected in 1995 on the grounds of the original 1905 smelter and the older Noranda smelter was retired and demolished. After 1916, each version of the smelter had associated gas recovery units which produced a sulfuric acid byproduct. Smelting operations continue using the new 1995 smelter. Concentrates arrive at the smelter via a concentrate slurry pipeline from Copperton. Anode plates are delivered to the refinery for further purification, and the sulfuric acid is recovered from the gases produced in the smelting process, stored and shipped in railcars as a byproduct to customers. All three different smelters at the site each had its own infrastructure, some of which could be used again in later modifications. For clarity, the original ASARCO smelter is called the "reverberatory smelter". The smelter built by Kennecott in 1978 and used until 1995 is called the "Noranda Smelter" and the post 1995 smelter is generally referred to as the "new smelter" or the Outokumpu Smelter. The acid plants which recovered the sulfur gases in the smelting process and produced sulfuric acid were numbered sequentially, with Acid Plant #1 being the oldest at the site (demolished long ago). This chapter describes the processes used at the three smelters, the various infrastructure associated with the smelter, and the sulfuric acid production and storage facilities.

AMERICAN SMELTING AND REFINING CO SMELTER (GARFIELD SMELTER; KENNECOTT UTAH COPPER SMELTER) (facility #96)

Construction of the world's largest smelter began in 1905 at the mouth of Kessler Canyon, a short distance from the Great Salt Lake. The first smelter was built by ASARCO following the negotiations of a 20 year smelting contract with Utah Copper. ASARCO chose the gentle slope at the mouth of Kessler Canyon, overlooking Black Rock and immediately purchased the property from H. T. Spencer. Many of the settlers were angry at Spencer for giving industry a foothold in the area, although others quickly followed Spencer's lead. The incentives were strong since the struggling farmers and ranchers were offered good prices for their property as well as an opportunity for steady income working in the processing facilities [Jones, 1995]. According to a contemporary newspaper account [DN, 1906], the site was chosen because it was "in a portion of Salt Lake County far removed from the farming districts where the danger of destruction to vegetation by fumes is remote, indeed." Using immigrant labor, the smelter, patterned after the Washoe Reduction Works at Anaconda, Montana, gradually took shape. First, the flues and smokestack were erected, then the sulphide and sampling units. By August 1906, the smelting circuit was sufficiently complete to allow startup. On Labor Day, the first furnace was fired, but when the No. 1 reverberatory failed, operations were suspended until October when a second furnace was started [Bailey, 1988; Arrington, 1963] The smelter grounds were served by 13 miles of railroad tracks. In addition, D&RGW added 16 miles to its Bingham line and San Pedro added 2 miles from its tracks. A 1909 publication of the Bingham Commercial Club reported that the main consignments came from Utah Copper and Boston Consolidated. It had a 3000 ton capacity, employed 1200 men, and used coal and coke from the mines of Utah Fuel Co.

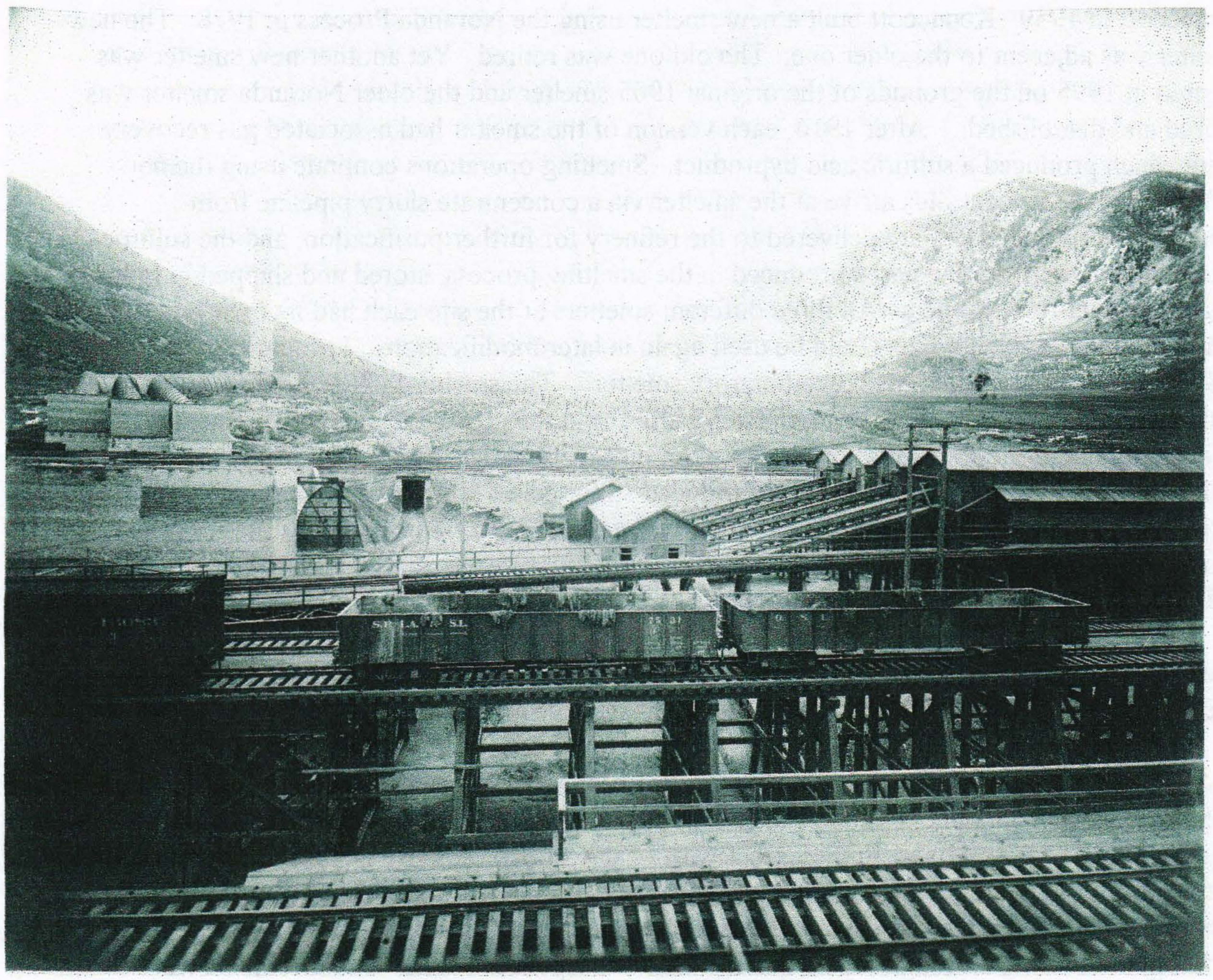

Figure 47: The reverberatory smelter erected by ASARCO in 1905. Note the use of railcars for delivery of concentrates, and the short stack.

The original plant consisted of two reverberatory furnaces, two blast furnaces, six acid-lined converters and eight roasters. The reverberatories were heated by means of hand-fired coal grates. These were replaced in 1911 by oil, which in turn was replaced by powdered coal in 1915. In 1930, natural gas was installed. The smelter was specifically designed as a copper smelting and converting plant, and was equipped to handle 500 tons of concentrates daily. The reported initial cost was $3 million. [Arrington, 1963] Kennecott reports that the original building was 840 feet long, 305 1/2 feet wide and 92 feet high. There were 24 buildings in the complex plus an additional 106 houses for workers. [Kennecott 104e, 1991] The smelter was located on a 160 acre industrial site.

By the 1950s, the smelter had 20 6-hearth roasters and 8 8-hearth roasters with 12 in operation at any one time. The roasters were 19.5 feet in diameter. There were 5 reverb furnaces and 3 were in operation at any one time. The furnaces were 24 feet wide, 120 feet long and 14 feet high. The crucible of the furnaces was made of magnesite with walls of silica. The slag went down a launder to 7 ton slag pots. The matte went into 10 ton ladles which were then taken to the converter furnaces. The converters were large cylindrical furnaces which were rotated. Air and silica flux was added to oxidize the iron and convert it to slag. In a refining furnace, oxygen was added to oxidize the remaining sulfur. Roasters produced calcine; reverbs produce matte. Gasses were treated with a Cottrell treater (which was an electrostatic precipitator) (Kennescope). Smelter gas was collected by water cooled hoods then sent to waste heat boilers where the particulates settled out. Then the gases went to a cyclone, then to an electrostatic precipitator, then to the acid plant. Shot coolers were the first step in treating converter gases (They were air to gas heat exchangers.) Dusts from the shot coolers were recycled. Hoods also covered the conveyors. The facility had 30 baghouses.

As might be expected of a revolutionary plant with new and unsolved metallurgical problems to cope with, many difficulties were encountered during the first few years of operation. One news report suggested that much of the concentrates were finding their way to the surrounding hills via the stack [Arrington, 1963]

Kennecott bought the ASARCO smelter in 1959. The purchase price was $20 million and capacity at the time was 625,000 tons of concentrate annually [Kennescope, 1958]. Since the purchase of the smelter, as of 1963, Kennecott had expended $5 million to modernize the materials handling facilities at the plant [Arrington, 1963]. In 1969, the smelter was modernized once again to treat 2,600 tons of concentrate and precipitate per day [BPMA, 1988]. In general, molten copper matte from the primary smelting furnace was transferred to the converter furnaces where a silica flux and compressed air was added to the molten material. After removing the slag, additional air or oxygen was blown in to oxidize the remaining sulfur and convert copper sulfide to blister copper. The sulfur was removed in the form of SO_2 gas that was delivered to acid plants. The molten copper was further fire refined and cast into large plates called anodes and sent to the refinery. [Kennecott, 1994]

A Kennecott employees magazine (Kennescope) describes slag disposal. From a bay in the end of the furnace, the slag flowed through a launder, then into slag pots of 7 ton capacity. Electric mules pulled a train of 7 slag pots to the slag dump. Kennescope reported that the sight of molten slag stopped many tourists along nearby highways especially at night. Kennescope also reports that the dusts and fumes from the smelter (flue dust and Cottrell dust) were recycled back to the reverb furnaces. The two Cottrell plants at the smelter were described in Kennescope - one plant was for the reverberatory furnaces and the other for the converter furnaces. Smoke and dusts were captured by hoods above the furnaces and blown by fans into the Cottrell treaters. The treater was essentially an electrostatic precipitator. The reverberatory and blast furnaces, converters, roasters and associated facilities of the old smelter were demolished in 1978 [Kennecott, 1996].

In 1978, a major refit was completed which included extensive modification of the process gas handling equipment to capture fugitive emissions, the construction of one 1,215 foot stack to replace the second of two 400 foot units, installation of a continuous converting and smelting unit developed by Noranda Mines Ltd, additional acid plants, and a computerized variable emission control system. According to Kennescope, the emissions mixture consisted of tail gases from the acid plants, fugitive gases from the smelting building, emissions from the molydenum plant along with waste heat from the boilers and coolers. Approximately 2.48 miles of flues were necessary to transport the emissions to the cleaners and stack. Final cost estimates for the overhaul were in excess of $280 million. [SAIC, 1991], The converters are Pierce Smith converters. [BPMA, 1988]. The Noranda process initially consisted of three reactors that produced a high-grade matte and four conventional converters. Oxygen-enriched air was used to increase the smelting rate, lower the fuel ration, and reduce the volume of process gases. At the time of conversion to the new process, the Noranda process used involved only one reaction and two operating converters. [Kennecott, 1994].

Kennecott [1994] described the typical wastes from their smelter as follows:

Waste	Copper (%)	As (ppm)	Pb (ppm)	Cd (ppm)
concentrate	28	1400	2000	10
precipitate	82	100	400	200
flux	1	200	5000	-
flue dust	20	100,000	120,000	2000
Slag	2	400	2000	<10
slag tailings	0.3	300	1500	<100

Although the Noranda Reactor smelting process increased sulfur capture, the slag produced by the new system contained a high percentage of copper. In fact, the slag contained more copper than the ore. To address this problem, a slag mill and flotation concentrator was constructed at the smelter facility. Feed from the slag concentrator is mixed with the regular concentrate and cycled back into the continuous smelting vessels. [SAIC, 1991]

Historically, slag has been disposed of throughout the smelter site, with a main slag pile immediately north of the present smelter complex. Smelter slag (also referred to as reactor slag) was deposited in the Magna Tailings Pond at the rate of 410,000 tons/yr. [SAIC, 1991]

Since 1975, EPA records reveal several small oil spills, one small PCB spill and approximately 30 spills of sulfuric acid and other acidic wastes in the vicinity of the smelter.

Construction of a new smelter facility started in 1993. The new smelter is built just to the southeast of the Noranda smelter. Production of the new smelter is twice the capacity of the Noranda smelter allowing Kennecott to process all of its concentrates rather than shipping them overseas. The atmospheric emissions are reduced greatly over the former facility.

Prior to the construction of the new smelter, Kennecott conducted an investigation about soil contamination in the proposed footprint. Eighteen bore holes were drilled down to groundwater (70 ft). Contamination was found only as deep as the first five feet. Since the basement/foundation of the smelter required excavations up to 35 feet deep, Kennecott believes that the contaminated soil was removed in the process.

Kennecott has signed an AOC stating that spilled concentrates will be recycled, and other contaminated soils will be disposed in the Arthur Stepback Repository.

Under the terms of the AOC, several of the historic smelter structures were demolished. Equipment was sold. These buildings include: [Kennecott, 1996]

1. The Hot Metals Building, where the copper smelting took place, was constructed in 1977. The major pieces of equipment associated with this building are three Noranda reactors, four Pierce-Smith type converters, two pelletizers, and the anode casting system. Contaminants associated with this building could be heavy metals related with concentrate and fugitive dusts. The anode casting portion of this building was used as storage for a time before the building was demolished in the Fall of 1999.

2. The Material Handling Area dried and conveyed copper concentrates from the storage area to the Noranda reactors in the Hot Metals building. Material Handling is made up of several thousand feet of conveyors and belt feeders ranging from 24 to 48 inches wide. In addition, two stainless steel rotary dryers, that were used for drying the concentrates, are present. Contaminants associated with this building and structures were heavy metals related with concentrate.

3. The Smelter Powerhouse was constructed in the early 1900's but has been through numerous modifications since that time. Operating at full capacity it could supply the 15 megawatts of electricity needed to power the Noranda Smelter. The primary equipment in the powerhouse is three generators, two electric turbines, four steam turbines, and five screw

Figure 48: Explosives are used to demolish the Noranda Smelter. Time sequence #1

Figure 49: Noranda Smelter demolition, time sequence #2

Figure 50: Back side of smelter, explosives used to demolish back addition of Noranda Smelter. Time sequence #1.

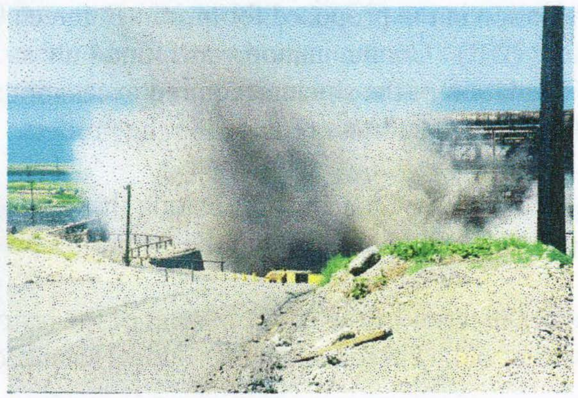

Figure 51: The bottom was blasted out, but the building was still standing - the roof was holding it up. Time sequence #2.

compressors. This structure is not expected to be contaminated with metals other than fugitive dusts.

4. The Gas Handling Area collected the fugitive gases from the Hot Metals building and conveyed them to the acid plant and subsequently to the stack. The large fans in Gas Handling are the primary pieces of usable equipment. Some gas handling flues are known to be contaminated with dust. [see also Acid Plant #8].

Accessible asbestos was removed from the building in June 1996. Miscellaneous demolition on the material handling system was completed in July, 1996. All material handling system facilities had been demolished by Dec., 1997. Chemical storage tanks were removed in July 1996. Contaminated soils north of the building were removed in Nov 1996. The smelter roundhouse was demolished in June, 1997. Demolition of the smelter powerhouse was completed in Dec. 1997. The flue ducts leading from the smelter were sent to USPCI/Laidlaw Grassy Mountain by Dec. 1997. Hydroblasting of the smelter precipitator was completed in Feb.

1998. Demolition of the Hot Metals building was completed in November 1999. The converter furnaces and the blowers were sold. The scrap steel was decontaminated and sold to Atlas Steel, a scrap metals dealer.

When the Noranda smelter closed, the furnaces were left with copper in them. As part of the demolition of the building, the furnaces were cut up and the copper was retrieved. Investigators found several very large slabs of copper underneath the furnaces weighing 1,000,000 pounds of 60 - 80% copper. It is suspected that some batches of copper in the furnaces were considered off-spec by the smelter staff and the copper was simply dumped in a hole dug underneath the furnaces. One of the slabs was 2 feet thick and 10 feet long. The slabs were cut up into manageable pieces and sent off site to another smelter for recycling.

Ground water contamination originating at or near the smelter facility has been identified and an RI/FS completed. There are several arsenic plumes and several selenium and sulfate plumes in the smelter area. The footprints of the historic smelter were addressed as a part of the North End ROD of Sept 2002.

Built on the site of the original reverberatory smelter, the new smelter was completed in 1995, and the older Noranda Smelter was immediately retired. The new smelter process treats copper concentrates from the Copperton Concentrator and the former North Concentrator. The process starts with drying the copper concentrate and injecting it and oxygen into a modern flash smelting furnace. The furnace was designed and supplied by Outokumpu, a Finnish technology company. The copper concentrate - containing 28 percent copper and similar quantities of sulfur and iron - burns, providing most of the heat to sustain the furnace temperature. Most of the iron and about 67% of the sulfur are oxidized. The iron forms a slag which is skimmed from the furnace, cooled and treated in a slag concentrator at the smelter to recover additional copper. The sulfur dioxide gas is cooled in a boiler to produce steam and then sent to a double contact sulfuric acid plant designed by Monsanto. In the acid plant, the sulfur dioxide is converted to high purity sulfuric acid (1.0 million tons) which is sold and transported to customers in tank cars.[Kennecott, 1997]

Copper produced in the smelting step is a molten copper sulfide called matte which contains 70% copper. The molten matte is tapped from the furnace and quenched in a water spray to form a sand-like solid. This granulated matte is then dried and ground to a fine powder so it can be injected into a second flash furnace. This step was patented by Kennecott. According to Kennecott [1997], the combination of matte granulation and flash converting, developed by Kennecott and the Finnish company, Outokumpu, represents a major improvement in smelting technology and environmental efficiency because the molten metal transfer and the resulting gas emissions are eliminated. The powdered matte burns to provide the heat for the process, liberating sulfur dioxide and producing molten copper metal which is 98.6% pure. The sulfur dioxide gas is cooled and sent to the double contact sulfuric acid plant.

The copper is transferred to one of two refining furnaces where it is upgraded to 99.5%

copper. The copper is then cast into 700 pound plates called anodes, which are transported by rail to the refinery.

The smelter recovers heat from the furnaces and the sulfuric acid plant as steam which is used to co-generate electric power. About 85% percent of the smelter's electric power requirement is produced by the heat recovery. [Kennecott, 1997].

The new smelter has six separate water systems: smelter process waters, acid plant blowdown, hydrometallurgical plant effluent, sewage, stormwater from the facility, and stormwater not in industrial areas. The RCRA facilities ID is UTD000826446.

As is the case with many new processes, the new smelter had start up problems including several spectacular accidents. In June, 1995, a "foam over" accident occurred spilling copper on the smelter floor. One worker was burned as he tried to escape. In September, 1995, molten matte ate through the brick lining in the flash converter. When the molten material then ate into the cooling water jacket, an explosion occurred damaging the converter. Then the molten material hit the floor and began to spread out toward a fork lift and gas tank. These exploded causing a fire. The fire damage was evident even on the outside of the building. The rapidly rising temperatures in the cooling water was noticed by the control room staff and staff on the floor were evacuated just prior to the explosion. There were no injuries. The smelter was taken off line and Kennecott went into the concentrate selling business. Two days after the smelter came back on line in June 1997, another spill occurred. About 750 tons of molten copper were dumped onto the smelter floor. Because a new containment system had been installed during the shut down, there were no explosions from gas tanks and rubber tires. Another accident occurred in January 1999 when a flash converter furnace sprung a leak. Again advanced warning allowed workers to evacuate. The basin underneath the converter filled up with molten copper and then spilled out onto the concrete floor of the smelter. Copper also went into the basement and melted the insulation off the wiring. The repairs took about a month. Later in 1999, one of the heat exchangers on the acid plant associated with the smelter failed and untreated black smoke poured out. A temporary fix with flexible rubber hosing also failed when the rubber melted. As a temporary fix, the heat exchanger was sealed inside a temporary shed built around it. The heat exchanger was replaced in 2000 during a regular maintenance period.

SLAG CRUSHING FACILITY (facility #96.01)

Because the slag produced by the former Noranda smelter contained more copper than the ore, Kennecott recycled the slag produced by that smelter back into the concentrating circuit. In order to do this the hot slag was dumped in an area near the smelter where it was crushed prior to shipment back to the concentrator.

Kennescope described this facility as a slag concentrator. When originally opened, the system was installed adjacent to the smelter complex and had complete crushing, grinding, and flotation circuits. After 24 hours of water cooling, the slag was dumped and then crushed using a jaw crusher, followed by a standard cone gyratory crusher, then a shorthead cone crusher. The crushed slag was then fed via conveyer belt to two outdoor ball mills, then to primary roughing flotation cells (the tailings from the roughing cells were sent back to the balls mills for further crushing) and then to secondary flotation. The slag concentrate was added into the regular concentrate going to the smelter. The tailings from the concentrator were sent to a "new" tailings pond just west of the facility known locally as Black Rock Springs. The capacity was cited as 2930 tons/day. Most of the slag concentrator has been retired except for the crushing operations.

Kennecott [1997] reports that the Slag crushing facility was constructed in 1977 as part of the slag concentrator. Originally the slag was cooled, crushed, grinded, flotated, and filtered to produce a slag concentrate that was fed to the smelter. Before 1984, the tailings were deposited in a slag tailings impoundment located immediately west of the concentrator. Between 1984 and 1986 during the shutdown of Kennecott operations the tailings pond was reclaimed. Operations resumed in 1987. Since then, the tailings have been sent to the Magna Tailings impoundment.

The current process involves cooling of the slag using water for 24 to 30 hours under a 300 gpm overhead spray. The slag is then dumped cold from the ladles and reduced with a crane and drop ball. The slag is then transferred to the loading/grizzly section where it enters the crushing circuit. The slag is ground from 10" to 6" or less where it enters the ball mill circuit. From crushing and milling, it is concentrated, filtered, and returned to the smelter for processing.

The process of slag crushing produces lots of fugitive dusts and the facility was cited with a Notice of Violation by UDEQ, Air Quality, in 1993. Use of water sprayers was required to reduce the dusts created by the process. EPA has received complaints about the dusts created by this facility, and frequent failures of the water sprayers. The state continues to monitor this situation.

Recently in an effort to increase production, slag pots are dumped before they were fully cooled. When the front end loaders start to break up the slag, hot molten slag spills out. When the hot slag encounters water, there is an explosion. On several occasions, the hot slag caught the tires of the equipment on fire. If the fire is discovered in time, the workers drive the equipment into a nearby pond to douse the tire fire. Workers report that sometimes because of the dustiness of the operation, the tire fires are not discovered and a nasty accident with injuries occurs.

In the past, during operation interruptions, some of the tailings and/or concentrate would be washed out to what was known as Last Chance Pond. The pond was a sediment basin for solid separation. (See Last Chance Pond #74). When this ponds is cleaned out, the materials are returned to the slag mill for recycling.

The slag mill was modernized in 1995 with the new smelter to improve the cooling, crushing, dust control and concentrating [Kennecott, 1997].

MODERNIZED SMELTER FOOTPRINT (facility #96.02)

In 1991, EPA urged Kennecott to conduct a study in the area where Kennecott planned to build its new modernized smelter. The new smelter facility was built just to the east of the present facility and was in the general location of the original reverberatory smelter. Removal of wastes and/or proper handling of the wastes prior to construction of the new smelter meant that the government would not have to interrupt operations later to investigate any potential problems.

Kennecott conducted two investigations. The first occurred in the summer of 1992 during the process of excavation of soils for the basement and foundations of the new smelter. Soil samples contained up to 6,700 ppm arsenic and up to 15,000 ppm lead. Some of the soils had economically valuable concentrations of copper, silver, and gold. Based on these findings, Kennecott classified the soils according to their reclamation potential. Three piles were created: (1) reclaim to smelter; (2) reclaim to the Bonneville Crusher; and (3) reclaim to the Mine Leach Dumps. Visual inspection and chemical analysis suggested that some of the soils were spilled concentrate, flue dusts, roaster wastes, and mixing chamber soils. A plan was made for disposal of construction materials such as bricks, steel and concrete.

In 1992, a total of 73,240 yards were excavated. Of that total, 32,603 yards were reclaimed, 17,000 yards were sent to the waste rock leach dumps, 1055 yards were sent to USPCI, 837 were landfilled or used for backfill, and 21,750 required further testing. The next year, further testing on the remaining materials took place. Unreclaimed materials were tested by TCLP. Those which passed TCLP were used for backfill or taken to the smelter landfill for use as cover. Those which flunked TCLP were taken to USPCI. After this process 1,510 yards were used on-site, 5685 yards were recycled, 50 yards were sent to USPCI, and 65 yards were landfilled.

After the excavation of materials for the footprint was completed, Kennecott conducted a Remedial Investigation (not with EPA oversight or review). Another round of sampling took place in 1993. Kennecott sent a report to EPA detailing these results in August, 1994. Of the 36 samples collected at the surface of the excavated area, 8 exceeded the arsenic action level for industrial land use (700 ppm derived at Midvale Slag), with a maximum of 2945 ppm arsenic, averaging 455 ppm. The maximum lead was 3003 ppm and averaged 602 ppm. The maximum subsurface arsenic was 41 ppm, averaging 13 ppm. The maximum subsurface lead was 61.4 ppm, averaging 5.3 ppm.

Kennecott decided that no further excavation was needed because the whole area would be capped by concrete or asphalt, thus preventing worker exposure. Construction of the new smelter was completed in 1995. The site is at an elevation of 4350 ft amsl.

EAST YARD SITE (facility #96.03)

The East Yard Site consists of strongly discolored slopes and terraces, located within the smelter complex, immediately south of the Acid Tank Farm. There is also evidence of a historic railroad within the site at the toe of an active railroad terrace. The area of the site covers about 5.5 acres. The East Rail Yard Site is bordered on the north by the Smelter Acid Tank Farm, on the south by an active railroad line, on the west by an outcrop bluff and the east by undisturbed lacustrine slopes. The Site is approximately 210 feet by 1200 feet east to west.

The site consists of three main sections: a moderate slope, level ground and a steep railroad terrace slope. The moderate slop section is located on the north portion of the site and is predominately sparsely vegetated, gravelly sand, with minimal disturbance. The second section is located in the center portion of the site and is a generally level area approximately 100 feet by 1000 feet. This area has evidence of a historic railroad line and also was a footprint of various historical stockpiles consisting of refinery fines and copper concentrate. The stockpiles were removed earlier, but residual material was still visible. The third section is distinguished by a steep, strongly discolored railroad terrace supporting an active rail line. This section is located on the south portion of the site. The slope appeared to be constructed of mine waste rock and showed signs of erosion. [Kennecott, 2003]

Characterization indicated that both samples were elevated in arsenic. The materials there included waste rock, concentrates, and flue dust. Maximum concentrations were 738 ppm As, 13.1 ppm Cd, 1810 ppm Pb and 79.1 ppm Se. The site was included in the North Facilities Soils removal. [Kennecott, 1996]. About 56,500 cubic yards was removed from the area and placed in the Arthur Stepback Repository. The soils on the slopes that bound the site on the south were not removed due to proximity to the active railroad system. This area was capped with a minimum of 18 inches of fill material and then revegetated. (The slope adjacent to and below the rail line was covered with 18" of clay.) The site was closed out by the North End ROD of Sept 2002.

OLD NORANDA SMELTER FOOTPRINT SOILS (facility #96.04)

The Old Smelter Soils site (which includes the #8 acid plant) is the footprint of the buildings and structures that were incorporated in the old Noranda smelter facility. The Noranda Smelter was demolished starting in the summer of 1996, taking three years, with soils characterization following demolition. [Kennecott, 1996]. When a demolition worker fell to his death while working high along the roof line, Kennecott changed their demolition technique to include explosives. The building was taken down in section with four series of blasts. The steel was decontaminated just to the west of the building footprint and recycled by Atlas Steel. After characterization, about 24,332 cubic yards were removed from the footprint area and taken to the Arthur Stepback Repository. Underneath the furnaces were several very large nodules of copper which had probably been off spec copper, or was spilled there. This amounted to about 504,060 pounds of copper. The area formerly occupied by Acid Plant 8 was paved over and is now in use for concentrate storage. The site was closed out by the North End ROD of Sept 2002.

RETURN CANAL (facility #96.05)

The Return Canal Site is actually two canals that were used as the storm water and surface runoff discharge point for the smelter. [Kennecott, 1996]. The canal was located in the southern part of the Garfield Wetlands. The return canal took water process water from the Smelter, nearby wells (such as the Garfield Wells), stormwater from the refinery and smelter and conveyed the water to Pump Station 4 for use in the milling process water circuit. Excess waters overflowed to the Great Salt Lake via a culvert.

The return canal was heavily contaminated apparently with concentrates which had washed down from the smelter, and it was a routine practice to muck out the canal occasionally. The sediments which were dredged up from the canal bottom were piled along the banks of the canal and allowed to drain. This process, over time, contaminated the banks and up to 200 yards on each side of the canal. The sediments were removed from the canal itself, the banks and the nearby soils as a part of the North Facilities Soils removal. About 356,052 tons of contaminated sediments were removed. During excavation of contaminated sediments from the two canals, the narrow berm between the two canals was also excavated, leaving one wider canal than before. (See also 102.01) The site was closed out by the North End ROD of Sept 2002.

SLAG TAILINGS PIPELINE (facility #96.06)

The Slag Tailings Pipeline Corridor Site is the pipeline that transported slag tailings from the smelter to the Tailings Impoundment. The slag tails pipeline has been in service since 1977. The Slag Pipeline (and the adjacent Weak Acid Pipeline) are located on the north side of State Highway 201. They parallel State Highway 201 on the north and the Smelter Return Canal on the South for approximately 7000 feet east to west. The area of the combined pipeline corridors is about 12 acres. The Slag Tailings pipeline is predominately aligned in an earthen berm that is approximately four feet above the natural ground level. Pipe bedding material ranges from well-sorted sand, tailings and slag. Material beneath the bedding material consists of native lacustrine sediments to imported sand. When the corridor was characterized, no contamination above action levels was found. The site was closed out by the North End ROD of 2002. .

RAILROAD YARD SOILS (facility #96.07)

The Railroad Yard Soils Site located behind the smelter is a loading and off-loading, sampling and weighing facility for the concentrate that is being transported off-site. Characterization indicated arsenic in soils with values as high as 10,900 ppm and lead maximums of 14,000 ppm. This part of the site is still active and cleanup will proceed aftger closure. Interim actions include runoff and runon controls and capping the concentrate storage

Section 17 Process Water Tanks
Section 17 Booster Pump MCC
Reverse Osmosis Building and Facilities
Section 21 Potable Water Tanks and Condensate Tank
Power Plant Cooling Tower
Power Plant Cooling Tower Electrical Room
Water Tanks

Smelter Material Handling:

- Conveyer Bag Houses
- Material Handling Substation CP-102
- Reactor Building Main Conveyor Gallery
- Dryer
- Dryer Feed Bins and Belts
- Dryer Scrubber
- Intermediate Storage Bill Building, Coal Flux and Concentrate Belts
- Coal Flux System

Smelter Gas Handling

- Reactor Hot Gas Fan and Cyclone
- Joy Inlet Plenum and Screw Conveyor
- Stack Booster Fans
- Mixing Chamber
- Joy Precipitator and Substation
- Converter Shot Cooler
- Converter Fans
- Feed gas Flue
- Tail Gas Flue

Smelter Miscellaneous

- Roundhouse and MCC
- Row 5 screening plant
- Acid tanks 2 and 4
- Slag Mill Concentrate and Filter Building
- Slag Mill Concentrate thickener
- Flue Dust Storage
- Oxygen and Acetylene Remote Storage
- Section 17 Pumphouse
- Pump House

As of May, 2002, on-going demolition activities were on-going at the following areas at the smelter:

Smelter Materials Handling

- Bunker and Catacombs
- Reverb Mixing Chamber

Smelter Miscellaneous
Weak Acid Lift Station
Slag and Water Pipelines

As of May 2002, the following older structures are still in use by current operations:

Railroad Area
Rail scale house and track
Railroad lunch room
Rail and ties
Smelter Miscellaneous
Main warehouse
Paint Storage Building
Brick Storage and other storage buildings
Davey McKee Warehouse
Old Administration Building
Acid Truck Scale
McKee area water tank
Modernization project offices
Oxygen and Acetylene Warehouse storage
[Kennecott, 2002]

ROUNDHOUSE (facility #96.10)

The former roundhouse, used to turn locomotives around, was later used as a slag pot repair facility. The roundhouse is located in the smelter complex area north of the decon pad and old Acid Plant #7 and south of State Highway 202. The roundhouse was a two story concrete structure built in the 1930's to service and rotate the Kennecott railroad locomotives and later was used to repair slag pots. The area of the site covers approximately 0.4 acres. The building was built on a hot dumped, air cooled slag bluff that is approximately 100 feet thick. The building was demolished in the early summer of 1997 and all concrete footings were removed. In January 1997, prior to demolition, the Roundhouse building materials were sampled and analyzed for total and leachable concentrations of the RCRA metals. None of the samples exceed the TCLP Toxicity Characteristic limits for any of the analytes. One additional sample of dust from inside the building was collected for health risk purposes. The building was demolished in June and July 1997, and in July characterization samples were collected from the footprint area. The footprint samples were comprised primarily of slag (80-100%) and were analyzed for total and leachable concentrations of RCRA metals. Six of the ten samples exceeded arsenic concentrations above the action level, but none exceeded the RCRA toxicity characteristic limits. Because this material was largely slag and the area was later paved with asphalt no further action was taken. [Kennecott, 1998] The asbestos abatement contractor was Thermal West and the demolition contractor was Integrated Waste Systems. The area is now in use as a maintenance equipment laydown yard. It was about 0.42 acre in size. The site was closed out by the North End ROD of Sept 2002.

ROW 5 SCREENING PLANT (facility #96.11)

Located at the end of Row 5 of pots in the slag pot cooling area was a "plant" used to separate large slag chunks from the fines. Chunks larger than 10" were removed here. The facility was loaded from the top with front end loaders and conveyors carried the fines coming out the bottom to piles located nearby. The facility was no longer needed after modernization of the slag plant and was demolished in 1998 as a part of the CERCLA action. Bare ground was not uncovered by the demolition of this screen as it was constructed on slag. The footprint is now in use as part of the slag pot cooling area.

SLAG MILL CONCENTRATE AND FILTER BUILDING AND THICKENER (facility #96.12)

There was a thickener tank and filter building associated with the slag mill before the concentration functions were eliminated in 1995. Here the water was removed from the slag concentrate prior to recycling back to the Noranda Smelter. The thickener tank and filter plant building were demolished in the spring of 1996. Two rail lines that paralleled the north side of the Hot Metals building were also demolished. (The rail lines were bedded on slag that was contaminated with concentrate.) Most of the soils contained demolition debris and concentrate. The site was located immediately north of the old Hot Metals building. The site covers an area of 0.8 acres. In May 1996, 25 soils characterization samples were collected from the site and analyzed for total arsenic, cadmium, lead, and selenium concentrations. Seven of the samples contained arsenic concentrations above the action level of 200 ppm. One sample contained lead above the action level of 2000 ppm. The extent of the contaminated soil was found to be from 0 to 2 feet below the surface over the entire site. In October, 1996, 2700 cy of contaminated soil was removed from the site. The soil was taken to the Arthur Step Back Repository staging area for temporary storage until final disposal in the Repository. Six samples were collected following the removal. None of the samples contained any contaminants above the action level. After removal, the site was backfilled with clean soil and paved to serve as part of a new Smelter Kress Haul Road.

STATION 17 PUMPHOUSE (facility #96.13)

A portion of this building was demolished to provide better access to the pipes, but no soils were exposed. There was no characterization. The site was closed out by the North End ROD of Sept 2002.

SECTION 21 REVERSE OSMOSIS (facility #96.14)

The Section 21 pump station is equipped with a Reverse Osmosis unit to purify smelter process water intake. The effluent can be routed to Pump Station 4 for use as process waters at the concentrators or directed toward an outfall (West C-7 ditch prior to 1999 or the new proposed outfall 012 after construction in 2000). The building was demolished in 1996, but the concrete foundation was saved to be used as a decon pad. The site was closed out by the North End ROD of Sept 2002.

PUMP STATIONS (facility #96.15)

In order to move process waters, Kennecott has several pumping stations. A summary of the intakes and outflows are given below.

Section 17 Pump Station

INTAKE	WATER PUMPED TO:
Slag Lagoon Hazelton Pond Japanese Springs Section 17 Well (500 gpm) Tooele Valley Canal (6000 gpm)	Slag Lagoon Hazelton Pond Outfall 004 Smelter

Water Disposal Pump Station - This is located near Copperton.

INTAKE	WATER PUMPED TO:
Eastside Collection System (2000 gpm) Curtis Springs (325 gpm) Bingham Creek and West Mtn. Shaft (2500 gpm) West Side (300 gpm) Dry Fork Extraction Well (500 gpm) Bingham Creek Cutoff Wall (300 gpm) Dry Fork Tunnel (1200 gpm) Acid Well (1000 gpm) Leach drawdown (1000 gpm) Active Dump leaching	Lime treatment, then tailings line with other flows (45,000 gpm)

Pump Station #1

INTAKE	WATER PUMPED TO:

Adamson Springs (5000 gpm)
Clarification Canal
  Tailings Pond
  Well #10 (3000 gpm)
  Riter Canal (30,000 gpm)
	Magna Reservoir then to Pump Station 3 and 3A
	
	North Concentrator

Pump Station #4

INTAKE	WATER PUMPED TO:

Smelter Return Canal
Smelter (4000 gpm)
Sewage Treatment Plant
  Smelter
  Refinery
  North Concentrator
  Praxair
Waste Water Treatment Plant
  Smelter decon water
	Magna Reservoir (20,000 gpm) then to Pump Stations 3 and 3a

Pump Station #3

INTAKE	WATER PUMPED TO:
Magna Reservoir	Bonneville Reservoir (15,000 gpm)

Pump Station 3a

INTAKE	WATER PUMPED TO:
Magna Reservoir	Pump station 3B (35,000 gpm)

Pump Station 3b

INTAKE	WATER PUMPED TO:
Pump station 3a	Copperton Reservoir (35,000 gpm)

PRAXAIR OXYGEN PLANT (facility #96.16)

Kennecott leases land to the Praxair Oxygen Plant just to the north of the former tank farm. The oxygen plant supplies the smelter and other industries with oxygen. Cooling water and plant wash down water from the plant is routed to the Smelter East Process Water Pond. A trench collecting sulfuric acid from two spills at the nearby Kennecott's acid tank farm was constructed on Praxair property as part of a RCRA corrective action order. This site was not addressed as part of the Kennecott site CERCLA action.

EAST AND WEST PROCESS WATER PONDS (facility #96.17)

Smelter process water, such as granulation and casting contact cooling water, is cooled in cooling towers and stored in lined East and West Process Water Ponds prior to recycling. Operations at the modernized smelter are designed to reuse contact process water within the smelter or to recycle the required blowdown of contact process water to the ore concentrators via Pump Station No. 4. Non-contact cooling water from the modernized smelter is directed to the lined East and West Process Water Ponds and recycled in smelter operations with the blowdown directed to the ore concentrators via Pump Station #4. In the event of a power failure, pipeline break, or other upset conditions at Pump Station 4, this water would be routed to existing pumps and pumped to the tailings impoundment.

Cooling water and plant wash down water from the Praxair oxygen plant is also routed to the Smelter East Process Water Pond. As part of a site remediation plan from the Acid Spill at the old acid tank farm, water (100 gpm) from a groundwater interceptor trench is also pumped to the East Process Water Pond.

The West Process Water Pond was constructed in the same area as Last Chance Pond (See Last Chance Pond). Also known as the Smelter Interim Process Water Pond, the West Process Water Pond was constructed in 1992. The state issued a groundwater permit for the pond. At the time this permit application, both the state and federal wildlife staff objected due to concerns about waterfowl. On May 31, 1993, a leak developed in the liner where the inflow pipes entered the pond. The leak caused a discharge into Kessler wash. Another accident occurred in September 1995 when a dredge equipped with a pump and auger started to remove accumulated sediments from the pond. In the process, the auger damaged the liner near the feed pipe located on the south wall of the west cell of the pond. The leak was detected by the leak detection system. The pump and auger method of sediment removal was abandoned - instead a fire hose was used to loosen the sediment before it was pumped out. The leak was repaired, at least Kennecott thought so at the time.

On 4-30-97, damage which occurred to both layers of liners in the west cell of the West Process Water Pond was reported by Kennecott to UDEQ Groundwater staff. Kennecott speculated that the rips in the liner actually occurred during the earlier incident in 1995. The clay layer underneath the HDPE liners had not been damaged. In the process of repairs, additional areas where the liners had been compromised were discovered. Repairs were completed in 5-2-97. UDEQ requested a groundwater damage assessment. Monitoring wells did not detect any significant changes due to the torn liners. Kennecott speculated that the heavy buildup of sediments in the pond prevented water penetration and the clay layer would have also been effective.

96.18 SMELTER HYDROMETALLURGICAL PLANT (facility #96.18)

The smelter hydrometallurgical plant uses acid plant blowdown and related acidic water from the smelter gas cleaning area to process solids from the flash smelter furnace electrostatic precipitator to recover copper and precious metals. The flow of acidic water to the hydrometallurgical plant is approximately 250 gpm. In addition, an estimated 50 gpm of refinery bleed electrolyte, precious metals plant blowdown, and miscellaneous bleed streams are directed to the hydrometallurgical plant for use as a reagent. An average flow of 250 gpm flow of gypsum/water slurry from this plant is routed through internal outfall 104 to the tailings impoundment via the slag concentrator tailings pump system.

For the UPDES renewal, the discharge associated with the smelter hydrometallurgical plant is governed by new source performance standards based on the production of sulfuric acid. The discharge itself goes to the tailings pond. The treatment is essentially a series of acid-base reactions with solids settling out at each step. Eonomic metals can be recovered and recycled. Assuming typical treatment from settling in the decant pond and clarification canal along with the typical production rate of 7.7 million pounds of sulfuric acid/day, the discharge limits are as follows:

Characteristic	Monthly Average Limit (lbs/day)	Daily Maximum Limit (lbs/day
TSS	236	295
Cadmium	1.57	3.93
Copper	12.0	25.2
Lead	2.56	5.51
Zinc	8.26	20.1
Arsenic	11.2	27.3

In addition, the hydromet plant at the smelter receives and treats 18,000 lbs. of selenium per month. About 75% of the selenium comes from acid plant blowdown, 22% from refinery bleed solutions and 3% from flue dust. The predominant form is probably elemental selenium. About 82% of the selenium is captured on the filter cake where it is mixed with copper concentrate and recycled to the smelter. Of the remaining 18%, 15% is sent to the tailings pond as a non-hazardous waste and 3% is in the arsenic/cadmium filter cake which is treated as a RCRA hazwaste [Kennecott, 1998]

EAST STORMWATER POND (facility #96.19)

A pair of stormwater ponds were built to contain the stormwaters created by a 25 year, 24 hour storm at the smelter. The East Stormwater Pond has a capacity of 6.5 million gallons. The pond services an area of 90 acres, of which 58 acres is impervious asphalt surfaces or building roofs. Primary facility areas draining to this pond include the acid tank farm, the smelter landfill, the repair and machine shop area, the modernized smelter, and several reclaimed and other basin areas.

After the storm is over the pond can be pumped at a rate of 600 gpm to the smelter East and West Process Water Ponds for use in smelter operations or to the concentrators via Pump Station #4. During overflow conditions, the East Stormwater Pond overflows to the Great Salt Lake via a weir to SW2.

The East Stormwater Pond can also serve to contain water from the East Process Water Pond during plant upset conditions. These waters are then pumped back to the Process Water Pond after the upset is rectified.

WEST STORMWATER POND (facility #96.20)

A pair of stormwater ponds were constructed to contain stormwaters created by a 25 year, 24 hour storm at the smelter. The West Stormwater Pond has a capacity of 3.5 million gallons. The pond services an area of 50 acres, of which 37 acres is impervious asphalt surfaces or building roofs. Primary facility areas draining to this pond include the slag concentrator area, patio area, filter plant area, west parking and office area, and slag pot cooling area.

After the storm is over, the pond can be pumped at a rate of 350 gpm to the West Process Water Pond for use in smelter operations or to the concentrators via Pump Station #4. During overflow conditions, the West Stormwater Pond overflows to the Great Salt Lake via a weir to SW1.

The West Stormwater Pond can also serve to contain water from the West Process Water Pond during plant upset conditions. These waters are then pumped back to the Process Water Pond after the upset is over.

REVERBERATORY SMELTER MIXING CHAMBERS (aka the Catacombs)(facility #96.21)

Located behind the current smelter was the location of the original reverberatory smelter site constructed in 1906. A part of this included a series of concrete vaults used to mix gases prior to entry to the stacks. Since the underground structures are now nearly 100 years old, they are no longer watertight. This area has been implicated as a major source of selenium contamination originating in the area. Nicknamed the "catacombs", the site was characterized and found to have high selenium. Because the area is crisscrossed with infrastructure associated with the new smelter, complete demolition of the structure is not feasible. Other alternatives for preventing further groundwater contamination from this area are being explored. The north side of the catacombs are open because the land to the north is at a lower level. The sides of the walls are multicolored indicating heavy contamination. The catacombs form a retaining wall of sorts which support current smelter infrastructure located to the south. The catacombs will be sealed and the exposed areas covered with clay.

THAW SHED (facility #96.22)

Located behind Materials Handling is a former thaw shed. Railroad cars full of concentrate were heated there to allow the snow and ice to melt. As the water and melted water drained out, the water just soaked into the ground leaving a residue of contaminants that leached from the concentrate. This area was cleaned up, paved, and protected with run-on and run-off controls to trap any contaminated water in the future. Today, it is used for a concentrate loading and unloading area. Railcars are loaded with excess concentrate which is sold and shipped to other smelters.

SMELTER PROCESS WATER PIPELINE (facility #96.23)

This pipeline carries process water from the smelter to the Number 4 pump station. It is a single wall 16 inch pipeline about 3/4 inch thick which roughly follows the path of the smelter return canal. It was made of HDPE and was first installed as a weak acid line which went from the smelter to the WWTP 25 years ago. In the summer of 1998, the pipeline failed on three separate occasions. Each of the failures occurred on the top of the pipe as it daylighted over the

Figure 53: Broken smelter process water pipe. Samples of the pipe were sent to the manufacturer. Sometimes leaks appear as wet spots on the surface. Sometimes they are geysers.

smelter return canal. All of these spills were stopped quickly because the spill created geysers shooting up. The waters were contained in the smelter return canal.

The pipeline failed again in September 1999, this time underground. The water bubbled out of the ground flowing into the smelter return canal then into adjacent ponds in the Garfield wetlands. Most was kept south of the old railroad grade which served as a dike. The spilled process water contained 7.28 ppm As, 4.30 ppm Cu, and 0.25 ppm Pb. The high content of arsenic allowed Kennecott to investigate the flow of water through the wetlands using the arsenic as a tracer. At the time of the spill, clean up of the smelter return canal and the Garfield wetlands had not started. Kennecott estimated that the spill added about 4000 cy of contaminated materials to the smelter return canal. The cleanup of the water spill involved flushing the contaminated water through the wetlands to Pump Station 4 for use in the process water circuit. Water from Garfield Wells 6 and 8 (clean water) was used to flush the water through.

Inspection of the smelter flow pressure readings revealed that the break occurred about a month before it was discovered. Investigators indicate that the spill was about 100 million gallons. The break was lateral along the axis of the pipeline, the kind typical of a failure due to excess pressure. The portion with the break was cut out and set to the manufacturer who wanted to inspect the failure. The smelter process water is now being sent to Pump Station 4 through an existing pipeline that was being used for conveying decontamination water from the cleanups to the WWTP. It is a double-walled pipeline adjacent to the former pipeline. The break was found across the highway from the Praxair plant a little to the north of the smelter return canal.

SLAG POT COOLING AREA (facility #96.24)

Because the slag produced by both the Noranda Smelter and the new Outokumpu Smelter contain substantial values of copper, the slag is not disposed of, but rather is recycled. The first step of the slag recycling process is the skimming of the slag into slag pots, each holding 48 tons of slag. The slag pots are then hauled to a cooling pad (via the Kress Haul Road) where they are cooled using water spray with a total flow of 300 gpm. The cooling pad is to the east of the slag crushing facility and the northwest of the former Noranda smelter. Slag is cooled for 24 - 30 hours. The solid slag is then dumped from the pots and broken up with trackhoes or backhoes equipped with pneumatic hammers. The smaller chunks are then hauled to the slag crusher where it is ground up and recycled back to the concentrators.

On Dec 30, 1998, an incident occurred where a slag pot had not sufficiently cooled and when the slag was broken loose, hot slag began to flow downhill. When it hit some water close to the backhoe, an explosion occurred splattering the backhoe operator with hot slag. The slag also hit the truck hauling slag pots and caught the truck on fire. The truck driver was able to escape. The hot slag caught a nearby trailer on fire also. The trailer was unoccupied.

When production at the smelter is high, Kennecott shortens the slag cooling times on a regular basis. This practice is called "hot dumping". The core of the slag is often still molten and hot. It is not unusual for the molten core to spatter on the backhoes catching the tires on fire. The workers drive their burning hoes into a pond of water kept for this purpose. Runoff from the slag cooling spray is collected and goes to the west process pond.

MATERIAL HANDLING FACILITY (Dryer and Hopper buildings) (facility #96.25)

According to the RI Report [Kennecott, 1999], the Material Handling facility was used to dry the concentrates, blend them (with flux) and transfer copper concentrate from the North Concentrator and/or Filter Plant to the Old Hot Metals building. Material Handling was composed of the Dryer building, Hopper building, and a series of conveyors. Built in 1978, these structures were demolished during 1997. The Material Handling facility occupied the southeast corner of the Old Noranda Smelter. The Dryer building footprint is located immediately west of the A-Frame Concentrate Storage building. The Hopper building footprint is located 150 yards east of the main stack on the south side of the new flue. The conveyor system was elevated and did not have a footprint. The Dryer footprint was contaminated with concentrate down to 1.5 feet, but the copper values were not high enough for recycling. The Hopper footprint was also contaminated with copper concentrate but the concentrate was recoverable. After removal of the recyclable concentrate, the soils were contaminated down to an average depth of two feet. About 2234 cy of soils were excavated and placed in the Arthur Repository during August and September of 1998. The material handling functions were also supported by several thousand feet of conveyors, 24 inches to 48 inches wide. Spilled concentrates were sometimes found underneath the conveyor belts. Two stainless steel rotary dryers which were used for drying concentrates were also present. The materials handling area occupied 22 acres. The Material Handling Building footprints were 1.2 acres. The new Dust Processing Building was built on the former Dryer Building footprint of the Materials Handling Facility. Before cleanup, the maximum concentrations were 1200 ppm arsenic, 56.6 ppm Cd, 3890 ppm Pb, and 169 ppm Se. [Kennecott, 2003]

COOLING TOWERS (facility #96.26)

A variety of cooling towers associated with the smelter were demolished in 1997-1998. They included: (1) Ecodyne Cooling Tower; (2) Upper Ecodyne Cooling Tower; (3) Lilly Hoffman Cooling Tower; (4) Power Plant Cooling Tower; and (5) Trombone Cooling Tower. The towers were constructed of steel with a covering of asbestos. The demolition contractor was Gibbons and Reed; asbestos removal contractor was RocMont; and the scrap metal contractor was Atlas Steel.

OVERHEAD FLUES (facility #96.27)

The flues from the smelter to gas handling were above ground on supports which carried them high above the truck traffic below. The flues were made of stainless steel and were about 6 feet in diameter. Flue dust deposits were about 1 foot thick in the bottom of the pipe in some


Figure 54: Jacks lowered sections of the overhead flues to the ground where crews could access them

places. Demolition of these overhead flues was particularly challenging from both a logistics and safety standpoint. In general, a jacking system was erected underneath each section of flue pipe, the section was cut apart from the pipe with a cutting torch, and the massive jack platform lowered each section to the ground. After removal from the jack, and placement of the section on the ground, each end of the section was covered with a plastic cover. Although some of the sections had over a foot of flue dust deposited in the bottom, no attempt was made to remove the deposits from the pipe sections. After each end was covered, the section was lifted onto a flat bed truck for transportation to a hazardous waste landfill. The stainless steel piping, therefore, served as a container during the transportation. Each section was hauled off-site to the Grassy Mountain facility. During 1997-8, 850 linear feet of flue ducts (366 tons of steel sometimes lined with concrete) along with 670 tons of flue dust were hauled away. An additional 2010 tons of flue dust and acid contaminated waste from Gas Handling and Acid Plant #8 were removed in 1998. The demolition contractor was Integrated Waste Systems with aid of Global Wrap and Auburn.


Figure 55: Flue dusts in the bottom of the overhead flue sections.

SHOT COOLERS (facility #96.28)

The shot coolers were the first step in treating converter gases. Each furnace had a cooler to cool off gases before they entered the gas handling systems. This was a collecting place for the dusts. In this area, dusts were packaged up, but spills occurred during the packaging. It is not known when the shot coolers were demolished (sometime prior to 1995). This area is the suspected source of very high arsenic in ground water from the well at the smelter parking lot (10 mg/l As).

CHERRY BOWL (facility #96.29)

Located on an erosional bench adjacent to the railroad tracks southeast of the new smelter was an area which was used as an unpaved storage place for excess concentrates and soils with potential for recycling. It was recently retired when the new concentrate storage pad was constructed and the accumulated contamination was cleaned up. After cleanup and paving, it found use again as a storage area for intermediate products. Today, it stores blister copper, matte, copper contaminated soils, cross contaminated soils and debris. It is now part of the operational area for the smelter. This site was closed out by the North End ROD of Sept 2002.

RR CROSSING (facility #96.30)

On Oct. 11, 2000, a haul truck and pup trailer struck a mine train and the entire load of contaminated soils was dumped on and near the tracks. The accident occurred 600 feet south of SH 201 and 350 feet east of the east smelter gate. The spilled material was immediately re-excavated and taken to its original destination, the Arthur Stepback Repository. The truck sustained about $10,000 in damages and the train locomotive about $300 in damages. The train was hauling sulfuric acid. This site was closed out by the North End ROD of Sept 2002.

MISCELLANEOUS SMELTER BUILDINGS (facility #96.31)

There were about 40 buildings, tanks, conveyor systems, flue systems, pump houses, etc., associated with the Noranda Smelter operations. Although some of the older structures are still in use by the new smelter, most have been demolished now. Asbestos was a common problem for these. The service building demolition contractor was Northern Nevada.

CONVERTER ANNEX BUILDING (facility #96.31a)

The site facility was the maintenance building for the Converter Aisle, which was a facility associated with the decommissioned Reverberatory Smelter. The building was demolished in 1990-1. This site footprint is currently located under the existing smelter (materials handling area); the area is capped with either concrete or asphalt. This site was closed out by the North End ROD of Sept 2002.

EGG CRATE BUILDING (facility #96.31b)

Formerly located immediately east of the "A" frame building, the Egg Crate building was also referred to as the Reverberatory Material Handling and Storage Building. This structural steel building consisted of concrete bins used to blend flux, concentrate and feed materials for the smelting furnaces of the Reverberatory Smelter. The site footprint is currently located under the existing smelter.

UPHILL STACKS (facility #96.31c)

Constructed in the 1930s, a series of three short stacks were located in Kessler Canyon just behind the reverberatory smelter. The stacks were connected to the smelter via flues that were largely above ground (except where the flues went under the railroad tracks). The stacks and flues were demolished in the early 1990s and associated dusts were hauled to Grassy Mountain. Remaining contamination was addressed as part of the Upper Kessler Canyon.

REVERBERATORY BYPASS FLUE (facility #96.31d)

A bypass of the baghouses, these flues are a part of the mixing chamber, now known as the catacombs. The lower portion of the flue between the historic Hot Metals Building and the Mixing Chamber (west section) was lifted in elevation to a series of 6 tunnels (catacombs). This portion of the site is located in the new smelter area and is paved over. A portion of the site from the Mixing Chamber to the Uphill Stacks was remediated as part of the railroad flues site.

STANDBY FUEL STATION. (Facility #76.01)

The smelter stand-by fuel station, also known as the oil pump house was located to the east of the old reverberatory smelter anode department, now in the new smelter footprint. It supplied the fuel source for the old ASARCO smelter during the winter months for approximately 50 years (1923 - 1973). The fuel station supplied No. 6 fuel oil as the primary fuel with periodic blending of waste oil as it was received. The fuel station had two above ground holding tanks for No. 6 and waste oil. The tanks held approximately 3000 gallons each. The tanks were set below grade but were not buried. Various pipe runs were associated with the station, some of which may still be in place. The stand-by fuel station was demolished in 1990.

Visual evidence suggests that the tanks may have overflowed on one or more occasions. In 1992, visually oil stained soils were excavated from the site and taken to the Little Valley petroleum soil staging area for later use in asphalt paving. Kennecott later decided to ship the materials to ECDC. Kennecott estimates that the volume of the soils was approximately 25,000 yards. The excavation was approximately 75 ft x 100 ft x 20 ft deep. Further excavation was not possible since concrete slabs and duct banks were encountered. Further soil staining was observed south of the site at the time of excavation.

Later in 1993, borings for the new smelter also encountered oil stained soils 30 feet east of the fuel station excavation. A survey of surrounding soils was conducted in 1993. The highest concentration of Total petroleum hydrocarbons in the soil was just to the south of the site at 29,300 ppm. This sample also had 290 ppm As and 625 ppm Pb. Twelve of the 115 samples exceeded 1000 ppm TPH. Groundwater was encountered at another location to the southeast which contained an oily sheen and was 313 ppm TPH. Kennecott believes that this groundwater was a perched aquifer since none of the other boreholes encountered groundwater. An internal Kennecott report recommended no further action, other than saving the information for reference later. [Kennecott, 1994]. It was surmised that the water came from the truck washing station. Since this was originally discovered the water has drained off. The site was closed out by the North End ROD of Sept 2002.

HISTORIC GARFIELD ACID PLANTS (facility #97a)

To provide the sulfuric acid to treat the ores at the leaching plant, the Utah Copper Company joined with the Garfield Smelting Company to organize the Garfield Chemical and Manufacturing Corporation, which constructed and operated an acid plant near the Garfield Smelter. A plant was erected in 1916 with a capacity of 75 tons of 50 degree acid per day, which was gradually increased to 150 tons/day. Over the years the plant has been periodically expanded and improved (1963 output was 700 tons/day) and has continued as an important sulfuric acid producer to the present day [Arrington, 1963]. Kennecott bought the plant in 1964. The plants are single-contact in design. [Kennecott, 1996, reports that the acid plants operated since 1937.]

The acid plants were numbered chronologically as new plants were installed and old ones demolished. Acid Plant 1 was constructed in 1937, Acid Plant 2 in 1944, Acid Plant 3 in 1950, Acid Plant 4 in 1950, Acid plant 5 in 1956, Acid Plant 6 in 1967 and Acid Plant 7 in 1970 (Kennescope, about 1975). The most recent acid plants were Acid Plant #7 (adjacent to the smelter on the northeast) and Acid Plant #8 (adjacent to the smelter on the south). Both were recently rehabilitated and containment systems installed. The plants became obsolete when the new smelter was put on line in 1995-6 and were demolished. Current sulfuric acid production is 4000 tons of 98% sulfuric acid per day. The new acid production facility, which is part of the new smelter construction is double contact. There have been numerous acid spills reported to ERNS regarding this facility.

The process involved (1) removal of particulates by electrostatic precipitators and shot coolers; (2) scrubbing of the gases in a humidifying tower with weak recirculating acid, with the dusts going to the WWTP; (3) packed scrubbing towers; (4) gas goes to electrostatic mist precipitator, (5) then to a drying tower; (6) then to catalytic converters which converted sulfur dioxide to sulfur trioxide using a vanadium pentoxide, gasses taking 3 passes; (7) absorbing towers where sulfur trioxide was absorbed into 98% sulfuric acid; and (8) the remaining sulfur trioxide was vented via the tall stack. In 1974, the total capture was about 57%.

The sulfuric acid was loaded onto railcars. The loading facility had spots for 6 railcars at a time and 4 tank trucks. In 1975, this was expanded to 16 railcars at a time and 6 tank trucks.

Kennecott [1996] indicates acid plants #1 and #2 were demolished in 1970, #3 and #4 in 1975, #5 in 1983 and 1989-1991, #6 in 1985 and 1989-1991. #7 was demolished in the spring of 1996; #8 was demolished in 1998.

Kennecott [1996] has characterized the footprint of the Acid Plant #7 site. The site covers approximately 3 acres and consists of a variety of fill soil, slag, and asphalt mixed with metal, concrete, and wood debris. Twenty-seven of the 45 samples collected contained arsenic above 200 ppm; eleven contained lead above 2000 ppm; and one contained selenium above 1000 ppm. The highest concentrations were 8960 ppm As, 262 ppm Cd, 31600 ppm Pb, and 1380 ppm Se. Removal of contaminated soils from the east site was completed in Nov. 1996. Removal of contaminated soils from the west side was completed in Dec. 1996. Demolition was completed in May 1997. According to the RI report [1999], 16,924 cy of contaminated soils were removed from the footprint of the Acid Plant #7 and disposed in the Arthur Stepback Repository. About 18 inches were removed over the entire footprint, up to 3 feet in the western part and up to 14 feet was removed from the eastern part of the site. The soils contained a variety of fill, slag and asphalt with copper and iron staining down to 6 feet in spots. (The site was divided into two portions by an asphalt road running north and south, creating two areas of the site, east and west.) During excavation, perched water was encountered at between 8 and 15 feet below the surface. Fill soil came from a borrow source located in upper Kessler Canyon. All soils excavations were completed in August 1997. This area was addressed in the North Facilities Soils Removal. The site has since been covered with asphalt. About 3/4 of the area is now used for a mobile equipment laydown yard and a small portion is used for railroad tracks entering the new hot metals building by the anode casting wheel. See also 96.04 (Old Smelter Soils). The demolition contractor was Gibbons and Reed with the aid of Staker Excavating.

Following demolition of Acid Plant #8 in 1997-1998, Kennecott [RI, 1999] characterized the Acid Plant #8 footprint in December 1998. The facility was composed of 25 structures just to the south of the former Hot Metals building where gases from the Hot Metals process were processed into sulfuric acid.

The flues leading from the hot metals building to the acid plant were sectioned and lowered to the ground in sections using a specially designed jack system. (See Overhead Flues.) An additional 2010 tons of flue dust and acid contaminated waste from Gas Handling and Acid Plant #8 were removed in 1998. The maximum concentrations found prior to the excavations were 7250 ppm As, 55.3 ppm Cd, 28,500 ppm Pb, and 3611 ppm Se.

During Feb - April, 1999, about 3 feet of soils from the footprint were excavated (36,796 cy) and placed in the Arthur Stepback repository. The area was brought up to grade with 30,000 cy of fill and covered with 6 inches of low permeability asphalt. The asphalted area was equipped with run-on/run-off controls and is currently being used as a concentrate storage pad by smelter operations. The entrance road to the pad is equipped with a cattle guard type device to shake off any concentrate from the bottom of the trucks. It can be mucked out to recover any concentrate.

NEW ACID PLANT (facility #97b)

A new acid plant to work with the new smelter was constructed at the same time as the Outokumpu Smelter. Unlike the older acid plants, the current acid plant is double contact and removes sulfur from the off-gasses more effectively. Located just to the west of the new smelter, the new acid plant, designed by Monsanto, has a capacity of 1 million tons/year of high purity sulfuric acid. There is a heat exchanger associated with the new gas handling system which allows recovery of heat as steam which is then used to cogenerate electric power. The heat exchanger has been plagued with corrosion and leakage problems.

WEAK ACID CORRIDOR (facility #97.01)

The Weak Acid Corridor Site consists of a pipeline that transported weak acid and process water from the Weak Acid Lift Station to the WWTP. [Kennecott, 1996]. No contamination was found. After the new smelter was built, the weak acid pipeline was no longer needed for its original purpose. During the demolition projects at the smelter, the weak acid pipeline was used to carry decon water to the treatment plant. Following demolition of the old smelter and treatment plant, the pipeline lay unused. When the nearby process water pipeline failed in Sept 1999 (see 96.23), the double walled weak acid pipeline was reactivated and is now in use to carry process waters from the smelter to Pump Station #4. The slag tailings pipeline travels in the same corridor as the weak acid pipeline. The site consists predominately of phragmites with localized stands of rushes of salt grasses. The weak acid pipeline is consistently at a depth of three feet below the natural ground level and in many areas below the ground water surface. In the course of investigating the weak acid pipeline/slag tailings pipeline corridor, another pipeline was identified. This pipeline also conveyed weak acid from the smelter to the Chevron (Stauffer) fertilizer plant.

WEAK ACID LIFT STATION (facility #97.02)

The Weak Acid Lift Station Site is the main pump station that pumped weak acid and process water to the WWTP via the Weak Acid pipeline. This facility was in operation until the Noranda Smelter was demolished. [Kennecott, 1996]. The site is located within the smelter complex immediately south of State Highway 201 and east of the West Process Ponds. The area of the site is about 1.5 acres, 250 feet (north to south) by 300 feet (east to west). The site consists of three main sections; the first section was the actual footprint of the Weak Acid Lift Station, which included a pump house and a large secondary containment for a series of holding tanks. The second section was the area to the north of the footprint, which included a small side drainage to the main Kessler drainage. The third section was the lower portion of Kessler drainage from the Kessler cutoff wall to State Highway 201. Soils within the site consisted of silty and sandy gravels, which were imported to the site during initial construction. [Kennecott, 2003]. Demolition began in 2000 by removal of asbestos. The contractor was Thermal West. Following demolition the soils were characterized and found to be contaminated mainly by arsenic. About 8345 cubic yards of contaminated soils were removed and placed in the Arthur Stepback Repository. Backfill was added to the site to a height of 2 feet in the footprint and the building and sump in order to improve drainage. A portion of the contaminated soil was left in place due to close proximity to active utilities and operations. Those portions were capped with 18" of fill.

ACID PLANT DEMOLITION PROJECTS (facility #97.03)

Various facilities associated with the different acid plants #7 and #8 have been undergoing demolition since 1995. As of August, 1998, the following facilities have been demolished:

Acid Plant #7
- Lower Ecodyne Cooling Tower Site
- Main LAP Substation Site
- Acid Plant Tank Site

Acid Plant #8
- Drying Tower
- Five heat exchangers
- Reheater
- Absorbing Tower
- Mist Precipitators
- Karbate Coolers
- Absorbing Pump Tank
- Drying Tower Pump Tank
- Trombone Cooler and Chemical Feed Building
- Lilly Hoffman Cooling Tower and Chemical Feed Building
- Upper Ecodyne Cooling Tower
- Sulfuric Acid Tanks
- Humidifier Tower and Pump Tank
- Packed Scrubber
- #8 Substation and Offices
- Blower Building
- Preheater and Building
- CIL Coolers
- Upper Acid Repair
- Converter
- Tail Gas Flue
- Ping Robison Fan

[Kennecott, 2002]

WEST WEAK ACID LIFT STATION (facility #97.04)

This is another name for the Weak Acid Lift Station - see 97.02.

CONCENTRATE STORAGE PAD (facility #97.05)

On the footprint of the former Acid Plant #8, Kennecott constructed an asphalt paved pad for storage of concentrates. The contaminated soils underneath the former acid plant were excavated and removed. Following the cleanup, the land was regraded, the surface paved with at least 6 inches of asphalt. Two detention basins were built along the north side so that any concentrate getting in storm water runoff could settle out and be collected later using a front end loader. To prevent concentrate from being tracked out of the storage area on tires and the undercarriages of the truck, a "cattle guard" was installed at the entrance/exit. Any concentrate clinging to the outside of the trucks would be shaken off and collected underneath the cattle guard. It was specially constructed out of scrap steel because the commercially available ones were not strong enough to hold mine trucks.

ACID STORAGE FACILITY (SMELTER ACID TANK FARM) (facility #98)

Kennecott operates a sulfuric acid tank farm for storage of acid prior to sale and shipment. According to Kennecott [1996], the facility was operational between 1976-1994. The facility was constructed originally to store fuel oil. It was converted to an acid storage facility in the mid-1980's. This facility is the site of numerous acid spills and groundwater is acidic. Kennecott demolished this facility and built a new one south of the former facility. There were 4 large tanks at the site. Tanks 1 and 3 were demolished in 1993. Tanks #2 and #4 were removed in April, 1994.

Leaks from Tank #4 on March 15, and from Tank #3 on March 20, both in 1991, contaminated the soils with sulfuric acid and also affected the perched aquifer in the area. Under an order from UDEQ-RCRA (Consent Order 9212006) program, Kennecott conducted a Site Characterization, an Interim Remediation Plan, and then prepared a Site Remediation Plan. The investigation indicated that 92,000 sq. ft. of soils had been contaminated to a depth of 9 feet. The most contaminated part of the groundwater plume is about 400 ft long (to the north west) and about 90 feet wide. The interim plan included pumping of the water out of the aquifer. So far 30,000 gallons have been pumped. Kennecott seeks to excavate soils with pH less than 4 and treat (neutralize) the soils. Kennecott estimates that 25,000 cubic yards will be excavated; treatment will take place in the asphalt lined pad of the former #2 tank. This area has a capacity of 28,500 yards. Groundwater will be remediated through removal of groundwater using a hydraulic barrier to intercept the groundwater plume with a trench. [Kennecott, 1994]. This water is pumped to the East Process Water Pond. This RCRA action is designed to remediate only the plume caused by the 1991 spill. It apparently does not address earlier spills.

The final report for this cleanup [Kennecott, 1997] indicates 43,000 cy of overburden was stockpiled, 17,000 cy were removed and treated with 10,000 cy of calcium hydroxide. The treated material was then placed and compacted on the former Tank #2 impoundment which had been lined with asphalt.

An interceptor trench dug downgradient of the site to capture low pH fluids and impacted groundwater had extracted 11 million gallons of water by early 1997, at a rate of 30 gpm. Sulfate concentrations in the groundwater have dropped from 23,000 ppm to 9,000 ppm. Operation of the extraction system is still continuing [Kennecott, Montgomery Watson, 1997], but Kennecott has sought permission to stop recovery operations because little acid now reports to the trench.

CONCENTRATE SLURRY PIPELINE (facility #109)

Concentrate from the Copperton Concentrator is sent via a slurry pipeline to a dewatering tank close to the smelter beginning in 1987. This pipeline is 6" in diameter (Kennecott, 1993). The pipeline was constructed of steel pipe and transported 2600 tons of concentrate per day to the filter plant at 63% solids. The pipeline was replaced in 1993 after a series of small spills in 1992. Spills were located at (1) along hwy 111 near Hercules, (2) near the refinery at the old Garfield townsite, (3) at the Hercules facility, (4) along the eastern side of the refinery, and (5) south of the smelter warehouse. Each of the spills was cleaned up. The concentrate is visually distinctive (dark green) and visual confirmation of the cleanup is possible. On two occasions, post removal samples were collected and low levels of metals were found. The spill at the warehouse occurred on asphalt. In this case the concentrate was shoveled and swept clean. The concentrate line and a companion return line are buried.

In 1991-2, a 4" concentrate slurry line was constructed from the Filter Plant to the Magna Concentrator because the Filter Plant was unable to filter all of the concentrate from the Copperton Concentrator. In 1996-7, the capacity of the Filter Plant was expanded and a positive displacement pump was reversed to pump concentrate from the Magna Concentrator to the Filter Plant using the same pipeline. The Magna Slurry line delivers approximately 600 wet tons of concentrate per day to the Filter Plant. (The Magna Mill was shut down in 2001.)

RAILROAD RIGHT-OF-WAYS (facility #145)

Evidence suggests that mine waste, slag in particular, may have been used as ballast for construction of the numerous rail lines on the site. The environmental impact of this is unknown. There is evidence that the railbed of the D&RG tracks from Midvale to Bingham was built utilizing slag from the Midvale smelter.

Early practice in the 1910's was to load the flotation concentrate into separate rail cars.

Because these concentrates were too wet to smelt, the rail cars were left on a siding for a week or two to let the water drain out [Rickard, 1919]. Kennecott [1997] suggests that no evidence of significant impact to the environment from this practice has been found. (Have they looked?)

To date, rail accidents have not been thoroughly researched. An inquiry to the National Railroad Agency revealed 15 spills of sulfuric acid since records were kept. All the recorded spills were < 5 gals. The early history of railroads in Bingham and Garfield as it related to mining is discussed by Billings [1948]. In one anecdote, he remarked, "The mill [Wall's mill] was erected just below the Copper Belt tracks at a sharp curve and quite often the runaway train would hold the rails to this curve and then land in the Wall mill."

Kennecott [1997] indicates that the rail system appears to be constructed of native cut and fill with a slag ballast base. The slag most likely came from the Garfield Smelter that was constructed in 1906. Garfield Smelter Slag does not leach metals above the RCRA test criteria.

Kennecott [1997] reports that an area of the North End rail system which has been identified for remediation is in a rail yard south of the Smelter. This area is used to transfer copper concentrate between rail cars during the weighing process. In many areas, copper concentrate has been spilled and has accumulated to over six inches deep.

The Kennecott rail system transport the following material between facilities: copper ore from the Bingham Canyon Mine to the Bonneville Crush, anodes from the Smelter to the Refinery, and scrap anodes from the Refinery to the Smelter. The Kennecott railroad system transports the following materials to local siding tracks where Union Pacific (and formerly Denver and Rio Grande) railroad systems pick up for transport to off-site locations for sale: Copper concentrate from the Magna concentrator, copper cathodes from the refinery, and sulfuric acid from the smelter.

NEW SEWAGE TREATMENT PLANT (facility #105.02)

The new Sewage Treatment Plant was constructed to treat sewage from the modernized smelter, refinery, Praxair, and North Concentrator areas, as well as neutralized laboratory wastes from the process and environmental laboratories. The plant includes flow equalization, chlorination, and aerobic digestion of sludge. The Sewage Treatment Plant is sized to treat 165,000 gallons per day and a peak hourly flow of 47,250 gallons of raw sewage based on a total work force of 1350. Discharges from the plant consists of a clarified effluent and a waste sludge. The effluent is hard-piped directly to Pump Station No. 4 from whence it is recycled. The pre-2000 NPDES permit did allow discharge of the clarified effluent at Outfall 008, but the infrastructure was not constructed for this.

KESSLER CANYON DRAINAGE (facility #136)

It is theorized that smoke stack emissions may have contributed soil contamination in area surrounding the smelter. To date, not much is known about the impacts or any residuals in the soil. However, one reference did remark that in the first few years of smelter operation, much of the concentrate went up the stack and settled on surrounding hillsides. SAIC [1991] reports that there were several shorter stacks at the smelter. The first one was a 300 foot brick stack which served the roasters and reverberators. Another smoke stack was installed in addition to the first in 1914 which was 350 foot tall to service blast furnaces and converters.

The old 300 foot stack was replaced about 1934 by a 420 foot steel and concrete stack. Others were added and replaced over the years. In 1978, the new 1,200 foot stack was in place.

Kennecott reports that soils in the Kessler Canyon show elevated concentrations of heavy metals. In general, As, Cu, Pb, and Mo have been deposited relatively near the smelter whereas Cd, Se, Fe, and Zn have settled out over a larger area surrounding the smelter. Since Kessler Canyon runoff is commingled with plant runoff waters, it is unknown how much the contaminated soils contaminate surface water. Groundwater contamination has been found downgradient of the smelter, but it is unknown how much originates in Kessler Canyon. [Kennecott, 1991]

In addition to soil contamination, the smelter emissions devastated the vegetation in the canyon. The denuded area resulted in severe erosion and flood events which flooded the smelter facility. A particularly bad flood occurred in 1927 washing out 21 of the 22 check dams in the canyon. Winsor [1964] described the 1927 flood as a mud flow containing large rocks and tree stumps. Three lines of ore cars behind the smelter were knocked off their tracks and the mud flow entered the smelter roaster house. New flood control measures were designed. The original 4' x 6' drain under the smelter was replaced with a 22' x 22' drain. Three barriers were constructed. Winsor [1964] indicates that these 3 barriers had to be raised several times after the basins filled up with debris during the storms of 1938, 1939, and 1945, but the dams had contained the floodwaters. One spillway crest was 114 feet tall. The average drop in the canyon is 12.5'/100'. The flood in 1945 was stopped by the dams but didn't work as designed. The water did not flow through the channel leading to the box culvert. It broke some water pipes, so an overshot was built to carry floods over the pipeline.

Revegetation efforts sponsored by Kennecott have been successful in establishing grasses such as white top and alfalfa. There is a spring near the uppermost dam and a resident elk herd. There have been no runoff events recently.

In 2001, Kennecott reported the following information about the three barrier dams:

Dam Number	Structural height (ft)	hydraulic height (ft)	area at spillway crest (ac)	storage at spillway crest (ac-ft)	storage at dam crest (ac-ft)
UT00484	15	13	13	71	NA

UT00485	45	34	14	90	295
UT00486	51	42	27	179	388

Kennecott (2001) also characterized the soils which had collected behind each of the 3 check dams in Kessler Canyon. The highest arsenic was 88 ppm (behind the second dam); the highest lead was 140 ppm (also behind the second dam). The average concentrations were 41.5 ppm arsenic and 60 ppm lead.

A recent ecological risk assessment found that the number of native plant taxa present in the canyon was reduced in comparison to Coon Canyon. Coon Canyon has 73% native plants; Kessler Canyon has 56% native plants.

ERI reports that there are several springs below the mouth of Kessler Canyon. The origin and rates of flow are unknown. Lower Kessler Creek has two permitted outfalls SW1 and SW2. Both are stormwater discharges. Lower Kessler Creek remains unclassified by the state.

146B. SMELTER AREA EMPLOYEES PARKING LOT

EPA has received a complaint about the potential of acid drainage into the employees parking lot used by workers at the smelter facility. The lot, according to the complainant can also get muddy with materials washing down slopes adjacent to the lot. The chemical composition of the runoff waters and the mud is unknown. Kennecott [1996] reports that the "muddy material" is believed to be overflow from the slag concentrate thickener.

Following the first use of explosives during smelter demolition activities, a number of employees complained that their cars had been "dusted" by the fallout. Kennecott management gave them a voucher for use at a local car wash. After that, workers were instructed to park at a remote location on days when demolition explosions were planned. They were bussed to the smelter. Air monitors in the area of the employees parking lot failed to detect unusual dust fall during demoliton.

CHAPTER 17
REFINERY NEAR MAGNA

Kennecott built a metals electrolytic refinery in 1950 to further purify their smelter product and recover precious metals. The refinery was modernized in 1995, and older facilities demolished.

OLD REFINERY (before modernization)(facility #99a)

In 1948, Kennecott announced plans to construct an electrolytic copper refinery at Garfield, near the smelter. Work started in 1948 and the plant was completed in 1950 at a cost of $17 million. Since then, a $3 million expansion program has been completed giving the plant a capacity of 16,000 tons of refined copper per month (99.96% pure). [Arrington, 1963] As of 1988, it had a productive capacity of 240,000 tons of cathode copper per year. It also produced as by products, 295,000 ounces of gold per year and 2,250,000 ounces of silver per year. The site is 45 acres located 1.5 miles east of the smelter.

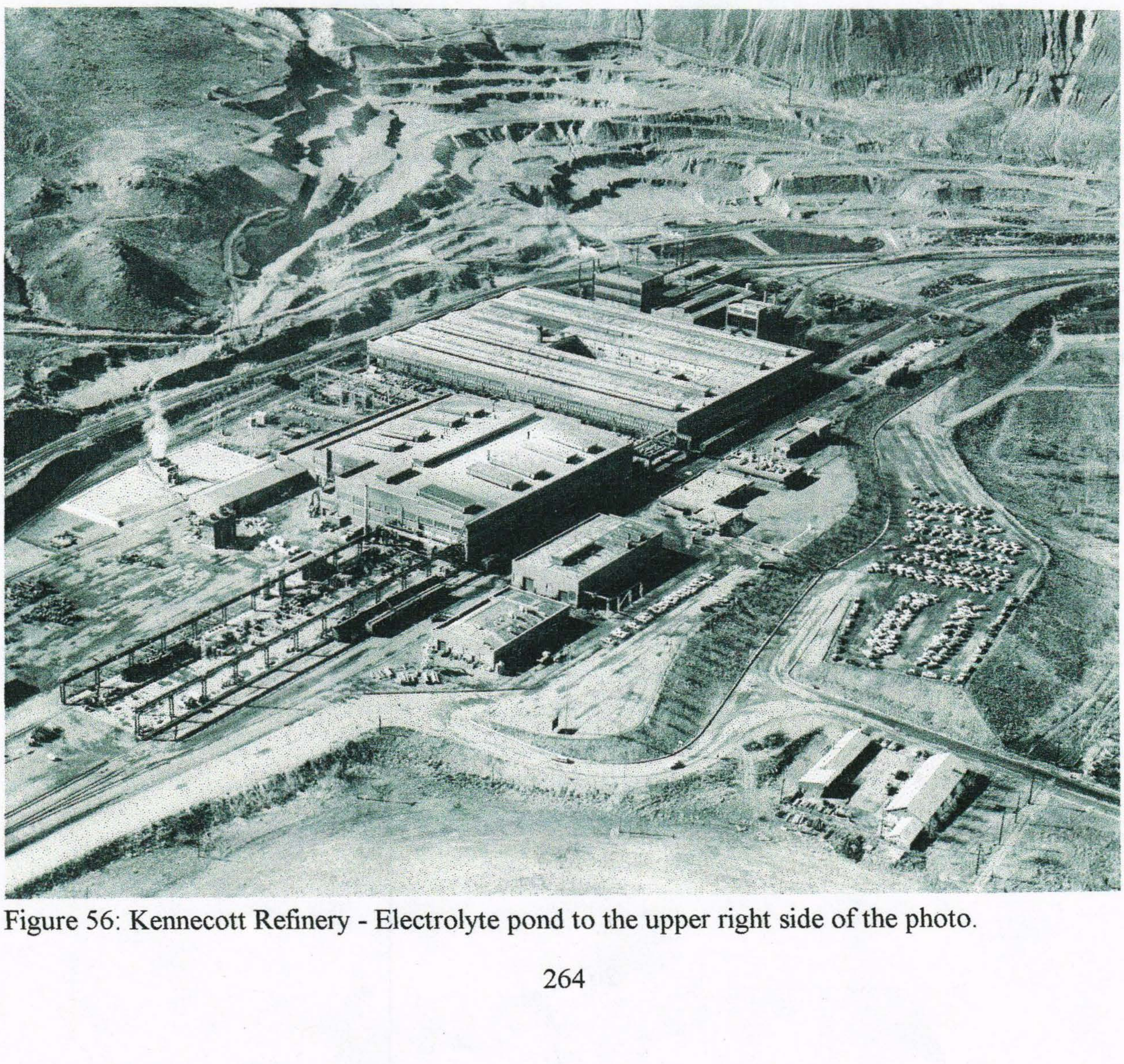

Figure 56: Kennecott Refinery - Electrolyte pond to the upper right side of the photo.

The tank house was described in a Kennescope article in 1954. The single story structure measured 546 x 410 feet. The cells were concrete, steel reinforced and lead lined and were filled with an electrolyte solution containing 200 gms/l of sulfuric acid and 40 gm/l of copper. The temperature of the cells was held at 140°F.

The refinery used a two step process: first, the cathodes of copper were produced; then the refinery slimes from this process were sent to a collocated precious metals refinery for recovery of the precious metals [BPMA, 1988]. The processes utilized in the functions of the refinery (metal electroplating) created a waste stream of spent electrolyte solution, which are sulfuric acid and water. Refinery bleed electrolyte waste was decopperized and then pumped to a central water treatment plant where water and a resulting sludge were separated. The water goes to the tailings pond at Magna and the sludge is deposited in a large unlined pond in an area northeast of the Smelter Slag Pile. Other waste streams were thought to exist. [SAIC, 1991]

The electroplating portion of the refinery was described by Kennecott in 1988. At that time, the capacity was 240,000 tons/year. Anodes weighing 760 pounds (99.6% copper) from the smelter were placed in lined cells containing electrolyte (a mild acid solution). Between each anode a starter sheet of pure copper was inserted as a cathode. Low voltage direct current was passed through the cells causing the anode to dissolve in the electrolyte and migrate to the cathode. There the copper redeposited on the cathode at 99.96% purity.

At the end of each cycle (28 days) the electrolyte was drained from the cells, the precious metals slimes washed from the anode scrap with high pressure sprays, slimes washed from the cell bottoms, all for delivery to the precious metals portion of the refinery, and the anode scrap removed for recasting.

During operation, the DC power was supplied by motor generators operated at 16,000 amps. The cells were electrically connected in series with the electrodes in each cell in parallel. Electrolyte flowed through the cells at 4-5 gpm in six circulating systems. Electrolyte temperature was maintained at 135°F - 145°F by steam heating though Karbate heat exchangers.

Kennecott [1988] also indicated that glue and thiourea were added to the electrolyte to enhance quality and smoothness of the cathode deposit. Electrolyte purity was maintained by bleeding a portion of the electrolyte for treatment. Electrolyte volume was maintained with water and sulfuric acid additions.

Cathodes were delivered to the cathode washing machine by overhead cranes. The cathodes passed through a three stage wash, were stacked, weighed, banded, and loaded. By-products of the plating included anode scrap which was melted by electric arc furnaces and casted into new anodes. The furnace was a 7 megawatt electric arc furnace which contained 50 tons with a melting capacity of 20 tons/hour. A Walker type casting wheel with 14 molds was used. A barite slurry was used as a mold wash on each revolution of the wheel. About 3200 tons of anode scrap was remelted each month.

Off gases from the refinery were offensive to the workers and was one of the reaons why Garfield residents were moved away from proximity to the refinery.

The Kennecott [1988] report listed the following by products which were recycled back to the smelter: SC cakes reject, anode pit metallics, refined pit metallics, arsenical cathodes, Dore slag, foul cathodes, reject anodes, spent refinery anodes, anode brick cobbings, anode furnace flue dust, baghouse dust, Bosh pond cleanings, cast house sweepings, EP sludge, refined brick cobbings, silver refinery concrete, and west yard cleanings. (The Bosh pond was a storage facility for furnace cooling waters and was located behind the tankhouse.)

A section of the refinery circuit was called electrolyte purification. In this section soluble impurities were removed from the electrolyte including arsenic, antimony, bismuth, nickel, iron and lead. The insoluble impurities created a sludge containing selenium, tellurium, gold, silver, platinum, and palladium. This sludge was sent to the silver refinery section for reclamation. The refinery in 1956 was described as 36 commercial and 4 stripper sections each 34 cells. Each cell could hold 41 anodes.

The silver refinery department was also called the slime treatment plant [Kennescope, 1956]. The process included leaching, filtering, fusing, and then smelting the slimes in a small furnace. (Before smelting, the slimes were cooked to volatilize the selenium which is then scrubbed and filtered to produce a pure selenium product [UDEQ]). A gold and silver alloy called dore was recovered and cast into small anodes. These anodes were electrolytically refined. The silver deposits out as loose crystals on stainless steel cathodes. The crystals were periodically removed and cast into ingots. The gold mud from the cells was boiled in sulfuric acid to remove remaining silver and the gold is then filtered and cast into gold anodes. The gold anodes were suspended in small porcelain cells in a solution of acidified gold chloride. Impurities drop to the bottom of the cell and platinum and palladium are dissolved. The gold cathodes formed are removed, washed, melted and cast into ingots.

Kennecott [RI, 1999] described the selenium circuit in the precious metals building. The process produced about 220,000 pounds of 99% pure selenium each year, and operated between 1950 to 1995. In general, selenates and selenites were produced by heating of the selenides in an electric furnace. Sulfur dioxide is added to convert the selenates and selenites to elemental selenium (97% pure) which is further purified in a retort to a final purity of 99%. Although Kennecott measured the selenium in the various steps of the process, they did not determine the exact species of selenium - just total selenium. Within the total process, all forms of selenium were present at one stage or another. It is known that the process solutions contained up to 100 gms/l of Se.

An abandoned evaporation pond is behind the refinery (see Refinery evaporation pond). Several processes are used in the refinery including commercial cells (electroplating), stripping and looping, electrolyte purification, silver refining (roasting, reverberatory furnace, electrolytic separation to recovery selenium, gold, silver, platinum, and palladium.)

According to Kennecott [1996] wastes included electrolyte contaminated debris and selenium contaminated debris. Both are sent to a RCRA-permitted facility now. The electrolyte debris is hazardous based on arsenic, cadmium, lead and selenium. Debris generated during the refinery modernization project was sent to the smelter landfill or smelter concrete monofill for non-hazardous waste and to USPCI for hazardous materials.

In a recent inspection by UDEQ, it was revealed that electrolytic wastes had been spilled over the years contaminating soils underneath the floor of the tank house. This report [UDEQ, 1994] indicated that prior to 1974 (1959 - 1974), electrolytic wastes were disposed into evaporation ponds. In 1994, UDEQ determined that a groundwater permit would not be necessary since the systems contributing to the releases would be replaced. UDEQ [1994] reports that the lead lined tanks are being replaced with acid resistant polymer concrete. Also the substructures and floors are being replaced with new acid resistant concrete, acid resistant paint and leak detection equipment. The sumps and drains are now part of a closed loop system which catches and recycles electrolyte.

Systems to be replaced include: (1) elimination of all furnace and casting operations and attendant cooling water requirements previously needed for casting purposes; (2) replacement of flooring, floor drains and pipes, sumps and other collection mechanisms for the Tank House Building where the electroplating operations are carried out; (3) replacement of the electrolytic purification building with a new building utilizing appropriate containment measures for any spills or leakages in this process; and (4) replacement of the precious metals recovery building with a new building and process that will eliminate potential discharges to groundwater [UDEQ, 1994]. UDEQ concluded that significant releases had occurred in the past. The refinery was modernized in 1993 - 1994. Structures include the Tank House, the new precious metals building, the old precious metals building, the old electrolyte purification building, machine and product control building, the administration building, shops, warehouse and garage. The refinery was modernized in 1995 to match the projected capacity of the new smelter. The new Precious Metals Building is located just to the west of the Tankhouse. The footprint of the Tankhouse remains the same. [Kennecott, 1996].

According to Kennecott [1996], the refinery area is about 45 acres located near the former town of Garfield, 1.5 mile East of the smelter. The facility before modernization produced 228,000 tons/year of electrolytic copper and 300,000 oz/year of gold and 2.8 million oz of silver.

A RI was conducted by ENSERCH [1994]. Previous sampling included the evaporation pond area in 1972. Soils underneath the refinery were studies in 1985. Copper concentrations ranged from 307 - 100,000 ppm. Concrete and bricks near the western fence line were studied in 1989. The materials were recycled for gold and silver. Soils beneath the foundation slab in the basement of the tankhouse were analyzed in 1992. In 1992, the concrete pad to the SE of the precious metals building and soils underneath the concrete were removed and recycled. Also in 1992, the railroad track bed in the East Yard was sampled. Railroad cars containing electrolyte purification sludges had been stationed there. Metals were elevated in the soils, but did not flunk TCLP.

During the Phase I RI [ENSERCH [1994], surface and subsurface soils in the vicinity of the refinery were sampled.

Surface soils

Element	Concentration	Where highest
As	1.9 - 975 ppm	new PM footprint, West Yard, existing PM building
Se	0.5 - 10,000 ppm	new PM footprint, West Yard, existing PM building
Pb	4.6 - 13,900 ppm	new PM footprint, West Yard, existing PM building

Surface Soils (SPLP)

As	above standard	new PM footprint, West Yard, existing PM building

Subsurface soils

As	1.1 - 9528 ppm	new PM footprint, West Yard, existing PM building
Se	0.5 - 21,340 ppm	new PM footprint, West Yard, existing PM building
Pb	0.7 - 5070 ppm	new PM footprint, West Yard, existing PM building

Subsurface soils (SPLP)

Se	above standard	existing PM building, new PM footprint, NW corner tankhouse, former Evap Pond

Two groundwater wells were installed downgradient of the Electrolyte Purification Bldg (which is also downgradient of the PM building) and at the SW corner of the Tankhouse. Groundwater in both wells exceeded MCLs for arsenic, selenium, and TDS. The MCL for selenium is 0.05 mg/l and the groundwater concentrations were 32 and 11.4 mg/l, and exceedance of 640 times and 228 times.

Additional samples were collected at the new Precious Metals building footprint, and adjacent to the existing Precious Metals building. The spot in the footprint with the highest metal and selenium values was a temporary stockpile of soil excavated from near the existing PM building. ENSERCH [1994] reports that this stockpile was sent to the smelter slag mill for reprocessing. Similarly excavated soils for waterline and pumphouse renovations were also sent to the smelter slag mill for reprocessing. Approximately 1500 tons were involved. Oversized materials were sent to USPCI (150 tons). "Visual observations of bright-red stained unexcavated soil remaining at each excavation indicated substantial selenium contamination remains in place" [ENSERCH, 1994]. They suggested that the major sources of today's groundwater contamination is near the existing Precious Metals and Electrolyte Purification buildings and that the former evaporation pond is a relatively minor source. Nitrate contamination sources were theorized to originate from nitric acid uses in the Precious Metals area. The RI concludes that the pattern of contamination indicates a source of repeated surface spills such as processing slimes, sludges, and liquids. This contamination is restricted to the top 15 feet. There is also indication of leakage from piping and sumps in the vicinity of the Precious Metals building. In both cases, there was enough gold and silver to warrant recycling.

The Garfield refinery was also the suspected source of high Se concentrations in the Garfield wells [EIS, 1995]. It is unknown how much Se escaped from the processing activities via spills and leaking pipes and sumps. For modeling purposes, Kennecott assumed that the Se present in the ground water originated from process solutions during the 1986 - 1995 time frame. Kennecott believes that the valence state of the Se in the soils and ground water was a function more of the original source than any reactions occurring after deposition. The highest concentrations of Se found in the ground water were 15 mg/l found in wells within the footprint of the former precious metals building or immediately downgradient. Kennecott removed contaminated soils surrounding the refinery for placement in the new repository on the Arthur stepback of the Magna Tailings Pond. The top 10 feet of the soils underneath the building were excavated and replaced with fill and a vegetated cap. Waste still remains underneath the cap.

Filter presses were stored in the backyard of the refinery on bare earth. This, along with broken pipes and leaky sumps, contributed to the selenium in the ground water.

Demolition of several older facilities was conducted [Kennecott, 1996]:

1. The old Precious Metals building processed anode slimes from the Tankhouse by thickening them with a filtered decant solution. The thickened slimes were pressure leached with sulfuric acid and oxygen. This removed over 99% of the copper content. The residue was filtered, washed, and air dried in a filter press. Elemental selenium, silver, and gold were produced at the refinery. Refinery waste solutions were pumped to the WWTP for neutralization and heavy metals removal.

2. The EP building was used to maintain the electrolyte solution, control copper content and soluble impurities such as arsenic, antimony, and bismuth, and control organics by electrowinning in cells containing insoluble lead anodes.

3. The chemical and physical laboratory was used as an assay laboratory to support Kennecott operations and quality control. The building was approximately 50 feet x 100 feet with a main floor and partial basement. The contaminants associated with the lab were found in the table hoods and dust.

4. The Lead Shop was used to construct and mold the liners for electrowinning cells used at the Electrolyte Purification (EP) building. The building is a small structure that has been cleaned and is currently being used as a shop with an adjoining lunch room.

Cleanup of the soils found around and under the old demolished refinery buildings involved excavation, stockpiling and recycling of 7140 tons of soils containing gold to Barneys Canyon, 950 tons of soils containing gold and silver to the smelter. About 16,400 cy of contaminated soils were located in places too deep to excavate (without undermining existing facilities). This area was capped, covered with soil and revegetated. This site was addressed in the North End ROD of Sept 2002.

MODERNIZED REFINERY (facility #99B)

In 1995, Kennecott modernized its refinery operations to increase capacity (310,000 tons/yr) to match that of the new smelter and to use more automation thereby reducing operating costs (35%). The modernization, designed by Bechtel and costing $164M involved upgrading the electrorefining process for copper within the existing Tank House building and construction of an entirely new precious metals refinery process and building.

In the Tank House, electric current causes copper to migrate from copper anodes (98,5% copper, produced by the smelter)to the cathodes which are 99.9% pure. One upgrade called the Falconbridge Kidd Process involved using stainless steel cathode starter sheets rather than the former copper sheets. Another was installation of thin-walled polymer concrete cells to replace the lead lined concrete cells. Also new rectifiers were installed to increase the electric current to the cells. Finally, automatic computer controlled laser guided vehicles to transport batch loads of materials from the cells to materials handling were added.

There were 1424 new cells, each 4 feet wide, 5 feet deep, and 16 feet long designed to hold 46 electrodes (cathodes and anodes). The battery powered automatic carts are 8 foot wide and 18 foot long. The carts are called robotic Automated Guided Vehicles (AGVs). After the cathodes are removed from the tanks (using overhead cranes), they are rinsed and the two copper plates are broken loose from each side of the starter sheets. The copper plates are corrugated for easier shipping, and the bundles strapped to await shipment, usually by rail.

In the process of producing the high purity cathodes, the impurities in the anodes drop to the bottom of the cells. These impurities, called "slimes" contain such impurities as gold, silver, and selenium. These slimes are processed in the new precious metals building.

The old process involved pyrometallurgical separations (high temperature). The new process is hydrometallurgical using sequential extractions, leaching, precipitations and filtration. Gold bars, silver bars, selenium powder and lead sulfate are produced [Bechtel, Pay Dirt, 1995].

The new hydrometallurgical process for recovery of by products from the slimes is described in some detail by Hoffmann, Sutliff, Wells, and George [1995]. In summary:

1. Copper and tellurium are removed from the slimes by pressure leaching with sulfuric acid in two steps.

2. The decopperized slimes are oxidized with chlorine to form soluble chlorides of gold, silver and antimony.

3. Gold is extracted from the chloride solutions using dibutyl carbinol (DBC) which is later scrubbed to remove co-extracted impurities.

4. Oxalic acid or sodium oxalate is used to reduce the DBC and liberate crystallized gold metal which is washed with water and alcohol.

5. Selenium is recovered from the gold-free solution by reducing the acid to elemental selenium using sulfur dioxide. The selenium is distilled to produce a pure product.

6. The metals remaining in solution include platinum, palladium, and rhodium which are recovered.

7. The chlorination leach residue is leached with ammonium hydroxide, washed with soda ash, then nitric acid. A silver chloride product is produced as a precipitate and the lead is in solution in the form of lead nitrate.

8. The silver chloride is further treated with ammonia leaching and then reprecipitation of the silver chloride as the ammonia evaporates and sulfuric acid is added.

9. The silver chloride is reduced using dextrose or other reducing sugar forming gray metallic flakes.

The refinery process also includes circuits for recovery and reuse of reagents and treatment of residuals, some of which are recycled through the circuits several times before purification.

Kennecott [1997] indicates that the new plant technology produces gold in five days, as opposed to the 45-day cycle required in the old refinery process. The refinery now processes 129,000 gallons of anode slime per day from the tankhouse. The slurry contains solids, electrolyte, cell washwater, floor washwater and anode/cathode washwater. The slurry is pumped from the tankhouse to receiving tanks where the precious metals slime is settled and the electrolyte is filtered for return to the tankhouse.

Kennecott [1997] reports that chlorination leaching is the heart of the precious metals recovery process. The purpose of the process is to oxidize and solubilize the precious metals in the slime using a hydrochloric acid leach. This leach solution contains essentially all of the gold in the electrolytic slime. The gold is further refined using solvent extraction, finally producing a gold filter cake which is charged into an induction furnace where the gold is melted and cast in 400-troy ounce bars with a purity of 99.99%. A similar process is used for silver which is cast in 1,000-troy ounce bars. Current production is about 500,000 ounces of gold and 4,000,000 ounces of silver per year. Small amounts of platinum, palladium, selenium, lead and tellurium are produced as by products. The RCRA facilities ID is UTD000826412.

Because contaminated soils from the old precious metals footprint were stockpiled temporarily on the footprint of the new building, some cleanups were required prior to construction of the new building. This site was addressed in the North End ROD of Sept 2002.

OLD PRECIOUS METALS BUILDING (facility #99.01)

The old Precious Metals Building site is the original Precious Metals building footprint. The building was constructed in the early 1950's and contained individual recovery circuits for gold, silver, selenium, and other rare metals. "Various process solutions escaped." [Kennecott, 1998]. The area south of the building was paved in 1990 and the operations ceased at the building in 1995. The building was demolished in the summer of 1996. Soils characterization followed. [Kennecott, 1996]. The demolition of the building was completed in March 1997. The concrete floors and brick and cinder block walls of the building contained leachable selenium and lead. About 385 tons of this contaminated material was crushed (< 6 inches in diameter) and disposed in the Arthur Step-Back Repository. The remainder of the demolition debris was either sold for scrap or disposed of at the Tailings or Smelter landfills.

The subsurface under the building consists of 10 feet of silty and gravel fill on top of an 5 foot thick clay unit with silty sand lenses. Beneath the clay are silty sands (3-4 feet thick) followed by sandy gravels. Bedrock is about 40 feet down below the site and the ground water level is at 108 feet down. [Kennecott, 1998].

Prior to the removal, selenium concentrations were 0.5 - 1.0% Se in the top 10 feet. The Se concentration gradually decreased to the detection limit at around 100 feet. The most prevalent form of selenium in the soil was selenite. During the removal the top 10 feet was excavated. Deeper excavation was impractical due to the proximity of the nearby refinery tank house. A portion of the excavated soils were high in gold and silver. About 4200 cy of soil had recoverable gold and was hauled to the Barney's Canyon Gold mine. Another 500 cy with recoverable silver was stockpiled for recycling at the smelter. The remainder of the excavated soils (2530 cy) containing > 1000 ppm As and > 1000 ppm Se were hauled to the Arthur Stepback Repository. The total area excavated measured 150 ft. by 350 ft. with depth ranging from 2 to 15 feet.

Post removal samples contained elevated levels of contaminants remaining at the site:

As	1.1 - 6410 ppm
Cd	0.2 - 2.4 ppm
Pb	1.0 - 3530 ppm
Se	0.8 - 15200 ppm

The area is now capped with 24 inches of clay, a 6 inch gravel drainage layer, and an 18" layer of soil that will be vegetated. Runoff from the capped area will go to the Smelter Return Canal for use as process water.

The old precious metals building has been implicated as a source of groundwater selenium contamination. In 1993, selenium concentrations in groundwater at a nearby well reached as high as 40 ppm. Currently the nearest wells contain levels as high as 15 ppm Se. [Kennecott, 1998].

In another study, Kennecott studied the speciation of the selenium in the soils underlying the old precious metals building footprint. The major species of the selenium was elemental selenium and selenite. However the speciation of the groundwater contained solely selenate. Column experiments using the contaminated soil indicated that the leachate contained selenite but no selenate indicating that oxidation of the materials to the more mobile selenate form was not occurring very fast. Kennecott speculated that the selenate may have come from the original leaks of selenate rather than leachate from the selenite species. [Kennecott, 1998]. Kennecott will begin to explore options for treatment or containment of the groundwater in a Focused Feasibility Study due to start in 1999.

In a presentation, Kennecott staff suggested that most of the selenium leakages from the building occurred in 1986. Another source [Kennecott, 1982] indicated that "some leakage of selenium occurred in 1981" By 1982, the report indicated that the leak had been corrected.

Post building demolition characterization sampling was conducted in November 1995 and September 1996 of the soil in the building footprint area. An area of high-grade gold-bearing soil with arsenic and selenium contamination was identified. Removal of this material was completed in November, 1997, and 7,140 tons of high-grade gold soil was hauled to Barney's Canyon Gold Mine for leaching. About 2,200 cubic yards of selenium and arsenic contaminated soil was hauled to the Arthur Step Back Repository. The average soil removal depth was four feet.

A Kennecott report [1999] described the metals recovery. During the cleanup of materials underneath the former Precious Metals Building, 7140 tons of gold-bearing soil was transported to Barneys Canyon where 2000 oz of gold were recovered. Approximately 950 tons of silver bearing soil was transport ed to the smelter for reprocessing. It is estimated that this soil produced 470,000 oz of silver and 570 oz of gold. Approximately 16,400 cy of soils contaminated with Se and As over a 1.7 acre area were left in place and capped. About 2230 cy were hauled to the Arthur Stepback Repository.

During the excavation of these soils, scientists observed that the footprint soils of the former building were discolored by process solutions and at some locations visually penetrate the underlying clay unit. The eastern third of the building footprint was primarily discolored green through the upper sandy gravel unit. In the southeast corner moderate to strong red discoloration was observed. The entire south side of the building footprint was discolored red, black and yellow-brown into the clay unit. In the location of a former sump, strong red discoloration was observed into the clay 9 feet below surface. The central precious metals section of the building was strongly colored green under the former moebious cells. The green discoloration penetrated the clay unit below the moebious cells but was primarily in the upper sandy gravel unit.

All post removal soil sampling was completed in December 1997. Fifty-seven samples were collected, 16 of which exceeded action levels for total arsenic, selenium, and lead. Thirty four samples exceeded leachability toxicity characteristics for selenium. The removal area has been backfilled. A cap for the site has been designed and approved. [Kennecott, August, 1998]. Capping was completed in 1998 [Kennecott, 1999].

REFINERY EVAPORATION PONDS (facility #77)

Between 1950 and 1974, Kennecott operated an evaporation pond behind the refinery building. Spent electrolyte and other refinery waste waters were discharged to the ponds at a rate of several gallons per minute. In 1974, when these waters were redirected toward the then new WWTP, they contained 250 mg/l Se, 350 mg/l As, <0.5 pH, at a flow of about 100 gpm. Reports vary as to whether or not the pond was clay-lined. The area was about 200 feet wide and 600 feet long and situated in a topographical depression, created by a railroad grade located to the north, the Oquirrh Mountains to the south, and the West Laydown Yard to the northwest. The pond was located to the west of the precious metals building across the RR tracks. Sludges were removed in 1972 and 1982 and processed for recoverable copper. ENSERCH [1994] reports that in 1972, the pond was drained and 830 tons of sediments were removed. This sediment contained 7137 pounds of copper, 21,575 pounds of selenium, along with gold and silver. The sediments were sent to the smelter for recycling. The pond measured 500 ft long by 200 ft. wide. The excavation materials from the work done in the 1980's was also sent to the smelter for metals recovery.

ENSERCH [1994] conducted a RI of the refinery area and two cores were collected in the evaporation pond area. At 55 feet down, one sample had 496 ppm As and 303 ppm Se. The other sample found 1850 ppm As and 334 ppm Se at 40 feet down. The zone of elevated metals occurred over 15 feet thickness with evidence of As leaching through underlying soils for another 15 - 20 feet. Se in the materials in the pond flunked SPLP leach tests. There are several layers of contamination on the pond area. Wells downgradient of the site contain high selenium.

Additional surface samples were collected in 1996 [Kennecott, 1996]. Five of 23 samples were elevated in arsenic, lead and/or selenium. Maximum concentrations were 513 ppm As, 9935 ppm Pb and 7332 ppm Se. In 1997, contaminated surface soils were removed to a depth of 3 feet. Approximately 400 cubic yards of material were removed and taken to the Arthur Set Back Repository. About half of the area still had elevated metal concentrations even after the removal of surface soils. Maximum concentrations after the removal were 8790 ppm As and 14800 ppm Se. The whole area was regraded, capped with four feet of fill, and revegetated. This area was capped and provided with run-on/run-off controls in 1998. Sensors indicate that water is not percolating through the new cap. This site was closed out by the North End ROD of Sept 2002.

EAST RAIL YARD SITE (facility #99.02)

The East Rail Yard Site is a bench area along the railroad corridor near the refinery. It was a dumping area for slag and fly ash with other metal debris. Characterization sampling indicated that one of the 23 samples was elevated in arsenic. This sample was collected from an operational area of the railroad, and removal will occur once all operations on this rail line are complete. Maximum concentrations were 211 ppm As, 5 ppm Cd, 427 ppm Pb, and 17.8 ppm Se. [Kennecott, 1996] The site covered about 4.8 acres.

ELECTROLYTE PURIFICATION (facility #99.03)

The Electrolyte Purification Site is the Electrolyte Purification building footprint part of the old refinery. The purpose of the electrolyte purification operation was to remove impurities from the electrolyte and recycle it back to the tankhouse of the refinery. It maintained the electrolyte solution, controlled copper content and soluble impurities such as arsenic, antimony and bismuth and controlled organics by electrowinning in cells containing insoluble lead anodes. It had 48 lead-lined concrete cells. Wastes were disposed of behind the building in the refinery evaporation pond (see 77) between 1950 and 1979. After then, the wastes were sent to the former wastewater treatment plant.

The Refinery Electrolyte Purification (EP) Building was demolished during April and May, 1996. Prior to demolition, 14 samples of soil were collected below the concrete floor of the building and analyzed for total arsenic, barium, cadmium, chromium, lead, mercury, silver, selenium, and copper. Other than arsenic, no analytes were found in elevated concentrations. Five of the arsenic samples contained concentrations in excess of 200 ppm, averaging 1060 ppm.

After demolition of the building with its 48 lead lined concrete cells and removal of the concrete floor, 69 soil characterization samples of the demolition footprint area were collected. Lead and arsenic contamination was found at scattered locations to depths of 18 inches. About 1650 cubic yards of contaminated soil to a depth of 18 inches were removed and ultimately stored at the Arthur Step-Back Repository. The full areal extent of the soil contamination was not determined as the site needed to be backfilled to provide a staging area for the demolition of the adjacent Precious Metals Building, although some post-removal, pre-backfill soil sampling did not contain any elevated concentrations of any of the analytes.

During demolition of the building, the lead liner and plumbing pipes of each of the concrete cells were removed prior to pressure washing of the concrete. The collected wash water was pumped to the New Precious Metals Building for recovery of gold and silver. The concrete cells were hauled to the Smelter Concrete Monofill for disposal.

LEAD SHOP (facility #99.04)

The Lead Shop Site is the Lead Shop Building footprint. The Lead Shop was used to manufacture lead linings for the electrolytic cells in the tankhouse. The Lead Shop was demolished in March, 1997, after collection of characterization samples. None of the building material was found to contain elevated concentrations of any of the analytes. The building debris was disposed of in the Smelter Landfill. The interior of the building was cleaned and the building is now in use as a shop and lunch room for the refinery. Site restoration was completed in April, 1997. The site is 0.11 acres.

Post demolition sampling was conducted in March, 1997 for soil characterization of the footprint area. Six samples were collected for total arsenic, cadmium, lead, and selenium and the leachable 8 RCRA metals. None of either set of samples contained exceedances of action levels or leaching limits. All work was completed at the site as of May, 1998.

ELECTROLYTE PIPELINE CORRIDOR (facility #99.05)

The Electrolyte Pipeline Corridor Site is the location of the old electrolyte pipeline that transported spent electrolyte solution from the Refinery Electrolyte Purification building to the WWTP. [Kennecott, 1996, 1998]. The site is located immediately north of the refinery complex. The pipeline trends from the refinery, northwest for approximately 500 feet and then northeast for approximately 2200 feet to the Waste Water Treatment Plant. The pipeline corridor passes through the old town site of Garfield and crosses underneath State Highways 201 and 202. The site was about 0.6 acres.

The pipeline is a six inch diameter, HDPE pipe that is buried to a depth of two to three feet. The site was characterized in the summer of 2001. The characterization sampling concentrated on the material immediately below the pipe. No contamination was found. The site was closed out by the North End ROD of Sept 2002.

WEST LAYDOWN YARD (facility #99.06)

The West Laydown Yard was located SW of the Refinery Precious Metals building and NW of the Electrolyte Pond. The site was an historic dump consisting of refinery demolition debris, refinery waste material and fill soil. The area of contamination was 75 ft by 350 ft and was about 2 - 12 feet deep in a V-shaped trench configuration along the tracks (SW boundary of refinery).

The debris at the site included metal, pipes, glass, brick, concrete, asphalt and lumber. Black, red, brown and green discoloration of the soil and debris was observed. Also present was assay lab wastes identified by crucible fragments. Elevated As, Se, and Pb were found.

The soil and debris was screened (6 inches). The metal and crucibles were hand picked from the screened material. The crucible fragments went to the Arthur Stepback Repository. About 14,550 cubic yards was sent to the repository. The metal debris was disposed at the tailings pond landfill. The rest of the debris was used for backfill at the site. This debris pile was 100 ft x 15 ft x 6 ft. The rest of the backfill was soil borrowed from a source immediately SW of the site. The site was then graded to drain to an existing culvert passing beneath the RR tracks on the NE perimeter of the site. [Kennecott, 1999]. It was about 1.3 acres. The site was completed in October, 1997. The site was closed out by the North End ROD of Sept 2002.

KESSLER SPRING DUMP (facility #99.07)

A dump of contaminated soils was discovered in the spring of 1998 near Kessler Springs (close to the intersection of Hwy 201 and 202). Approximately 4156 cubic yards of soil were removed from this area and hauled to the repository. The soils contained elevated concentrations of arsenic and selenium, and were nearly 1% copper and about 100 ppm silver. Because of the elevated silver, Kenecott theorized that the wastes originated at the refinery. The area affected was about 350 ft x 150 ft (1.2 acres). Post removal samples did not contain elevated levels of contaminants. The highest arsenic after removal was 129 ppm. See also Springs.

OIL STORAGE SITE (facility #99.08)

This site contains some berms around a oil storage tank with piping through the berms. The piping was still suspected to contain product. The site is 280 feet by 170 feet. Initial characterization took place in July, 1997. No elevated metals were found in the soils, but 2 samples contained elevated petroleum hydrocarbons [Kennecott, 1998]. After removal of the tanks and piping the area was regraded. No other actions were taken. The site was closed out by the North End ROD of Sept 2002.

BOILER BUILDING FOOTPRINT (facility #99.09)

This site is the footprint of the former boiler building at the site, which is approximately 100 feet by 100 feet. For new refinery operation, the function of this lab were transferred to the new consolidated laboratory near the Arthur Administration Building. Characterization of the building itself took place in January, 1995, prior to demolition due to detection of lead in air monitors. It was found that the lead was due to paint. After demolition the footprint was sampled and no elevated contaminants were found. The site was reclaimed. It was 0.25 acres. Now a new building occupies this site. [Kennecott, 1998] The site was closed out by the North End ROD of Sept 2002.

ASSAY LAB FOOTPRINT (facility #99.10)

This site is the footprint of the former refinery chemical and physical laboratory and measures approximately 100 feet by 100 feet. The building was characterized in May and June, 1995, prior to demolition. Contaminants found in the building (scale, precipitate, and dust) were removed when the building was washed prior to demolition. The wash water was directed to the Waste Water Treatment Plant. Contaminated sediment found in the duct work was taken to the WWTP Pond C for temporary storage until disposal in the Arthur Stepback Repository. The sediment amounted to less than 3 cubic feet. Following demolition, characterization of the soils underneath the former building was conducted in July, 1995. The soils contained no elevated levels of contaminants. [Kennecott, 1998]

BRIDGE CRANE REMOVAL (facility #99.11)

After modernization of the Tank House building, a bridge crane in the Materials Handing portion of the building was no longer needed. It was removed from inside the building and sold. There was no characterization needed. [Kennecott, 1998].

99.12 R1-R2 CONTAINMENT AREA (facility #99.12)

This 50 feet by 65 feet area was characterized in May 1995 and found to contain contaminated soils from diesel fuel. At least 1500 cubic yards is estimated to be contaminated. The site is located just to the east of the anode storage area. Kennecott operations paved this area over to expand the storage area. When operations no longer needs the area, Kennecott plans to reopen the site, more fully characterize it and dispose of the hydrocarbon tainted soils. There were two above ground storage tanks which contained #2 fuel oil. After draining these tanks, Kennecott discovered about 1" of sludges in the bottom of both tanks. The sludges were removed and the tanks demolished.

99.13 BOSH POND (facility #99.13)

The Bosh pond was a water storage area for cooling water for the anode remelting furnaces at the old refinery. It was located SE of the tank house. It was concrete lined and was mucked out occasionally. Kennescope described the Bosh Pond as a settling pond for the cooling water for the three arc furnaces at the refinery. The circulation rate was 3000 gal/min. The water was pumped from a pond into a cooling tower equipped with numerous redwood baffles. A fan near the top created a jet of air. The cooled water flowed into the Bosh pond. From here, the water was fed under pressure through pipes to the furnaces. After use for cooling, the water went back to the Bosh pond. Make-up water was added at a rate of 95 gal/min. Some of the water was drained to prevent formation of scale. "Chemicals were added to prevent scaling and corrosion". Also brome and chlorine gases were added to combat algae. (Kennescope, July, 1958). The pond has been removed. The area is currently capped with asphalt and is used for storage of electric rectifiers and transformers.

99.14 SANTA FE BASIN (facility #99.14)

The Santa Fe Basin was east of Materials Handling, south of the Rl/R2 tanks and directly south of the outdoor overhead anode crane. It was used to decontaminate trucks. The facility consisted of a concrete basin, sump, and pumphouse that is approximately 60 feet by 70 feet. The basin is appproximately 8 feet deep and is ramped up to the north. The concrete was weak to moderately degraded locally and discolored from copper and iron oxidation. There was concrete, scrap metal and tainted soils scattered about the area. Prior to demolition in 1997, the concrete was sampled and found to contain high levels of arsenic, particularly on the basin floor. After demolition, the underlying soils did not contain metals above action levels. No further cleanups were needed.

REFINERY STORM WATER CANAL (facility #99.15)

On an old map a drainage was marked which started just downstream of the refinery and ended at a culvert leading to the Garfield wetlands near Kessler Springs. In a letter to Rob Walline (EPA, 1981), Kennecott indicated that there were leakages in the selenium circuit and they planned to abate the problem by blocking a storm drain and installing overflows on the sumps. In 2000, the storm drain was found and sampled. Just upstream of a head gate, sediments were high in both selenium and arsenic. At the head of the drain was a concrete structure that was apparently used as a storm drain outfall. The ditch leads to a culvert under SH 201 right at the Kessler Springs. The site is bordered on the south by the refinery complex, on the east by the Garfield Town Site, on the west by a railroad corridor, and to the north by State Highway 201. The site consists of two settlement ponds and a ditch. The settlement ponds are approximately 300 feet by 100 feet each and constructed with earthen berms. The wester most pond in lined with a HDPE liner. The settlement ponds drain to an unlined ditch at is approximately 20 feet wide by 1400 long. The ditch drains through a culvert to the Garfield wetlands in the Kessler Spring area. The area of the site is approximately 20 feet wide by 1400 feet long. Apparently, the ditch had been mucked out previously with the sediments piled on the banks. The contaminated soils (1700 cy) from this old ditch and banks were removed in 2001-2002. Additional sediment removals were required later when additional contaminated soils were found (NFS, 2003). A total of 4240 cy of soils were removed to the Arthur Stepback Repository. Now the storm waters when originally went into the canal are piped underground to the Smelter Return Canal. From thence, the waters go the Pump Station #4 for use as process water.

CHAPTER 18
HISTORIC WASTE AREAS NEAR MAGNA

Before environmental regulations, milling, smelting, and refining operations of the past generated wastes which were typically dumped or piped to nearby areas for disposal. Some of the waste areas were obvious even to the casual observer. Others were found by examination of historic photos and records. Yet others were found during the course of recent construction activities. There are undoubtedly other waste locations yet to be found. This chapter describes what is known about the origin of these historic waste locations and what was done in terms of cleanup activities.

BLACK ROCK TAILINGS POND (facility #72)

Located approximately one mile west of the Garfield Smelter is an impoundment at the mouth of Black Rock Canyon. It was created by Kennecott Corporation for the disposal of tailings produced by the use of a slag mill and concentrator that was erected at the smelter complex in 1977.

Implementation of the continuous smelting process at the smelter in late 1977 caused a considerable amount of metal loss in the slag produced by the Noranda Reactor type smelting vessels. This necessitated the re-treatment of slag to recover those losses. The waste product of that re-treatment (slag tailings) was initially disposed of in the Black Rock Tailings Pond. Kennecott indicates that the use of the impoundment at Black Rock Canyon was discontinued in 1984. According to Kennecott [1996], the site was a disposal area for tailings from a slag mill. Approximately 434,000 cu yds were generated. After 1984, the tailings were piped to the main Kennecott tailings impoundment. The Black Rock Tailings have been capped. This site was closed out in the North End ROD of Sept 2002. Since then, a company has leased a portion of the Black Rock Canyon for the purpose of a sand and gravel operation. Kennecott has required that the area be reclaimed after the sand and gravel mining ceases. The state has indicated that no materials containing lead greater than 500 ppm leave the site.

SMELTER SLAG (facility #73)

Generation of slag as a waste product from the Garfield Smelter has occurred almost continuously since the fall of 1906 when the smelter first began operations until 1977 when the smelting process was changed to the Noranda process. Historic deposition of smelter slag has occurred throughout the area of the present smelter complex, with construction of many subsequent plant facilities on historic slag dumps. [SAIC, 1991]

The predominant area of deposition is located immediately north of the smelter complex, between State Highway 201 and Interstate Highway 80. The slag heap contains approximately 20 million tons of slag derived from two distinctly different processes. Early deposition resulted from the use of trams hauling large vats or pots of slag that were dumped directly onto the ground. [SAIC, 1991] The smelter slag was first air cooled and deposited on the south side of Highway 201. The disposal was moved to the north side of the highway when space became limited. Historically, small quantities of flue dust and storm water sediments from the north concentrator were also deposited of on top of the slag pile. [Kennecott, 1991]. In 1967, a process that granulated or prilled the slag was put into operation. This allowed the slag to be transported in the form of a slurry to the disposal pile.

Since the redesign of smelting operations to use the continuous smelting process, slag has been re-treated to recover its high copper content at a milling and concentrating plant built at the smelter facility. Wastes (slag tailings) from this plant are currently disposed of in the Magna Tailings Pond. Until recently, the historic smelter slag remaining at the disposal pile north of the smelter was being processed by Union Pacific for use as an abrasive and roadbed and railbed material. [SAIC, 1991] The entire slag pile was leased to Union Pacific in 1991. [Kennecott, 1991]. At that time, it was estimated that the slag would be gone within 5 - 10 years at the rate of export by Union Pacific.

Beginning in 1995, Kennecott canceled the lease with Union Pacific and began using the slag for its own needs. It is being used as rail ballast for the relocated railroad tracks (the former railroad tracks were in the pathway of tailings pond expansion) and for a drainage blanket underneath the dikes of the new tailings pond expansion. Union Pacific equipment which has completed crushing and sizing the slag for Kennecott's drainage blanket was demobilized from the site (1998). The stockpiles of slag will remain in place until it is needed in Phase 11 Tailings Pond construction projects in 2004. It is anticipated that the slag on the north side of Hwy 201 will be completely removed by the Tailings Pond Construction project. Slag from the south side of the road (which forms a massive bluff adjacent to the road) may also be used for the tailings pond project. Currently the top of this slag bluff is used for a laydown yard for the smelter demolition and removal project.

Most of the slag above the water line has been excavated on the north side of Hwy 201. In the process of excavation, a historic dump of construction or demolition debris, and lab wastes was found under the slag. This dump was excavated and staged at the site for later placement in the Arthur Stepback Repository. Now, slag under the water is being excavated for use at the tailings pond. In this process an area of slag with heavy petroleum contamination was found. The oil contained substantial concentrations of PAHs. Kennecott plans to mix the slag/oil mixture with clay to stabilize it and place it in the Arthur Stepback Repository. Soils underlying the slag will be sampled and removed as needed during the North Facilities Soil Removal project.

Because the slag was proposed for reuse as a drainage blanket underneath the new dikes of the Magna Tailings Pond expansion, Dames and Moore conducted some sampling of slag to assess the useability of slag for this purpose. They reported the following average concentrations (ppm): As = 213, Ba = 331, Cd = 34, Cr = 154, Pb = 665, Se = 14.5, Ag = 1.0, Cu 3031. The slag was not leachable under SPLP testing. Very few TCLP tests are available.

The footprint of soils beneath the slag dump (former Union Pacific portion) will be characterized once the slag is removed. If necessary it will be removed as a part of the North Facilities soil removal.

SMELTER POND (LAST CHANCE POND), also see West Process Water Pond. (Facility #74)

There is a small pond just north of the smelter which was originally installed to contain spills at the smelter. Kennecott [1997] reports that prior to the construction of the new smelter the pond was used as a settling basin for storm water runoff from the Noranda Smelter. Over time, the Last Chance Pond filled with slag concentrate from the slag mill located up gradient. Kennecott says that the old sediments in this pond are largely concentrates. They excavated this area and recovered these concentrates for further processing. This pond was called Last Chance pond because it was the last chance to recover product spills before they went to the Great Salt Lake. All the concentrates and discolored soils were excavated and recycled to recover the copper. A composite sample of the sediment in this pond contained about 21% copper.

A new lined stormwater pond was constructed near this site as a part of the new smelter facility. In 1992, a groundwater discharge permit was issued by UDEQ for a facility called the Smelter Interim Process Water Pond at the same location as Last Chance Pond. See West Process Water Pond. The site was closed out by the North End ROD in Sept 2002.

FLUE DUST DISPOSAL AREA (facility #75)

Flue dust was disposed in a small bench area just to the south of the smelter stack. This area was used between 1970 and 1990 [Kennecott, 1996]. Since the flue dust exceeded the RCRA toxicity characteristic levels for As, Cd, and Pb, Kennecott has removed most of the flue dust itself to USPCI, but traces of flue dusts and underlying contaminated soils are still visible by blue-green staining and elevated arsenic concentrations in this area. This area was included in the North Facilities Soils Removal, and was completed in 1998. The site was closed out by the North End ROD in Sept 2002.

RAILROAD FLUE DUST AREA (facility #76)

In the early days of Garfield smelter operations, flue dust was deposited in an area where the old flues serving the 300 ft stacks were located. This area is now under some railroad tracks near the smelter.

Kennecott [1997] reported that prior to the Noranda process, reverberatory furnaces were used at the smelter. Off-gases were carried by brick-lined flues to an electrostatic precipitator. The "cleaned" gas was directed through underground tunnels (flues) which passed beneath the smelter upper railyard to the two 300 foot stacks.

Kennecott [1996] reports that off gases from the old reverberatory smelter, after treatment by an electrostatic precipitator were directed through 6 tunnels that passed beneath the plant railroad tracks to the inlet breachings of two stacks. Over the years, particulates carried past the electrostatic precipitator of the the old reverberatory smelter accumulated in the underground tunnels and uptake flues resulting in an accumulation as much as 5 to 6 feet of material in the tunnels and flues. The majority of the material was contained in the concrete tunnels. The uptake flue tunnels were 180' x 15' x 20' and are all that remain of the reverberatory gas handling system.

Because the south end of the tunnels were left open, some flue dust may have migrated leading to contamination immediately beneath and adjacent to the tunnels. Kennecott excavated accessible material and took it to USPCI. A portion will be retained for speciation purposes as this material may have similar characteristics as historic smelter emissions. Following excavation of flue dust in 1993, both ends of the tunnel were backfilled to prevent further migration. The tunnels were backfilled with structural materials because the tunnel walls were deteriorated and unsafe. The backfilled stack uptake flue area was landscaped and covered with 4 inches of topsoil. Residual contamination will be addressed during the North End Facilities removal action. The initial removal removed 11,463 tons of flue dust at a cost of $1,682,673 which was included in smelter modernization costs. The flue dust contained up to 66,970 ppm As, 120,600 ppm Pb, and 502 ppm Cd. The site was closed out by the North End ROD of Sept 2002.

SMELTER LAGOON (facility #102)

The smelter lagoon is a shallow unlined pond initially created from mining of lime sands for use as process flux. The lagoon is located along the northern edge of the Smelter Slag Pile by Interstate 80. Until recently, the lagoon received plant runoff from the smelter and drainage from Kessler Canyon. Runoff from the smelter includes meteoritic runoff, nonacidic process water and acidic water discharged during periods of operational upset (a.k.a. spills).[Kennecott, 1991].

According to a 1982 report, the "West Slag Pond" collected slag cooling and process water from which the waters were then pumped to the Smelter Return Canal for use at the North Concentrator. This lagoon was also tied into the stormwater system of the smelter and Kessler Canyon. The west slag pond covered an area of 31 acres at that time.

In 1981, Kennecott built a breakaway dike so that during periods of very high flows due to storms, the water would flow directly into the Great Salt Lake rather than cause the slag lagoon to overflow. This actually occurred 3 times in 1981. The Kessler Canyon drainage is about 3000 acres.

According to Montgomery-Watson [1993], the smelter slag lagoon has been identified by a number of names in the past: Smelter Pond, east slag pond, pond #2 east and west, Hazelton Pond, Smelter Process water pond, east Smelter Pond and Ponds 3 and 6. In Parametrix [1997] the west pond is labeled "slag pond" and the east pond is called "I-80 pond". In Montgomery-Watson, these are analogous to the West Slag Lagoon and East Slag Lagoon.

The lagoon covered roughly 21 acres and contained approximately 80 acre-feet of water. The sediments and sludges at the bottom of the lagoon were estimated to be 150,000 to 200,000 cubic yards. [Kennecott, 1991]

Kennecott [1996] indicates that the pond also holds surface water and well water prior to use in the smelter process water circuit. Kennecott thinks that some seepage to the Great Salt Lake may have occurred in the past. Today pond levels are maintained below lake levels.

Kennecott performed a site characterization study of the Lagoon in 1993. The Lagoon has existed since before 1977. In 1987, the lagoon was divided by a berm creating two ponds. It is not known how the ponds discharged water before 1980; either the C-7 ditch or conduits under I-80 to the Great Salt Lake were possible. At one time there was a conduit under I-80 but since the highway was raised in 1983-1984 the conduits, if any, are unknown. The ponds were 27 acres in size containing 1,669,000ft3 in the west lagoon and 335,000 ft3 in the east lagoon. Sediments in the lagoon range between 190 - 910 ppm As, 570 - 3500 ppm Cu, and 160 - 4200 ppm Pb. Four of 16 sediment samples flunked TCLP for arsenic. The water contained between 800 - 5700 ppm Na. Sediment ranged from 3" to 15" thick. Since the 1993 study took place, Kennecott has continued to remove slag from the southern boundary of the slag pond and the size of the pond has increased to 67.5 acres. The bottom of the new slag lagoon areas created by dredging of the slag is a layer of 2 - 4 feet slag. The rest of the lagoon had a layer 3" - 15" of black sandy sediment with the composition of concentrates. Since the initial study, copper in the sediments of the pond have increased and the As and Se decreased. This has been attributed to disturbances due to dredging along the north and northwestern portion of the slag pile (along the southern boundary of the slag pond).

The ponds sport a fringe of common reedgrass and Russian olive. There are several small islands some built up around power line tower footings. The Deepwater ponds are used as resting and feeding ponds for coots, ducks, and pelicans. The islands are used as nesting areas by avocets and stilts. Along the fringes nest wrens, redwinged blackbirds, and yellowheaded blackbirds. There is 1 endangered species (peregrine falcon) and 1 threatened species (bald eagle) plus several sensitive species identified by the state.

The north end wetlands contained the following concentrations of hazardous substances:

Substance	Water (mg/l)	Sediment (mg/kg)
As	0.012 - 1.02	<0.3 - 4142.9
Cd	<0.0005 - 0.015	<0.1 - 71.4
Cu	0.008 - 1.83	36.4 - 206508
Pb	0.0005 - 0.84	3.3 - 2156.9
Se	0.001 - 0.05	0.3 - 984
Zn	0.0025 - 0.21	9.4 - 2732

The slag lagoon was drained and the non-slag contaminated sediments were dredged. About 247,600 cy were removed and placed in the Arthur Stepback Repository, with 35,000 cy left in place.

SMELTER RETURN CANAL (facility #102.02)

The Smelter Return Canal, located parallel to SH 201, carried water from the WWTP back to the smelter. The canal is lined with common reedgrass with occasional stands of Russian olive. The vegetation is used by various songbirds, especially the marsh wren. The canal is no longer used for this purpose. East of SH202, the contamination extended 12 feet below the surface.

The canal sediments were contaminated with materials that looked like concentrates and other smelter wastes. It was the practice in former days to muck out the canal on occasion and place the sediments along the banks. The spoils were just left there to drain and erode into adjacent wetlands. Therefore, not only the canal itself was contaminated, the banks up to 200 feet away were also contaminated. The western end of the canal was dredged in 2000, and the wastes were hauled to the Arthur Stepback Repository. About 222,532 cy were removed from the canal and banks. This also included wastes from the Wooden Bridge site.

EAST HAZELTON (facility #102.03)

Located just to the south of the slag lagoon and just to the west of the slag piles are some wetlands called the Hazelton because the Hazelton pump station is located here. East Hazelton consists of a 3.5 acre area which was devoid of vegetation. It was formerly used as a dump site with a series of irregularly placed piles. Contamination at some places was at least 8 feet deep. Groundwater is at 1-2 feet beneath the surface and the ground surface is unstable for heavy equipment (Kennecott, 1999). About 99,400 cy of contaminated soils were removed from this area and West Hazelton.

WEST HAZELTON (facility #102.04)

Located just to the south of the slag lagoon and just to the west of the slag piles are some wetlands called Hazelton because the Hazelton pump stations is located here. West Hazelton consists of two bermed settlement ponds covering about 6.5 acres. The area is vegetated with a thick mat of grasses but has elevated As levels (Kennecott, 1999). This area was originally created by a delta of Kessler Canyon and was later contaminated with smelter runoff, spills and dumping. About 99,400 cy of contaminated soils were removed for this area and East Hazelton.

I-80 POND aka 120 ACRE POND (facility #102.05)

The I-80 Pond has been known by several names over the years in various reports including the East Slag Lagoon and the 120 Acre Pond. It is located just to the east of the Slag Pond and separated from it by a berm. There is no direct hydraulic connection between the pond except waters that infiltrate through the berm. In some seasons there is as much as a 6 foot water level difference between the two ponds (the slag pond being higher). In 1998, as the result of a settlement between Kennecott, UDOT and Saltair, UDOT installed a culvert between the I-80 Pond and the Great Salt Lake. (Saltair complained that water from Kennecott ponds was leaking under the highway and seeping onto their beach properties. The slow stagnant water created both an aesthetic eyesore and a odor nuisance. The new culvert was installed to reduce the head between the ponds and the lake thereby reducing seepage.)

The UPDES permit for the culvert is UTR 000467, issued June 12, 1998, and expires Dec. 31, 2001. The source of the water in the pond was described as a mixture of stormwater and ground water and the flow as less than 100 gpm. The culvert is about ½ mile west of the intersection of I-80 and SH202.

Removal of contaminated sediment from the pond was begun in the fall of 2000. The heaviest contamination was found in the western end of the pond. About 182,302 cy of contaminated sediments were removed from this pond.

WETLANDS LANDFILL (facility #102.06)

Located near Sludge Pond A was a former landfill which contained waste crucibles. The site was discovered during construction of the UP tracks. The natural ground surface was white to tan sandy clay. When the open water recedes, the flat barren surface was defined by desiccation cracks. The wastes were underneath salt grass. The area of the landfill was bout 1100 ft. x 400 ft. The crucibles were heavily contaminated but the rest of the landfill debris was not. Rather than try to pick out the crucibles from the waste, the entire land fill was excavated and placed in the Arthur Stepback Repository, about 17,691 cy.

WOODEN BRIDGE SITE (facility #102.07)

At one time, before the smelter return canal was cleaned up, there was a wooden bridge across the canal. Just to the west of this wooden bridge was a dump along side SH201, now called Wooden Bridge West. A similar dump along SH201 just to the east was called Wooden

Bridge East. The dumps were both about 300 feet in diameter. These sites were capped with clean fill, not because of high metals but because of the high acidity (low pH). The area was barren of vegetation because of the acid soils. The size of the site was 270 ft x 190 ft. The soils of the dumps were characterized as follows:

Wooden Bridge east

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	154	20.7	84.5
Cd	2.4	<0.2	1.7
Cu	686		686
Pb	911	13.6	428
Se	<0.5	<0.5	<0.5
Zn	-	-	-

Wooden Bridge West

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	691	23.9	202
Cd	12.4	<0.2	8.8
Cu	15200	499	3518
Pb	591	5.9	270
Se	5.6	<0.5	1.4
Zn	-	-	-

The soils were excavated because of their acidity and the volumes are included in the smelter return canal totals.

RAIL GRAVEYARD (facility #103)

In an area just to the south of the Bonneville Crusher along the railroad tracks was an extensive railroad equipment yard which contained rail stock no longer needed for ore transport. Old cars, rails, and ties were dismantled and sold for scrap. The site included multiple rail tracks for staging and storing the obsolete equipment. The area was covered with a few inches of silica slag from the Power Plant to drain the site and keep it dry. In 1993, a few railroad side dump cars remained in this area and also some relic coal piles.

In 1994, the site was reclaimed with the exception of one rail track that is maintained for scrapping old rail cars. The silica slag and excess soil from the site were used as fill for the Magna Mill Reclamation project. Some slag remains on-site. [Kennecott, 1997]. No contamination above action levels was found.

WASTEWATER TREATMENT PLANT SLUDGE (facility #105)

The Wastewater Treatment Plant was located southwest of the Magna Tailings Impoundment and just to the north of the refinery. The facility treated about 3,000 gpm of wastewater produced in the Kennecott refinery, smelter, and north concentrator, and discharged treated water to the tailings impoundment. The process produced about 250 tons/day of sludge. Five impoundments, covering approximately 115 acres were constructed in the vicinity of the treatment plant to contain the sludge produced. Of the five ponds, only Pond C-extension had a liner. This liner is constructed of clay. The earthen dikes of Pond D was constructed with a natural clay core. However, the construction of a bottom to this pond is unknown.

The major process equipment at the WWTP includes ferric chloride and slaked lime storage and delivery systems, mixing and neutralization basins, clarifiers, and sludge pumping and disposal facilities. The RCRA facilities ID is UTD000826436.

The northern portion of the facility area is marshy, and is subject to periodic inundation by flooding from the Great Salt Lake, and from surface runoff. The formerC-7 ditch flowed north of the plant, circumventing the sludge ponds A and B area north of the plant.

The sludges were the residue of lime treatment of low pH wastewater derived from acid plant blowdown in the smelter and spent electrolyte from the refinery. The plant also treated non-acidic process water and sewage from the smelter, refinery and North Concentrator. The treatment process was described in a Kennescope article as involving ferric chloride (conditioner), a flocculant, an anionic polymer, and lime. The clarified discharge flowed by gravity to the C-7 ditch. The cumulative processing of wastewater streams has left about 875,000 wet tons of accumulated sludge.

Treatment processes at the WWTP have been modified several times during past operations through the addition of lime, ferric chloride, or both. These modifications resulted in concentration variations of both total and leachable metals in the sludge. From start-up in 1974 through 1978, ferric chloride was added to the wastewater influent to stabilize some of the heavy metals. When the Noranda smelter was introduced the arsenic in the waste water increased from 1.59 mg/l to 9.68 mg/l. It is thought that this was due to increased air pollution equipment efficiency at the Norada smelter. The addition of ferric chloride was discontinued in 1982 due to operational difficulties, but was resumed in August 1991 to reduce the concentration and leachability of arsenic in the effluent. During the period 1983 to 1989, the WWTP was modified to use a high concentration lime process. The WWTP was completely shut down between 1985 and 1987. In mid 1989, the neutralization process was changed by reducing the pH from 12 to 10 to provide better control of the pH of the final effluent at the discharge location. The addition of ferric chloride resumed in August 1991 to reduce the concentration of arsenic in the effluent and to reduce the leachability of arsenic from the sludge. Most of this low-lime sludge was stored in Pond D, but some ferric chloride-treated, low-lime sludge was placed in Ponds B and C. [Kennecott, 1996]

The WWTP treated approximately 3000 gpm of which approximately 1250 gpm came from the smelter, 1300 gpm from the power plant, 300 gpm from the refinery and 150 gpm from the North Concentrator. The WWTP clarified effluent stream was approximately 4000 gpm due to the addition of lime slurry and water as a part of the neutralization process. The treated effluent produced a sludge residue at a rate of approximately 250 wet tons per day. Due to modernization of the Smelter and Refinery in 1995, the WWTP was no longer needed. The plant remained operational for treatment of decontamination waters generated from soil removal and demolition activities. [Kennecott, 1996] The effluent from the plant goes to the tailings pond. During the clean ups at the North End, the WWTP was used to treat decontamination waters. It was taken out of service in January 2000. Following closure, the plant was demolished and the footprint was cleaned up. About 20,371 cy of soils were removed to the repository. There were some storage tanks full of reagents. The ferric chloride (17,00 gallons) was disposed and the lime (150 tons) was taken to the Bingham Mine.

Recent investigations suggest that the volumes listed below may be in error. Coring revealed that several of the ponds were deeper than originally estimated.

The sludge is deposited in five locations; each is described below.

Impoundment (A) covers about 80 acres of partially diked salt flat northeast of the slag disposal area, of which 12.5 acres contains sludge. Pond A was used between 1974 and 1981. It contains approximately 63,000 wet tons (52,000 cu. yds), with depths up to 4 feet. Some of the Sludge is Pre-Noranda smelting residues and was produced with lime only. Lime/ferric chloride precipitation processes were used from 1974 to 1978. Upon further investigation, Kennecott [1998] indicated that the pond was 58.5 acres (750 feet x 3400 feet). A slag covered haul road acted like a dike on the southeast side - the entire pond was surrounded by dikes. The site is adjacent to the 120-acre pond. The sludge flowed to the southwest after filling the northeast quarter of the Pond area in a sheetwash manner for approximately 300 feet and appears to have continued southwest in several elongated lobes dictated by topography. Vegetation on the sludge improved with increasing distance from the discharge point with grass in the low lying areas and forbs and shrubs more prevalent on the higher ground. The majority of the sludge was mounded in the northeast end of the Pond around the vertical discharge stand pipe and was deposited up to eight feet thick in the center. The mounded area had little vegetation and was weakly cemented on the surface. It overlaid lacustrine sediments consisting of light gray-brown, oolitic, silty sand. The soil underneath the sludge was contaminated to an average depth of 12 inches. Two additional areas were discovered during the investigation where sludge was identified outside the limits of the dikes. One of the areas was at the northwest corner of the Pond where sludge breached the dike and flowed to the north 50 to 100 feet. The other area was to the southeast of the stand pipe on the southeast side of the slag haul road. Sludge was deposited adjacent to the haul road in a 50 feet x 300 feet area and also extends 150 feet farther in a shallow ditch. The volume of contaminated sludges, soils and sediments associated with Pond A was estimated at 120,000 cubic yards over a 20 acre area. The sludges and contaminated soils were removed to the Arthur Stepback Repository. No fill was brought in and the area was not revegetated. The area began to fill with water from the surrounding wetlands. Future restoration work is pending. The total sludge removed from this area was 145,842 cubic yards. [Kennecott,2000]

Impoundment (B) is located 200 feet north of the Wastewater Treatment plant, covers about 6 acres, and is approximately 16 feet deep. It was originally used from Feb 1981 to March 1983. In 1987, approximately 65,000 wet tons of sludge were stabilized in place with cement and the removed to the tailings impoundment. Impoundment B was again placed into service in 1988 and filled to capacity with about 145,000 tons of wet sludge in early 1989. High-lime Noranda sludge was derived from the high-lime processing operations in 1983 until operations shutdown in 1985. Operations were resumed in 1987 using high-lime processing until mid-1989.

Figure 57: Rusty colored calcium sulfate sludge slurried to a pond.

The sludges from Pond B were removed between June and September, 1997, dried and placed in the Arthur Stepback repository. Sludge volume was 104,000 cubic yards. The soils in the dikes surrounding the pond were originally as a roadbase for haul roads during the sludge removal. After completion the dike soils (47,090 cubic yards) were also removed to the repository. After the sludge and dike soils were removed, 35,000 cy of tailings were used to reclaim the site at the original grade pre-dike. Biosolids were then added and mixed into the top foot with grasses. The borrow source for the tailings was located at the southeast corner of the Magna Tailings Pond about 1/3 of the way up. [A temporary haul road was built over the top for use during the Pond C removal.] [Kennecott, 1999] The total removed from Pond B was 151,090 cubic yards [Kennecott, 2000]

Impoundment (C) is located about 500 feet southeast of the Wastewater Treatment Plan. It covers about 8 acres and varies from 16 to 36 feet in depth. This impoundment was used from 1983 to 1985, and again from 1987 to 1989. It currently contains about 283,000 tons of wet sludge (235,000 cu. yds) with approximately 5 feet of free board remaining in the pond. The pond periodically receives sludge during upsets where there are problems transporting material to Impoundment D. A total of 310,690 cubic yards was removed from Pond C. [Kennecott, 2000]

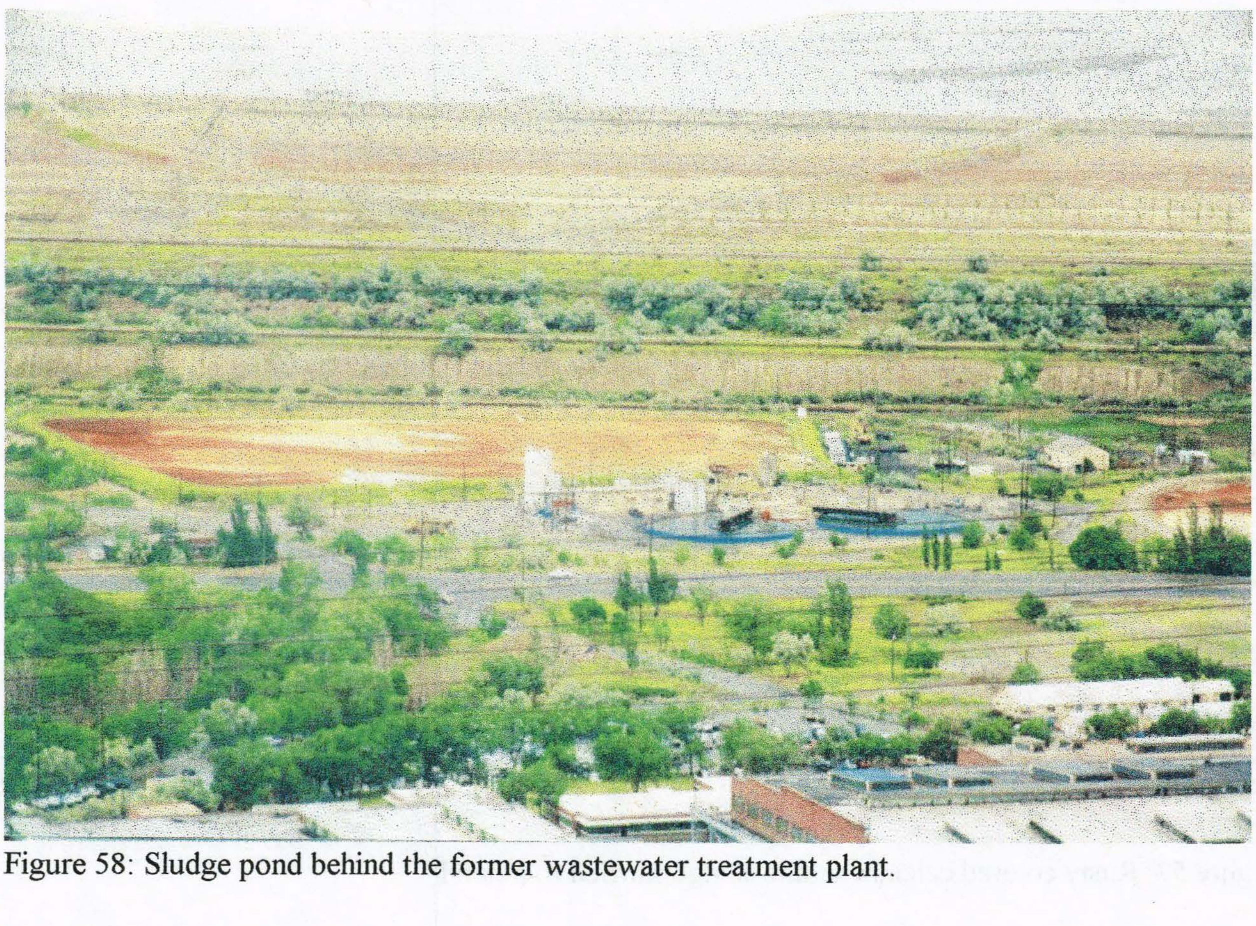

Figure 58: Sludge pond behind the former wastewater treatment plant.

Impoundment C extension is located directly southeast of Pond C. It covers about 4 acres with depths up to 14 feet and is the only pond with a clay lining. This pond was activated in the spring of 1992 and used continually until 1993. Currently, it receives sludge only when the material becomes too thick to pump to Impoundment D. It is estimated to contain about 60,000 tons of wet sludge. A total of 77,101 cubic yards was removed from Pond C extension.

Impoundment (D) is located northwest of the tailings impoundment (west of the tailings impoundment and immediately north of the current Union Pacific Railroad tracks), and occupies about 14 acres. When it was first started in 1981, Sludge Pond D was called the "new lagoon". It received adverse water from the North Concentrator. The flow went there for floc treatment and settling. Prior to its being used for treatment plant sludges, the sediments from the adverse concentrator water were excavated and placed on the north slag dump for storage prior to recycling [Kennecott, 1999]. It first received sludge in 1989 and was filled in 1993 after which the dikes were raised 10 feet to increase capacity. The original dike is earthen with a clay core. When its capacity was increased, a Claymax liner was placed on the interior slopes and keyed into the initial dike clay core. It currently contains approximately 326,000 tons of wet sludge and was receiving about 250 tons/day until the smelter was modernized. Removal of the sludges from Pond D was completed in the fall of 1999. A total of 271,640 cubic yards of sludge was removed and placed in the Arthur Step-back Repository. Another 15,715 cubic yards of materials used in the dikes were also removed to the repository. The slag used in construction of the dikes (28,594 cubic yards) was taken back to the slag pile.

Low-lime Noranda sludge resulted from the mid-1989 neutralization process which reduced the pH from 12 to 10 to improve control of the pH in the final effluent. The addition of ferric chloride was resumed in August 1991. The sludge is stored in Ponds B, C, and D. The chemical composition of the sludge is given below:

As	2500 - 4300 ppm
Cd	14 - 70 ppm
Pb	520 - 2200 ppm
Se	50 - 250 ppm
Cu	2600 -19000 ppm

Kennecott began studying alternatives for remediation of this area in 1993 under EPA oversight. The results of these early investigations were presented in an EE/CA for the North Facilities/WWTP Sludge Removal project (1996). Early results indicate that the volumes of material may be in error; a drilling program and mapping provided a better estimate of the volumes. A pilot test was conducted by ITEX to determine if the sludge could be chemically stabilized with a mixture of 10% cement and 5% lime kiln dust. The product passed TCLP when it was first generated, but upon aging for a month, most of the stabilized product failed. (This was also tried in 1987 when 65000 wet tons was treated and the product put into the tailings pond.)

Upon discovery and confirmation that the product produced by the pilot experiment failed TCLP leach tests, Kennecott chemists conducted a bench-scale evaluation of different chemical stabilization options and aging characteristics. They concluded that each metal had a narrow range of pH's when that metal would not leach. This would mean that there would have to be very tight materials handling during production coupled with constant testing to assure an acceptable product. Complicating factors also indicated that the pH range for non-leachability in one metal did not necessarily overlap with the analogous range for other metals. In addition, the aging question was still a problem. To ensure the integrity of the product with time, it would be necessary to build a cell for it. Addition of these stabilizing materials with only marginal effectiveness could only double the volume of wastes without significant environmental benefits.

Figure 59: Layers of sludge excavated from pond and check dams added to contain ground water infiltration into the excavation. The layers indicate that the sludge varied chemically over time.

Other alternatives identified at this time included, chemical treatment, disposal into the tailings inflow line, placement into an onsite repository, and placement into an offsite repository. Studies performed at this time included a chemical treatment pilot program, pumpability testing, physical stabilization testing, pond characterization sampling, tailings inflow disposal analysis, clay source investigation and chemical treatment studies.

Based on these studies, EPA and Kennecott decided that the best course was to mix the sludges with contaminated soils from the refinery and smelter grounds (to improve their materials handling characteristics) and place the mixture in a RCRA-like cell located on the Arthur stepback of the Magna Tailings Pond. Several lining systems are currently being evaluated. The EPA OSCs/RPMs include Eva Hoffman, Steve Way and Erna Waterman. The budget for this project is estimated at $33.5 million. Another estimate (in the EE/CA) indicates a budget of $62M for sludge disposal (plus contaminated soils from other north end facilities) and $14M for the disposal part.

The Arthur Stepback Repository has been designated as a CAMU. Ponds C, C-Ext., and D have been designated as temporary CAMUs for the purpose of mixing the soils and sludges together and for temporary storage for drying before transportation to the repository.

Excavation of all sludge from Pond B was completed in August 1997. Removal of sludge from Pond C was completed in July 1998. Removal of sludges from Pond D was completed in November 1999. Ponds B and C were backfilled with tailings and revegetated using biosolids for fertilizer. Ponds A and D were restored to wetland habitat.

WWTP Soils (facility #105.01)

The WWTP Soils site is the footprint soils of the WWTP facility. This facility was operational but will not be needed in the future. In preparation for demolition of the WWTP, the various reagent tanks had to be emptied and cleaned. The lime storage tank was full. The lime was transported to the mine for their use and this tank was cleaned. Also there was a tank full of ferric chloride (17,000 gals) with an acidity of <1 pH. This material was hauled to the drying pad of the Arthur Stepback Repository where it was mixed with soil and placed in the repository. After demolition, the underlying soils were characterized and found to be high in arsenic. These soils were excavated and removed to the Arthur Stepback Repository (20,341 cy) with 1.5 to 5 feet of fill added. The site currently consists of two 140 feet diameter depressions as a result of the removal of the clarifiers. The site is 310 feet by 400 feet and encompasses an area of 2.86 acres.

KENNECOTT TAILINGS POND LANDFILL (facility #106)

Kennecott reports that various demolition debris was placed in the Kennecott Tailings Pond Landfill which is located on the western side of the Magna Tailings pond. The demolition debris includes: anode building, reverb building, and the convertor building. Other wastes are also placed here. The nature of these wastes is unknown. [Kennecott, 1997, indicates construction debris, lunchroom and office trash.]

The location now is on the southwest portion of the Magna Tailings Pond, previously on the southeast corner. Actually the location of the Tailings Pond landfill has been moved from time to time. Over the past 30 years, there have been a few different landfills within the tailings impoundment. Typically these landfills would be used for a number of years until such time that the tailings rose high enough to cover the site. Then the landfill would be relocated to a newer portion of the impoundment. These landfills were not officially closed as they were not regulated at the time. No records exist regarding types and quantities of waste. With the exception of the current landfill, all of the previous landfills have been buried under several feet of tailings. Other than "old timers" memories, no records exist of the exact location of the previous landfills. The landfill prior to the existing landfill was located on the southern embankment of the impoundment across from the highway from the Arthur Concentrator and was buried approximately 12-14 years ago [Kennecott, 1998].

In 1992, Kennecott placed 2800 tons of "waste rock" in the landfill as a cover [Kennecott, 1991]. Later it was revealed this material had come from the slag pile and had high concentrations of lead. Originally, Kennecott stated that it planned to excavate the material and haul it to USPCI. A later letter revealed that Kennecott instead covered the waste in place in Sept, 1992.

Kennecott [1997] indicates that the 2800 tons of "waste rock" was actually material that was originally supposed to be used for flux at the smelter. The material originated from the Tintic Mine and was intended to be used as a precious metals bearing flux. At first it was stored on top of the slag pile until it was subsequently determined that the contained metal value was not economically recoverable at 1992 silver prices. For this reason, it was decided not to use the flux material. At this point, according to Kennecott, it became a Bevill exempt waste, and was disposed of in the tailings pond landfill. It contained 29 mg/kg silver, 1100 mg/kg arsenic, 34 mg/kg cadmium, 3900 mg/kg lead, and 8 mg/kg selenium. Of the RCRA metals, only Pb exceeded the TCLP limit of 5.0 mg/L. [Kennecott, 1998].

The landfill is permitted by the Salt Lake City-County Health Department to receive non-hazardous solid waste from KUC facilities. The solid waste material consists of construction debris and general office and lunchroom trash. The wastes are covered immediately upon disposal eliminating the air pathway, according to a Kennecott fact sheet [Kennecott, 1997].

SMELTER LANDFILLS (facility #107)

There are two landfills located to the south of the smelter. The lower landfill is designated for garbage, and the upper landfill for demolition debris. Kennecott reports that various demolition debris was placed in the Kennecott Smelter Landfill which is located behind the present Smelter. The demolition debris includes: back shop, egg crate building, the gas cleaning plant, and uphill stacks. Kennecott does not know what kinds of wastes may have been deposited there by previous owners. (Kennecott bought the land from ASARCO in 1959.)

Kennecott [1996] describes these landfills as several flue dust and copper concentrate contaminated stockpiles and ground surface along with other debris such as bricks and concrete. Characterization sampling indicates that 196 of 481 samples are elevated in arsenic, lead, and/or selenium. The maximum concentrations were 50,000 ppm As, 1703 ppm Cd, 68578 ppm Pb, and 492 ppm selenium.

The lower landfill (smelter landfill) is currently permitted for construction debris, lunchroom and office trash. The upper landfill (concrete monofill) receives only concrete and associated rebar.

On August 13, 1992, approximately 88 pounds of flue dust samples were mistakenly disposed of in the smelter landfill. A total of 8 buckets of flue dust were placed in a trash bin and subsequently dumped in the land fill. Landfill operations were immediately stopped and three buckets were recovered intact. The lids had popped off the remaining five with some material lost in the landfill [Kennecott, 1997]. The flue dust and buckets were disposed in a local hazardous waste TSD facility. [Kennecott, 1998]. The lower landfill was later excavated as part of the Kessler Canyon removal and 161,098 cy were disposed of in the Arthur Stepback Repository. Some wastes were left in place near utilities, pipelines, and tracks.

WOODEN FLUME SITE (facility #136.02)

At the end of Kessler Canyon below the smelter near SH 201 and the slag bluff, there is a check dam to trap sediments coming down the canyon. The overflow was sent via a 200 foot wooden flume which fed a pipe. The water went to the Smelter Return Canal. Over the years, both the impoundment behind the check dam and the wooden flume filled up with sediment and the sediments in the flume overflowed to the soils underneath the flume. The soils were sandy silt sized sediment with moderate copper oxide. The water entering the flume entered the lower Kessler Canyon from the upper canyon, plant process, plant storm water and spills. The water would flow down the concrete and cobble lined section of lower Kessler drainage to a cutoff wall. The water would then backup behind the cutoff wall and flow out a side drain that fed a wooden flume. From the wooden flume, water fed by two HDPE pipes from the anode wash area of the Old Noranda smelter. The maximum concentrations of contaminants in this area were 5150 ppm As, 64.5 ppm Cd, 3490 ppm Pb, and 564 ppm Se. This area was remediated by removal of the accumulated sediments behind the dam, the wooden flume and adjacent soils. The flume was replaced with a pipe and 1400 feet of the existing pipe was hydroblasted. About 3194 cy was removed, and some wastes near utilities were left in place. The site was then covered with fill.

MISCELLANEOUS SPILLS

As an operating facility, Kennecott does have occasional spills (or "upset conditions") which require immediate response to rectify the problem itself and cleanup any resulting spills of products or wastes. CERCLA does require immediate notification of these incidents including the location of the spill, the substance involved and what was done to rectify the problem. In addition, RCRA requires secondary containment in locations where chemicals are stored. Some of the spilled materials are trapped by these containment structures. For the more serious spills, state staff from CERCLA and sometimes water quality will conduct a site investigation.

The Emergency Release Notification System (ERNS) has a database which lists the spills, provides some data on the incident and can provide the identification numbers to allow access to full reports. For the serious incidents, the details are given as a part of the individual site descriptions in this document.

An examination of the ERNS data base yielded the following observations. There were 118 reported "incidents" in ERNS (1980-2001) on Kennecott property. By far, the location where the spills are most frequent is at the smelter/acid plant (42%). Locations with 5 or more spills include pipeline, the refinery, Barneys Wash, Bingham Canyon, and the former Wastewater Treatment Plant.

The most common product or waste spilled was sulfuric acid (ranging in size from 1 gallon to a high of over 10,000 gal. Substance with more than 5 spills were leach water, tailings, weak acid blowdown, process water, sulfur dioxide, and metal sludges.

DEMOLITION DEBRIS (facility #144)

In the process of renovation of facilities over the past few years, Kennecott has disposed of a wide variety of demolition debris at various on-site and off-site locations. In 1992, EPA requested information about the fate of these materials. There were approximately 60 buildings which were demolished. The wastewater from decontamination of these facilities also were disposed at various on-site and off-site locations. Demolition debris disposal information where available has been incorporated into information about the various facilities.

Kennecott [1997] reports the method used for determining the fate of various demolition debris. First it is determined if the debris is recyclable material. If recyclable debris is identified, it is collected and processed on site (e. g. Concentrate, flue dust, etc.) Or sent off-site (e.g. steel, batteries, equipment, etc.). If the debris is determined to be non-recyclable it is characterized for asbestos, PCBs, characteristic wastes and listed wastes as appropriate. If the waste is characterized by one or more of the items listed above, it is disposed of in accordance with applicable NESHAP, TSCA, RCRA, and state regulations. Demolition debris not characterized with the above items is disposed of in on-site permitted landfills and/or off-site industrial landfills. Decontamination water from demolition sites is routed to the Waste Water Treatment Plant for lime and ferric hydroxide treatment.

CHAPTER 19
GROUND WATER, SURFACE WATER AND WETLANDS NEAR MAGNA

Groundwater contaminants were found to be entering the wetland areas between the refinery/smelter areas and the Great Salt Lake. These wetlands were the traditional receiving waters for runoff and spills from the smelter and refinery. Also, the wetland areas were a convenient dumping ground for a wide variety of wastes (as described earlier in Chapter 18).

East of the tailings pond are a number of canals, creeks, and wetlands, some of which have been modified by Kennecott to receive discharges. Recently, to compensate for the loss of wetland habitat when the tailings pond was constructed, Kennecott bought additional lands which were modified to create wetlands for use as bird habitat.

MAGNA GROUNDWATER PLUMES (facility #141)

There are a number of contaminated ground water plumes associated with North End facilities. The sources of the contamination are varied. A plume of elevated selenium starts in the area of the refinery and ends at Garfield Well #5. This plume also surfaces at contact springs (Kessler Spring). This plume originated from leaks in the selenium by-product recovery circuit, presumably from piping underneath the building and spills into a floor sump underneath the selenium retort. High concentrations of selenium were found in soils underneath the former precious metals refinery where the selenium recovery operation was located. An arsenic plume also originates near the refinery. Its source was probably the refinery electrolyte evaporation pond.

There are several areas of ground water contamination in the area of the smelter and only recently has one of them found surface expression. Springs containing elevated selenium (about 100 ppb) were uncovered in 2005 when the slag deposits on the north side of Rt. 201 were excavated. Sources included the dumping grounds behind the smelter, the thaw shed, spills at the acid plants, the slag concentrate thickener, flue dust storage areas and sulfuric acid spills.

There are isolated pockets of ground water contamination near several of the former WWTP sludge ponds and near the smelter return canal.

The Record of Decision for the North End contained a table with the different plumes and their areas listed [EPA, ROD, 2002]:

LOCATION	AQUIFER	CONTAMINANTS	ACREAGE (acres)
Refinery	Principal and bedrock	Se, As, Sulfate	206.6
Pond C	Principal and shallow	Se	5.7

LOCATION	AQUIFER	CONTAMINANTS	ACREAGE (acres)
Reverberatory Smelter	Principal	Se	17.2
Slag Bluff	Principal and shallow	Se, As	31.5
Acid plants	Principal and shallow	Se, As, Sulfate	126.2
Slag mill area	Principal and shallow	Se, sulfate	5.7
Kessler Spring	shallow	Se	2.9
North of Garfield townsite	shallow	Se	4.3
Pond A	Shallow	Se, As, sulfate	34.4
Smelter Return Canal	Shallow	As	5.7
Smelter Return Canal	shallow	As	5.7
Slag Lagoon	shallow	As	8.6
Slag Lagoon	shallow	As	8.6
Wetland	principal	sulfate	5.7
Pond B	principal	sulfate	22.9
Acid tank farm	principal and shallow	sulfate	5.7

Rather than wait for the completion of the RI/FS, some interim actions were taken to divert the contaminated ground water away from the wetlands. Arsenic tainted ground water which originated from the area of the reverberatory smelter is withdrawn from a well close to the smelter parking lot. The Garfield Wells are either shut off or the well water is diverted for us in the process. When originally re-discovered in 1998, Kessler Springs water was diverted to a canal along SH 202 and discharged into the West C-7 ditch. Later the selenium tainted water was piped to Pump Station 4 for use in process. The spring water was also used to test various selenium removal technologies. Later, when another series of springs with elevated selenium were found across the highway from the smelter (in the process of excavating slag), these spring waters were also re-routed to the process water circuit.

A RI/FS was completed on the ground water contamination and wetland contamination in 2002, and a Record of Decision was issued later that year. The selected remedy calls for injection of selenium-reducing microbes into the aquifer. Should that fail to have sufficient effectiveness, a bioreactor using the microbes will be built to treat Kessler Springs waters above ground (should those waters cause Kennecott to exceed their selenium discharge limits in their UPDES permit. The interim use of Kessler Springs water in the process water circuit was successful. Bench tests revealed that the tailings could absorb about 50% of the selenium from the water. This removal was sufficient to meet the discharge limits while the in-situ bioremediation technique was being tested. The in-situ bioremediation technique was eventually dropped from further consideration. Although the injected microbes worked very well in the alluvial portion of the aquifer, the microbes could not be injected throughout the bedrock aquifer where the highest concentrations were located. The process circuit seems to be working well to keep the selenium levels beneath the UPDES permit limits for selenium. Kennecott continues to evaluate different selenium technologies for use at Kessler Springs (and the new smelter springs) should this be needed to reduce discharges to the Great Salt Lake or at closure.

There are other areas of ground water contamination associated with the North Concentrator and the Magna Tailings Pond. The groundwater contamination in these areas were evaluated as part of the Tailings Pond Expansion Environmental Impact Statement. Both of these facilities are covered under the provisions of a state ground water permit. A plume originating from a large spill at the former acid tank farm is being addressed under a RCRA corrective action permit. A collection trench downgradient of the spill was installed and continually pumped until no more acid was entering the trench. Pumping has stopped, at least temporarily.

GARFIELD WELLS (facility #141.02)

The following summarizes the status of the 8 Garfield Wells

Well	Historic use	Current status
Garfield Well 1 (1000 gpm)	Formerly used as a source of process water	conveyed to the West Cyclone of the North Tailings Pond for use as gland seal water
Garfield Well 2	Formerly used as a source of process water	valve is closed
Garfield Well 3	Formerly used as a source of process water	valve is closed
Garfield Well 4 (500 gpm)	Formerly used as a source of process water	conveyed to the West Cyclone of the North Tailings Pond for use a gland seal water

Garfield Well 5 (500 gpm)	Formerly used as a source of process water	Contaminated with selenium, conveyed to Pump Stn #4 for use as process water
Garfield Well 6 (250 gpm)	Formerly used as source of process water	valve is closed
Garfield Well 7	Formerly used as source of process water	abandoned and buried under new north tailings impoundment
Garfield Well 8 (250 gpm)	Formerly used as source of process water	valve is closed

Garfield Wells 4 and 5 have been shown to be contaminated from a leak in the selenium circuit underneath the old refinery building. Garfield Well #4 has Se concentrations as high as 456 ug/l Se (1999-2000). Garfield Well #5 has exhibited Se concentrations greater than 1000 ug/l, typically bouncing around 500 ug/l. Both of these wells are artesian and, when not used for process water, the well waters, until recently, were allowed to flow into the nearby wetlands.

Because of the risk of Se to the wetlands, in 1998 the artesian flow from Garfield Well #5 was captured and diverted to UPDES Outfall 008. The wetlands near the well dried up. In 2000, the Garfield Well #5 water was redirected to Pump Station #4 for incorporation into the process water circuit. Kennecott studies revealed that half of the selenium in the water could be removed by the tailings. The Se adsorbed to the tailings then becomes sequestered in the tailings pond (see also 141.02).

SPRINGS (facility #141.03)

SPITZ SPRINGS (facility #141.031)

Spitz Springs was known as Toronto Springs on earlier maps. The springs were named after Toronto Cave (known as Dead Man's Cave today).

The soils at Spitz Springs contain the following components:

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	552	22.8	287
Cd	<0.2	<0.2	<0.2
Cu	37800	1090	19445

Pb	384	14.2	199
Se	<0.5	<0.5	<0.5
Zn	384	41.5	212.8

Spitz Springs is located north of Sludge Pond C and south of the railroad tracks along the western base of the Magna Tailings Pond. There are two springs indicated on several maps, Spitz Springs and East Spitz Springs. Water from these springs has been collected at times for use as process water. The water can also be discharged via Outfall 012. Historically these springs were contaminated with arsenic, probably due to the proximity of Sludge Ponds B & C.

JAPANESE SPRINGS (a.k.a. Japanese Springs 1 and 2) (facility #141.032)

According to Kennecott (2000), Japanese Springs has a flow of about 50 - 100 gpm with the following water chemistry: As = 141 ug/l, Cd = <1 ug/l, Cu = 34 ug/l, Pb = <5 ug/l. Japanese Springs is located west of the smelter entrance and south of SH 201. It feeds a small wetlands. On older maps, these springs were known as Japanese Springs 1 and 2. These waters have been used for process water at times. The water can also be discharged via Outfall 004.

SPRINGS 3 - 5 (a.k.a Japanese Springs 3, 4 and 5) (facility #141.033)

According to Kennecott (2000), Springs 3 - 5 have intermittent flows ranging from 0 to <5 gpm with the following water chemistry: As = 141 ug/l, Cd = <1 ug/l, Cu = 387 ug/l, Pb = <5 ug/l. Springs 3, 4, and 5 are located in lower Kessler Canyon along the slag bluff below the smelter. On older maps, these springs were known as Japanese Springs 3, 4, and 5. Sometimes the water is collected for use in the process or it can be discharged via Outfall 008.

NO NAME SPRING (facility #141.034)

The spring is located halfway between the tailings impoundment and the smelter on the north side of SH 201. This water has been collected at times for use in the process circuit. It can also be discharged via Outfall 008. Located near Praxair, the spring water now flows into the Smelter Return Canal.

KESSLER SPRINGS (facility #141.035)

Kessler Springs, located under SH 201 and discharging via a culvert to the Garfield Wetlands are bedrock contact springs downgradient of the refinery complex. The springs consist of three springs located within 100 yards. The springs are heavily contaminated with selenium from the past leakages at the old Precious Metals Refinery Building. When the springs were rediscovered and found to be contaminated, they were initially diverted to Outfall 008. Later, they were piped to Pump Station 4 for use in the process water circuit. Bench scale tests found that 50% of the selenium could be sequestered into the solid phase when they are shaken with tailings. This would mean that about half of the selenium would be captured along with the tailings in the tailings pond. The other half still in solution would be recycled for use in the process or discharged to the Great Salt Lake along with the decant pond water. Additional treatment of the spring water is not required so long as the decant pond water complies with the discharge limits in the UPDES permit (27 ug/l).

HANSSEN SPRINGS (West Kessler Springs, Hazelton Springs) (facility #141.036)

In the process of excavating the slag north of Rt 201 and the smelter, Kennecott uncovered a series of small springs along the south face of the excavation. The springs were tainted with selenium. There is a selenium-tainted groundwater plume in the area and the springs appear to be a surface expression of the plume. There are 8-10 springs and the total flow of the springs is estimated at 40 gpm. The selenium concentration in the winter of 2004-2005 was 38 - 90 ppb. Kennecott is planning to route the spring water into the process water circuit in a manner similar to that used at Kessler Springs.

TOOELE CANAL DITCH (facility # 102.01)

The Tooele Canal Ditch, located between the slag pond and I-80, carries water from Tooele to Section 17 pumphouse to use as KUC process water to the C-7 Ditch. Pump Station 17 receives 5000 gpm in summer, 3000 gpm in winter via the canal from wetlands near Tooele and an additional 1000 gpm from the Section 17 well. 2000 gpm goes to slag pond A, the remainder goes to the smelter return canal. The water travels in a pipe from Tooele Valley along I-80 to Kennecott. The Se concentration is 0.011 mg/l. The Tooele Canal Ditch and pipeline are a source of water to the Garfield Wetlands.

The sources of water from Tooele Valley include underground springs which flow into Old Droubay Ranch reservoir, Mill Pond on the Clark Ranch which is piped underground to a storage reservoir on Castagno Ranch. Factory Creek also goes into this reservoir. From thence the flow goes to an intake reservoir then via a 48" underground concrete pipe to Lake Point. In 1953, the water was sent from Lakepoint to Pump 17 via a wooden pipeline above ground. One source described the Tooele Canal which went from Pump 17 to Pump 4 as 8 feet wide and 3.5 feet deep. Another said it was 20 feet wide and 5 feet deep.

GARFIELD WETLANDS (facility #141.01)

In the spring of 2000, Kennecott with the aid of the Salt Lake County Fire Department conducted a controlled burn of the Garfield wetlands. The goal was to discover how the water flowed through the system. The burn revealed a number of seeps just to the west of Kessler Springs along the edge of SH 201. The water flows northward in small channels which are about 6 inches across. The water then collects in two places. One is a previously unknown ditch just to the south of the smelter return canal. The burn also revealed where the spoils from previous dredging of the old smelter return canal. There was a linear mound about 6 feet south from a road along the canal. The mound prevented water from entering the canal. Another collection point was a pond a little east of the springs. This pond was previously known, but investigators discovered the pond was three times bigger than originally thought. The burn also revealed the presence of a historic rail spur. Kennecott crews began using this rail bed as a haul road. The wetlands have been divided into subzones in the RI (2000).

The wetland soils which are not associated with open water are in three general areas: Area 1 (between SH 201 and the smelter return canal); Area 2 (between the smelter return canal and the old mainline tracks); and Area 3 (between the old mainline tracks and I-80 pond). The soils were characterized for contaminants:

Area 1

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	519	30.1	143.4
Cd	13.9	<0.2	3.5
Cu	3580	1390	2391
Pb	1250	25.5	639
Se	150	0.5	19.2
Zn	359	60.8	199.9

Area 2

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	849	<0.5	146
Cd	3.8	<0.2	1.0
Cu	16100	99.1	3690
Pb	1400	<0.5	374
Se	295	<0.5	42
Zn	954	34.5	216

Area 3

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)

As	188	<0.5	26.2
Cd	1.3	<0.2	0.3
Cu	2550	71.9	913
Pb	1080	9.1	232
Se	<0.5	<0.5	<0.5
Zn	1240	57.2	165.4

The Garfield Wetlands are vegetated with small areas of open water (20%). The open water areas dry up by mid-summer exposing a flat sandy clay surface. Historically, the site received water from flowing artesian wells. Now that water has been diverted to process or to the West Cyclone for industrial use. The area is about 35 acres. Contaminated sediments were removed (49,780 cy). Also see 141.02, Garfield Wells.

MARSH AREA 1 (facility #141.011)

Marsh Area 1 is located just to the south of SH 201 between the main entrance to the smelter on the east to the Cobalt Refinery entrance road on the west. It is about 3000 feet long (E-W) and about 180 feet wide. The following is a summary of the characterization of the marsh sediments: [Kennecott, RI, 2000]

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	1390	47.3	396.5
Cd	19.2	3.8	10.2
Cu	12300	914	504.5
Pb	990	94.6	529
Se	102	<0.5	30.6
Zn	2920	13.3	1173

The highest concentrations of different metals were found at different locations indicating a variety of sources. For example, the highest As was in the middle; the highest Cu was on the east and adjacent to the smelter entrance.

MARSH AREA 2 (facility #141.012)

Marsh Area 2 is located just to the east of Praxair. It is about 1500 feet long and 300 feet at it widest. The concentrations in the sediments are summarized below:

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	140	92.7	115
Cd	4.4	3.5	3.9
Cu	286	145	207
Pb	253	140	197
Se	16.8	7.5	11.4
Zn	153	103	130

MARSH AREA 3 (facility #141.013

Marsh Area 3 is located to the north of SH202 just west of Pond B and south of the Smelter Return Canal. It is trangular in shape about 1000 feet long along SH 202. Because it had a few spots of high arsenic, it was cleaned up as a part of the Smelter Return Canal cleanup.

POND 1 (facility #141.014)

Pond 1 is located just on the other side of SH201 from Marsh Area 1. The concentrations of contaminants in the sediments of this pond are given below:

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	436	128	252
Cd	11.5	5.4	7.9
Cu	4910	1080	2695
Pb	1440	159	745
Se	20.6	5.0	11.9
Zn	315	135	221

POND 10A and 10B (facility #141.015)

Ponds 10A and 10B are ponds located just west of Pond D. Both ponds have southern boundaries along the railroad grade recently abandoned when the tailings pond was expanded beginning in 1996. Pond 10A is the larger of the two on the west measuring about 1000 feet by 750 feet. Pond 10B, between Pond 10A and Pond D is about 1000 feet N - S by 180 feet. The sediments in these ponds were characterized:

Pond 10A

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	137	86.5	108.7
Cd	2.3	1.7	2.0
Cu	1480	688	1035
Pb	363	133	194
Se	7.4	<5	3.4
Zn	131	62.3	87

Pond 10B

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	169	33.6	96.4
Cd	2.3	1.3	1.8
Cu	1690	422	1064
Pb	240	132	192
Se	6.2	4.1	4.8
Zn	169	49.6	103.4

POND 2 (facility # 141.016)

Pond 2 is a small pond, 375 ft x 100 ft adjacent to I-80 opposite Black Rock close to the railroad overpass. The sediments in this pond were characterized (one sample)

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	33.3	33.3	33.3
Cd	1.9	1.9	1.9
Cu	706	706	706
Pb	236	236	236
Se	6.2	6.2	6.2

Zn	61.2	61.2	61.2

POND 3 (facility #140.017)

Pond 3 is just to the east of Pond 2 also adjacent to I-80. It is long and narrow - 1500 ft x 100 ft. The sediments of this pond had the following constituents:

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	74.9	23.9	49.0
Cd	1.8	1.5	1.7
Cu	477	114	295
Pb	75	15.7	45
Se	<0.5	<0.5	<0.5
Zn	53.2	45	49.1

POND 4 (facility #140.018)

Pond 4 is adjacent to I-80 just east of Pond 3. It is 1875 x 500 ft. It is just west of the marina and Hazelton Pump Station. The sediments of this pond had the following constituents:

Constituent	Maximum (ppm)	Minimum (ppm)	Average
As	174	42.3	
Cd	3.7	1.0	
Cu	1120	387	
Pb	209	53.5	
Se	12.7	<0.5	
Zn	98.7	43.7	

SAMPLE UNIT 1 (facility #140.019)

Sample Unit 1 appears as a sampling area in the North End RI, Appendix J [2000]. It is located just to the south of Pond D on the south side of the former mainline RR tracks. (Pond D is on the north side of these tracks.) It is a low area covered with phragmites. The samples were apparently collected to augment the ecological risk data. The soils had the following concentrations of contaminants:

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	56.4	1.1	35.1
Cd	4.7	1.0	2.5
Cu	2200	281	934
Pb	310	<0.5	205
Se	22.3	<0.5	21.4
Zn	146	37.7	74.5

I-80 OFF RAMP (facility #140.14)

There are some wetland areas located between I-80 (Eastbound) and the off-ramp (Eastbound, approaching SH 202), Southwest quadrant of the intersection. It is on the DOT right of way, but the land was formerly Kennecott land. Sometimes waterfowl are observed here. The sediments contained the following constituents:

Constituent	Maximum (ppm)	Minimum (ppm)	Average (ppm)
As	56.9	<0.5	28.8
Cd	<0.2	<0.2	<0.2
Cu	409	68	228
Pb	37.8	10.7	27
Se	<0.5	<0.5	<0.5
Zn	106	53.1	76.5

WETLANDS MITIGATION AREA (INLAND SEA SHOREBIRD RESERVE) (facility #77.03)

The Wetlands Mitigation Area covers approximately 2,600 contiguous acres north of I-80 between former Morton Salt property on the south and the Goggin Drain vicinity on the north. The acreage is located in T 1 N., Rs 2 and 3 W.

Natural, but modified, creeks and man-made ditches and drain outlets cut across the property to the shore of Great Salt Lake. Topographic relief is limited to a few feet across the beach area which consists mostly of mud flats with ponds of standing water.

The purchase of the land is in response to the Corps of Engineers' Permit No. 199250147 (replacement of jurisdictional wetlands in association with the Magna Tailings Pond Expansion Project) and replacement of wetlands for alleged wetlands violations in the vicinity of Sludge Pond D and the smelter.

The surface waters include Lee Creek at the southern end of the property, several ponds called South A Pond (Dowitcher Pond), South B Pond (Egret Pond), West A Pond (Avocet Pond), West B Pond (Curlew Pond), a large pond called North Pond or Blackhawk Pond, man-made drainage ditches, the North Point Consolidated Canal which crosses the middle of the site flowing East to West, and the Goggin Drain through the northern part of the site. There are three artesian wells on the property. The site is about a mile from the current shoreline of the Great Salt Lake. The Blackhawk Pond receives water from a ditch along the road, and an artesian spring, but normally has no outlet.

Until recently, the site was open space for cattle grazing, agriculture, birdwatching, duck hunting, sunbathing, camping, unauthorized dumping and off-road vehicle recreation. Past uses include oolitic lime sand mining, salt evaporation impoundments, livestock pasture, and rights of way for a railroad and a conveyor to transport construction materials from Antelope Island to Salt Lake City. Cleanup of trash and tires was done as a part of the wetlands development project. It is now a part of the south shore wetlands ecological reserve. Additional properties were purchased for inclusion in this area: Morton International, Bothwell and Swaner, and Heughs Creek. The site is now called the Inland Sea Shorebird Reserve.

Initial concerns were that mill tailings, smelter slag, stack emissions, together with organic and inorganic contamination from other sources (municipal landfills, other industrial, etc) might be intermixed with naturally occurring sediments. Such metal contaminants might include arsenic, cadmium, chromium, copper, lead, and selenium.

Kennecott conducted sampling/analytical surveys of soil, sediment, surface water including ponds, springs, seeps, and creek/drain flows, and groundwater to:

Identify existing organic and inorganic constituents in water and soil environments on the mitigation site;

Establish minimum standards and supporting baseline conditions for those constituents of concern for wildlife and aquatic life;

Identify sample points, procedures, and target constituents;

Monitor water and aquatic substrate quality on the site to establish baseline conditions; and

Identify constraints or opportunities for providing wetland functions and values.

SWCA [1995] reported the results of water, soil, sediment, and well water sampling for this area. Also included was a survey of different animals and plant types at the site. All samples of the surface waters were beneath EPA chronic standards for these metals: As, Cd, Cu, Se, Zn, Hg and Ag. There was one violation of chronic standards for iron (Goggin Drain), chromium (Blackhawk Pond, and lead (North Well). Eleven of 14 samples violated Al chronic and/or acute standards. The acute violations all occurred in the Blackhawk Pond.

The soil and sediment results were also reported by SWCA [1995]. Arsenic ranged from <4 - 30 ppm with an average of 17 (ecotox threshold = 8.2); cadmium ranged from <1 - 1.2 ppm (ecotox threshold = 1.2); copper ranged from 45 - 135 ppm (ecotox threshold =34; mercury was below 0.1 ppm (ecotox threshold = 0.15); selenium was below 4 ppm; lead ranged from 36 - 109 ppm with an average of 61 (ecotox threshold = 47) and zinc was 39 - 103 (ecotox threshold = 150).

SWCA [1995] suggests that the poor water quality in Blackhawk Pond especially for boron and aluminum will improve once additional water is added from the North Point Canal during the wetlands mitigation and restoration project for the 404 permit. The data suggested that inputs of metals to the waters and sediments of this area were not related to mining. This site was closed out by the North End ROD of Sept 2002.

Wetlands mitigation area - Morton Salt property (facility #77.031)

In 1995, Kennecott purchased additional properties near their initial wetlands mitigation area to allow them to more effectively manage the restored wetlands with impacting neighboring property owners. One area owned by Morton Salt consisted of four parcels totaling 773 acres. Two of these parcels abut the existing wetlands mitigation area on the west. The area is characterized by mud and salt flats, marshes (with seagulls and ducks) and prairie fields. An Environmental Assessment [ERM, 1995] found garbage and debris, a large acetylene tank which had washed up on shore, and a large abandoned cattle barge. There was no evidence of hazardous substances or spills. ERM reported evidence of 4-wheel drive vehicles particularly on the south end of the property near I-80. They also reported that the entire property could be submerged if the Lake rises to Lake levels of 1983. Morton Salt purchased this property in 1927 from Crystal Salt Company. Since that time, the properties have been vacant.

Wetland mitigation area - Bothwell and Swaner (facility #77.032)

In 1995, Kennecott purchased additional properties near their initial wetlands mitigation area to allow them to more effectively manage the restored wetlands without impacting neighboring property owners. One such property was owned by Bothwell and Swaner Company and was owned by the family since the early 1900s. Previously it was referred to as the Everson Tract. The Bothwell family used the land for grazing cattle. The parcel is 200 acres. The property consists of mud and salt flats, and prairie fields. The land was undisturbed except for limited areas of garbage and debris, the Goggin Drain, and evidence of 4-wheel drives and grazing cattle.

Wetlands mitigation area - Heughs Creek Associates (facility #77.033)

In 1995, Kennecott purchased additional properties near their initial wetlands mitigation area to allow them to more effectively manage the restored wetlands with impacting neighboring property owners. One property, formerly owned by Heughs Creek Associates totalling 25 acres consisted of three separate parcels. Heughs acquired the three parcels in 1993 and 1994 from three individuals Briquet, Bagley and Hines with the intent of developing commercial water fowl hunting areas. Previously the land was used for livestock grazing. There was use by 4-wheel drives and hunters. Garbage, debris, and evidence of a past fire was found [ERM, 1995].

Wetlands mitigation area - Blackhawk Pond (facility #77.034)

Blackhawk Pond was constructed by the Blackhawk Duck Club in the 1960s and 1970s by the construction of dikes. Water came from the North Point Consolidated Canal via a ditch on the East side of 8800W. The Duck Club abandoned the use of the area during the flooding of the Great Salt Lake in the mid-1980s.

Wetlands mitigation area - North Point Consolidated Canal (facility #77.035)

The North Point Consolidated Canal originates in the Salt Lake City area as a spur off the Surplus Canal (which transports Jordan River Water). It also gets water from the Brighton Canal which gets its water just south of Salt Lake City from the Jordan River. It flows 1 mile west of the river. From there it flows through the mitigation area and then into the Great Salt Lake. There is little or no flow today because upstream landowners owned the water rights. Kennecott now has enough rights to support development of impoundments in the Wetland Mitigation Area.

Wetland mitigation area - Goggin Drain (facility #77.036)

The Goggin Drain receives water from the Jordan River via the Surplus Canal. It is a water diversion canal to reduce flows of the Jordan River through Salt Lake City. It is fast flowing and sometimes floods into shallow depressions between the drain and Blackhawk Pond.

C-7 DITCH (facility #140)

The C-7 Ditch is a man-made canal constructed around 1917. Until recently, the C-7 Ditch was the receiving water body for the Kennecott operations in Magna and Copperton. It receives flow from Lee Creek, Kersey Creek, Riter Canal and the Utah-Salt Lake Canal, resulting in a drainage area of 73 square miles. [EIS, 1995]. Water from the Magna Tailing

Pond first went into a reclaim water canal from which it was recycled or discharged to the C-7 Ditch. Kennecott has a UPDES permit for the discharge. Now Kennecott discharges directly to the Great Salt Lake.

The C-7 Ditch has two parts, the C-7 Ditch and the C-7 West Ditch. (In addition, the clarification canal is sometimes referred to as the East C-7 Ditch.) Both the West C-7 Ditch and the C-7 Ditch discharge to the Great Salt Lake. The West C-7 Ditch collects 1000 gpm of seepage from the existing tailings pond. The West C-7 ditch originates near the WWTP, travels north along the foot of the tailings berm, and joins the C-7 ditch on the NW corner of the tailings pond. It receives water from the tailings pond, the Garfield wells and surface runoff. A biological survey of the ditches found several species of fish living in this water. The C-7 ditch had carp, Utah sucker, channel catfish, mosquitofish, and walleye. The C-7 West Ditch had carp, Utah chub, mosquitofish, white bass, and walleye.

The C-7 Ditch is the receiving water for Kennecott's outfall 002 and 007 (1996 - 1999). The 002 water comes from concentrators, power plant, slag concentrator, hydrometallurgical plant, mine, sewage treatment plant and stormwater. The average flow is listed at 65,000 gpm (when active). Treatment is described as neutralization, chemical precipitation, solids settling either by pretreatment or in the tailings pond. The 007 water comes from the tailings impoundment toe ditch collection pond. The average flow is listed at 5000 gpm. Treatment is described as settling. Kennecott plans to divert most of these flows out through the new outfall 012 directly to the Great Salt Lake starting in 2000.

Water quality in the C-7 ditch indicated iron levels above the chronic water quality standard and copper above the acute water quality standard for freshwaters. [Kennecott, Army Corp of Engineers Wetlands Application, 1994]. Water quality standards are not applicable since the ditch is Class 6. The flow is estimated at 73 cfs. After expansion of the Magna Tailings Facility discharge in the C-7 ditch was largely diverted to the Great Salt Lake.

The C-7 Ditch is covered under UPDES permit UT0000051 valid until 2000. As per that permit (prior to 1999), Kennecott is required to conduct biomonitoring of the 001 and 002 outfalls to the C-7 Ditch on a quarterly basis. Under the permit Kennecott discharges to the C-7 Ditch only under emergency situations (storm events) when the return process water system cannot handle the load. An additional source of contamination to the West C-7 Ditch is the Garfield wells. Mitigation is required by either the MOU or the 404 permit. [see Magna Groundwater] With the new tailings pond expansion outfall 001 is rarely used.

As part of the tailings expansion project, a sedimentation pond was constructed at the head of the clarification canal and outfall 002 was relocated immediately south of the sedimentation pond. The C-7 ditch was rerouted around the perimeter of the North Expansion into the lower Lee Creek drainage. The Sedimentation Pond receives flow from the North Siphon and allows tailings particles to settle prior to discharge from Outfall 002. Outfall 007 was also constructed as part of the tailings expansion project to allow discharge of seepage and dike runoff water associated with the new embankment. Outfall 007 is also on the C-7 ditch.

The current sources of water to the West C-7 Ditch (Outfall 008) include flows from artesian Garfield Wells (1, 4, 6,and 8), flows from refinery non-contact cooling water blowdown, Section 21 reverse osmosis effluent, Hazleton Pond, stormwater runoff from the refinery area and spring effluent redirected from the wetlands to the outfall. The C-7 ditch has a state water classification of 3E.

Also see 140.06 (East C-7 Ditch, aka Reclaim water canal and clarification canal.

LEE CREEK (facility #140.01)

Lower Lee Creek/Brighton Drain is located north and east of the salt ponds. Its outfall is 2 miles NE of the C-7 outfall. Lower Lee Creek was separated from most of its drainage during the construction of the C-7 Ditch.

Upper Lee Creek originates as a spring fed wetlands location at SR 201 about 2 miles east of the tailings pond. It passes through several landfills, then flows into the C-7 Ditch. Lower Lee Creek is not connected to Upper Lee Creek. It receives most of its water from Brighton Drain, which originates at Salt Spring, 5 miles East of the Mitigation Area. Lower Lee Creek is a wide shallow drainage that usually has no water. [Kennecott, 1996]. After construction of Kennecott's 012 Outfall to the Great Salt Lake, Lee Creek receives water from Kennecott only from 007.

The Sampling Unit #2 for the Ecological Risk study was located at the confluence of Lee Creek and Kersey Creek, just to the south of the railroad. In the spring, this wetland fills up with water then slowly evaporates to form dry playas. Saltgrass and common reedgrass grow along the fringes. There is also iodine bush, sampire and arrowgrass, with large aggregates of poison hemlock along the roadberms. Islands support greasewood, rabbit brush, salt brush, cheatgrass, foxtail barley, peppergrass, tumble mustard and toadflax.

The 404 permit requires that Lee Creek by monitored upstream of the diversion structure to confirm the EIS conclusion that water quality does not need mitigation. Also monitoring was required in lower Lee Creek to ensure selenium concentrations do not exceed 0.012 mg/l as required in the 404 permit. Kennecott outfalls 007 and 002 are on Lower Lee Creek via the C-7 ditch. Discharge from 007 is typically less than 5000 gpm, and 002 will not be used routinely when the direct outfall 012 is constructed.

EAST LAKE (facility #140.04)

Kennescope [1958?] referred to a water body called East Lakes. East Lakes was described as an important source of water for the Arthur and Magna mills. East Lakes was fed by the North Jordan Canal. Two pictures were given. In one, the caption read "Another source of milling water is East Lakes. This photograph shows some of the cabins left high and dry recently while contaminated water was drained off. The article mentions that Utah Lake water had a deleterious impact on the recovery of copper in the flotation plant of Magna. The specific "contaminants" in Utah Lake water were not described -- contaminants here is used in the process sense rather than the pollution sense. The second picture stated that the Riter Canal delivers water westward from East Lakes to the east end of the tailings pond.

Old timers described East Lake as a duck hunting preserve for Kennecott executives. This was not mentioned in historic articles.

Another Kennescope article [1956] also mentioned the water contamination problem. The problem was attributed to contamination from seepage of irrigation water from alfalfa fields. When this happened, contaminated water was diverted from East Lakes back to the Jordan River. The article reported that the impact was felt most severely in the molybdenum flotation recoveries and that the specific culprit had not been identified. Water purification methods were being tried when this article was written.

According to Jones [1995], East Lake was located near 2100S and 4000 W according to a 1919 Bingham and Garfield RR map. The map shows two outfalls - one into the Riter Canal and the other was called "drainage to the Great Salt Lake" which flowed to the NW from the lakes to intersect with the C-7 ditch (at the NE corner of the tailings pond).

Today, the area is occupied by marsh land, an industrial park, and the Stone Bridge Golf Course.

KERSEY CREEK (facility #140.05)

Kersey Creek originates from springs to the south and west of Lee Creek. It also receives effluent from Magna's WWTF. It then flows through a construction debris landfill. It discharges into the C-7 ditch.

EAST C-7 DITCH (Reclaim Water Canal, Clarification Canal) (facility # 140.06)

The East C-7 Ditch is called by several names, including Reclaim Water Canal and Clarification Canal. It receives decant water from the tailings pond and returns it to ore-processing operations. The Ditch receives water from the Riter canal, Utah-Salt Lake Canal and Adamson Spring (2000 - 4000 gpm from the bedrock aquifer). With the tailings expansion project, a sedimentation pond was constructed at the head of the clarification canal. The effluent of the canal goes to the C-7 ditch and the lower Lee Creek through NPDES outfall 002.

RITER CANAL (facility #140.07)

The Riter Canal is a drainage and irrigation canal which originates at 3800W and SH 201, and then flows west along the south side of SH 201. KUC can divert water from the canal into the Reclaim Water Canal (East C-7 Ditch). Water in the Riter Canal comes from urban and agricultural runoff and from the North Jordan Canal and was the former outlet of East Lake water. Schroedl [1993] indicates the canal was dug in 1906 as part of the construction of the Magna Tailings Pond. Although it is in good condition and is still used as a canal, investigators did not think it worthy of registry as a historic place because it is "not distinctive of an engineering style".

UTAH-SALT LAKE CANAL (facility #140/08)

The Utah/Salt Lake Canal is an irrigation diversion canal receiving water from Utah Lake. It also receives urban and agricultural runoff. It passes to the west of Magna. KUC uses some of the water for processing and the rest merges with the Riter Canal and flows into the East C-7 Ditch. Utah-Salt Lake Canal is the receiving water for a permitted Kennecott outfall (011). Outfall 011 is Adamson Springs water when it is needed for processing. (See Adamson Springs)

RIGHT OF WAY CANAL (facility #140.09)

The Right of Way Canal originates in the 4800 W block of I-80 and travels west along the northern frontage road of I-80. It merges with Lower Lee Creek. The canal is a source of irrigation water and process water. Kennecott does not discharge to the canal.

ADAMSON SPRINGS (facility #140.10)

Adamson Springs is a series of contact springs located between the south edge of the Magna Tailings Pond and State Hwy 201 near the Diving Board Tailings Area. Since the opening of the Magna Concentrator the Springs were used for process water. The Springs were discharged into the tailings pond return canal where the waters mixed with runoff from the tailings pond and were pumped to the process water circuit at Pump #1.

Kennecott indicates that the springs are discharging groundwater from areas in and around Kennecott's former and existing operations. Two sumps collect the water. The southerly sump receives water from the south side of the pump station. The northern sump receives water from the north side and East Pond. Kennecott proposes to collect the water from the Springs separately from the process water. The total flow is estimated at 6000 - 8000 gpm. During March-October, the Power Plant will use the entire flow of the south sump (2000 gpm). The East Cyclone Plant will use 1000 gpm from the north sump during March-October. The rest of the flow will be pumped to a new outfall located 2000 ft. to the south into the Utah Salt Lake Canal. (The Utah Salt Lake Canal discharges to the C-7 ditch.) The new outfall will be 011 in the Kennecott UPDES discharge permit. Kennecott applied for this new outfall July 30, 1998. According to the application for the change, the water quality of Adamson Springs is as follows:

Parameter	Southern Sump	Northern Sump
TDS	2200 mg/l	5800 mg/l
Cl	890 mg/l	3700 mg/l
SO4	370 mg/l	960 mg/l
As (T)	4.9 ug/l	6.5 ug/l
Cu (T)	10. ug/l	35 ug/l
Pb (T)	2.5 ug/l	2.5 ug/l
Se (T)	5 ug/l	5 ug/l
Zn (T)	88 ug/l	10 ug/l

Kennecott performed a WET test of the separated and combined effluents. Although the combined effluent is not acutely toxic to Ceriodaphnia, the north sump was toxic due to elevated "Naturally occurring" chlorides. The water was not toxic when a more chloride tolerant test species was used (Hyalella Axteca).

During the reconstruction of Pump Station #1, Adamson Springs was segregated from the tailings return water in the clarification canal and can now be directed toward Outfall 011 when it is not needed for processing and will no longer add volume to the process water circuit when this volume is not needed.

NEW KENNECOTT OUTFALL 012 (facility #140.13)

In the new NPDES permit renewal of 2000, Kennecott proposes to consolidate Outfalls 001 and 002 which currently go into the C-7 Ditch into one outfall numbered 012 which would be a direct discharge to the Great Salt Lake. It is expected that the water quality would be similar to waters in outfalls 001 and 002, except for elevated levels of salt from the former Morton Salt evaporation ponds. The levels of salt would slowly decrease as the ponds are buried under tailings. In their permit application, Kennecott indicated that the total flow would decrease because Adamson Springs would have its own outfall (011).

Discharge from the integrated tailings impoundment will occur from the decant pond located in the North Expansion. Water will be pumped from the decant barge to the dilution vault located on top of the Magna Tailings Impoundment. From the dilution vault, the flow will be directed to the West Cyclone Station and from there into a 36-inch HDPE pipeline to the Great Salt Lake in the vicinity of the West C-7 Ditch.

The outfall structure will consist of a drop box and flowmeter. A 32-inch pipeline will extend from the outfall structure through existing culverts beneath the UP railroad, Interstate 80, and the frontage road to the Great Salt Lake to ensure that the discharge is directly into the Great Salt Lake and is not discharged along the shoreline. The length of the outfall into the Great Salt Lake was not described in the permit application. The design is likely to include a diffuser at the end. A 2:1 mixing zone was assumed in calculations.

The outfall will have waters which originated from several Kennecott wastewater and process circuit waters including all the waters which now go to outfall 008 or Pump Station 4. Current 008 discharges which would be redirected to Pump Station 4 along with other process waters include waters from artesian Garfield Wells, Kessler Springs and other West C-7 ditch waters.

In January, 2000, Kennecott began using the new outfall 012. According to a newspaper article (Tooele Transcript Bulletin, 3-16-2000) the outfall was built because the elevated salt content of water from the new tailings pond might wreck the wetlands at the mouth of Lee Creek and kill freshwater organisms in the creek. The salt was coming from the former Morton Salt ponds on which the new tailings pond was built.

GREAT SALT LAKE (facility #140.02)

The Great Salt Lake is a closed basin that collects drainage from a large part of northeastern Utah and parts of Idaho and Wyoming. It has no outlet and water losses are due primarily to evaporation (or diversion into evaporation ponds). Water comes from the Bear River (1.2 million acre-ft/yr), precipitation (1.0 million acre-ft/yr), the Jordan River (0.4 million acre-ft/yr), the Weber River (0.4 million acre-ft/yr) and other minor surface sources. Groundwater input is unknown. Kennecott [1996] estimates the groundwater inputs to be about 75000 acre feet/year, and precipitation inputs at 900000 acre feet/year. The Great Salt Lake is approximately 70 miles long and 30 miles wide.

According to Clark [1971], the watershed is 54,000 sq. mi. In 1960-1, the rivers contributed 82% of the water inflow to the Lake. Approximately 55% of the TDS came from the rivers and the rest from springs, drains, and sewage canals. The salt input in 1960 was estimated at 2 millions tons/yr. (but removal of salts was also estimated at 2 millions tons/yr). The inventory of salt in the lake varies with water level. In 1963, when the lake contained a low of 8,7 million acre-ft, the salt inventory was 4 billion tons. But in 1873, when the lake level was higher, the lake contained 30 million acre feet of water and 6 billion tons of salts. Clark [1971] explains that the difference in salt content arises because during high water levels, the water dissolves shoreline deposits of salt. When evaporated, Great Salt Lake water components precipitate in the following order: $CaCO_3$, $MgCO_3$, $CaSO_4$, NaCl, then $MgSO_4$, K_2SO_4 and Na_2SO_4.

The Great Salt Lake is a remnant of ancient Lake Bonneville which had a surface elevation of 5090 feet. The historic high of the Great Salt Lake (1987) was 4221 feet. Salinity of the lake varies between 5% to 27%. Today salinity in the north arm is about 20%; the south arm is about 10%. In addition to bacteria, the Great Salt Lake has blue-green algae, brine shrimp and three species of brine flies.

There are 6 algal species which live in the lake. The predominant one in the south arm is a green alga, Dunaliella vividis. The north arm can tolerate only one very brine tolerant algae. The difference in algae causes the north arm to be reddish in color while the south arm is green to blue green.

Brine flies (Ephydra cinerea) live on organic matter in the Lake. It is estimated that 5000 billion brine flies hatch each year and consume 120,000 tons of organic matter per year. The larvae live in bottom sediments along the shore, but can't survive in the heavy brine or anoxic sediments. Brine flies are food for several bird species.

Brine shrimp (artemia franciscana) live in the Lake during April through September. From 2 - 12 million pounds of brine shrimp eggs are harvested each year and sold mainly to prawn farmers in the Orient. It is a $30 million/year industry.

There are other species which are found in the freshwater lens at the top of the lake which come from washout from the rivers and streams. The birds feed on these species also.

Morgan [1947] indicated that birds have nested around the shores and on the islands of Great Salt Lake throughout recorded history. Birds noted by Fremont in 1843 included seagulls, great blue herons, white pelicans, double crested cormorants and Caspian terns. The large quantity of guano on the islands testified to the presence of birds long before historical records began. As early as 1852, it was noted that the gulls flew south in late summer. Morgan noted that location of each species nesting grounds varied from year to year, most likely due to predation and habitat competition from the gulls. Some birds were at one time viewed as competitors for local fish and sportsmen and the state killed several thousand pelicans in 1918. Later it was learned that the cormorants and pelicans feed mainly on trash fish (carps, chubs, and suckers) and not upon trout or other game fish. The source of the fish is Utah Lake or the mouths of the Bear and Weber Rivers.

The Utah Division of Wildlife Resources with the help of the Audubon Society conducts an annual Bird Survey of Great Salt Lake. They have found 250 species breed and winter over on the Great Salt Lake and 400,000 acres of associated wetlands. Seven waterfowl species breed on the lake (470,000 birds) and 10 more waterfowl species migrate through the area (2.69 M birds). The lake is home to the largest nesting population of California gulls and the largest staging concentrations of America avocets, blackneck stilts, and Tundra swans. Endangered or sensitive species include peregrine falcons, bald eagles, American pelicans, and snowy plovers. They feed on 23 species of fish which live in river estuaries and freshwater wetlands and impoundments.

Morgan [1947] noted that Indians used the brine shrimp for food and several people in 1893 sampled them and pronounced them "actually delicious".

Another less known biological species of the Great Salt Lake documented by Morgan [1947] was the so-called Salt Lake monster (a similar creature had also been observed in Bear Lake and Utah Lake in 1868.) The monster was described as nondescript with a body half seal, half serpent and a head somewhat like a sea lion. Morgan noted that it seemed to be invisible when scientific observers were at hand. It was also described as very agile if it had to migrate between Salt Lake, Utah Lake and Bear Lake.

Mineral resources are extracted from the lake by diverting the salty water into evaporation ponds. 1.6 million tons worth $150 million were recovered in 1990. The main products are salt, potash and magnesium. Compared to seawater, lake water is enriched in Li and depleted in K and B.

Six mineral extraction companies operate near the lake today using solar evaporation to recover minerals. The value of the minerals was estimated at $230 M/year in 1997. About 31 billion gallons of water was pumped. Sodium chloride is sold for deicers. Other by-products include potassium, sulfate and magnesium chloride. [Swensen, DN 8-8-99]

The shrimp industry in 1998 had 32 companies hiring 1000 year round jobs. The GSL supplies about 90% of the world's supply of brine shrimp cysts. [Swensen, DN 8-8-99]

The shrimp industry has been plagued with poor harvests the last several years which they blame on the railroad causeway and other dikes which interfere with the even distribution of salt. The northwest arm of the lake is now too salty for the prime shrimp food, and the southern part of the lake is too fresh. The shrimp industry would like the openings in the causeway deepened and enlarged. The mineral industry on the north arm likes it the way it is. [Sanchez, DN 8-5-99].

There have been two special studies of the trace metal content of the Lake [Tayler, Hutchinson, and Muir (Kennecott), and a study by Johns Hopkins investigators]. The Kennecott investigators found two layers in the south arm of the lake with the top 26 feet being oxygenated, and the bottom anaerobic. Average concentrations of Cu and Pb were 17 ppb and 13 ppb, respectively. The authors concluded that the concentrations of heavy metals are "extremely low" [Low, compared to what?]. The authors attempted a mass balance calculation, but did not include industrial or municipal sources. The only use of the lake described by the authors was the use as a "natural waste disposal system". They concluded that the influent metals rapidly precipitate out because most of the metals were associated with particulates. The metals in GSL sediments were also studied. Lead concentrations ranged from 26 - 229 ppm; Arsenic concentrations ranged from 10 - 100 ppm.

Johns Hopkins investigator found similar results to the earlier Kennecott study for Lake water. The Hopkins group also studied sediment cores and found that several trace metals were increasing in the cores. They attributed the cause to copper mining in the Oquirrhs.

Since the Kennecott paper was published [late 1970's?], both the state and the USGS have monitored the Great Salt Lake at several locations. The state data do not agree with the Tayler, et al results. Copper and cadmium are routinely both much higher in the state data set. The division between dissolved and particulate is also different in the state data.

In the fall of 1995, Kennecott consultants began a survey of the Great Salt Lake to determine present chemistry and begin preparations for some bioassay testing of the brine shrimp.

Kennecott outfalls to the Great Salt Lake include Outfall 004 and 012. Outfall 004 is a combination of artesian flow and stormwater from the Kessler Canyon drain canal, Japanese Springs, excess water from Tooele Springs and Section 17 well overflow into Hazelton Pond. Outfall 012 is a proposed outfall which would replace 008 and 002 (flow from the Magna Tailings Pond and the Garfield Wetland areas via the C-7 Ditch and West C-7 Ditch).

Stormwater discharged out 004 comes from three areas. About 127 acres on the west side of the smelter drain to Japanese Springs with eventual discharge into Hazelton Pond or to the Great Salt Lake via 004. About 79 acres east of the smelter drain to wetlands northeast of Praxair. About 3450 acres of Kessler Canyon above the smelter drain to the Kessler drain canal which flows underneath the smelter site. This canal also collects stormwater flow from the smelter parking lot and the reclaimed smelter landfill area. The Kessler drain canal discharges into Hazelton Pond or the Great Salt Lake Outfall 004.

The Great Salt Lake's water classification by the state is 5. There are no numeric standards at present, but 27 ppb Se has been proposed.

GREAT SALT LAKE SHORE (facility #140.03)

Several calls to EPA have been received from citizens with questions about the health impacts of recreational use of the Great Salt Lake and its shoreline. Contamination on the beaches could arise from deltaic type deposits near major outfalls, long shore transport of particulates and deposition of lake sediments near or on the shore from wave action. EPA could find no systematic study of shoreline sediment analyses. The state does monitor for fecal coliform and metals in the waters near beaches and marinas.

The owner of the Saltair sued Kennecott in 1993 alleging that seeps of contaminated groundwater was leading to noxious odors rendering use of their facilities unpleasant. A brief study of conditions near the resort as it related to groundwater seeps was conducted by Hansen, Allen, and Luce for Plumb and Dalton. They suggested the source of the groundwater seeps onto the beach was ponds along I-80 and the frontage road. They confirmed that odor problems were present where the ground was saturated, but none where the ground was dry. They suggested that a drainage system be installed to direct the seepage away from the resort and perhaps drain the ponds themselves. A few water samples from the ponds were collected and analyzed as a part of this study. In the process of investigating the problem, KUCC learned that the culvert draining the I-80 pond adjacent to Saltair was buried when the level of the highway was raised. The lawsuit was settled when the Utah Dept. of Transportation agreed to re-establish the culvert under the highway. Seepage was greatly reduced. It was never proved that the seeps were the cause of the noxious odors.

In the summer of 1995, the Bureau of Reclamation completed a beach shoreline survey for EPA. The results indicated that all the beach sediments/sand/soil contained Pb and As below residential health risk levels.

SALTAIR AND OTHER BEACH RESORTS (facility #140.11)

According to Morgan [1947], the first record of a community beach excursion occurred in 1851 when Salt Lake residents traveled by horses and carriages to Black Rock Beach. The first beach resort was developed at Lake Point where Jeter Clinton had a landing for his steamship. The Utah Western RR (narrow gauge) reached this area in 1875. The resort had a pavilion and bathhouses. In 1878 a small competing establishment was founded at Black Rock. Garfield Beach was founded in 1881 when the captain of the General Garfield steamship beached her a short distance west of Black Rock resort. Both resorts near Black Rock were serviced by the Utah Western RR. Eventually these resorts were bought by the railroad. Because they were closer to Salt Lake City, Clinton's establishment at Lake Point went out of business by 1885.

The services at Garfield Beach were expanded to include a pavilion which was 165 ft x 65 ft built over the water about 400 feet from the shore. The beach was the only resort on the lake having "a clean, sandy beach, free from mud, rocks, and offensive vegetable matter" [Morgan, 1947].

The first Saltair pavilion was built in 1893 and was owned by the LDS Church. The pavilion was built in the Moorish style on the end of a pier 4000 feet out into the lake. It was 2 stories and about the size of the tabernacle. There was no beach at the first Saltair. The church sold the resort in 1906 but retained a share of the income.

In 1904, the Garfield Beach resort burned to the ground along with the steamship General Garfield. Morgan [1947] reported that the Western Pacific Railroad built its road bed "ruthlessly across the charred remains of the General Garfield".

The original Saltair pavilion burned in 1925 except for the pilings, the beach office, and the roller coaster. The pavilion was rebuilt in 1926. Due a series of dry years, the lake level began to drop in the 1930's. By 1933, Saltair was high and dry. In 1935, the Saltair pavilion was over ½ mile from the water. They installed a small railroad line to get the bathers to the water. Competing beaches were opened at Black Rock and Sunset Beach (near Fritch Island). These resorts actually had a beach.

Over time, Saltair became more and more dilapidated. It was given to the state in 1959 and burned to the ground in 1970. Again, Saltair was rebuilt on a less lavish scale in 1982 on the shore to the west of the original location. The rise of the Great Salt Lake during the high water year of 1984 flooded the first floor to a depth of 5 feet. The building was sold in 1992 to Walter Plumb, who restored the building. It is now available for concerts and conventions. (See also 140.03)

SOUTH SHORE BOATING AND PORTS (facility #140.12)

Pleasure boating has been a lake activity since the early days of settlement. Brigham Young had a boat which he used for excursions and later to ferry cattle to Antelope Island. Lake Point became the home port of the a steamship, the General Garfield (formerly the City of Corinne), where it was a port for ores being shipped from Stockton and Tintic via wagon. From Lake Point, the ores were shipped via steamship to Corinne which was a stop on the transcontinental railroad. The Utah Western Railroad reached Lake Point in 1875. After that the General Garfield was not used for shipment of ores and Lake Point became a beach resort.

The Salt Lake Yacht Club was founded in 1877. Interest waned for a while but revived in the 1920s. The Great Salt Lake Yacht Club was organized in 1929 and opened a clubhouse beneath the south pier at Saltair. When the lake level dropped in the 1930s, the salt began to crystallize on the boats. Eventually it was decided to separate boating activities from bathing facilities. Salt Lake County boat harbor was built about 1 mile east of Fritch Island (Sunset Beach). The water was fresher there due to shoreline springs and boats did not cake with salt. [Morgan, 1964]. Kennecott thinks the springs were not right at the shoreline, but along the southern boundary of the wetlands (such as Kessler Springs, No Name Springs, Spitz Springs), and the fresher water near the boat harbor comes from surface water runoff from the wetlands. Occasionally boaters at the marina have complained that fallout from Kennecott creates a dust buildup on their boats.

CHAPTER 20
AREAS CLOSE TO KENNECOTT OPERATIONS NEAR MAGNA

Because of proximity to Kennecott operations near the Great Salt Lake and Magna, several areas were investigated to determine if environmental impacts had occurred. These areas included former and current power plants, former and current town sites, nearby canyons, and an adjacent industrial facility.

UTAH COPPER POWER PLANT (facility #78)

Power for the Magna mill was provided by the construction of an 8,500 kw steam generating plant at Magna in 1906. The plant was 158' x 288' and was located 2000' east of the Magna mill. [Kennecott, 1997, reports the location as 2000' north of the concentrator, near the southern embankment of the tailings impoundment adjacent to the No. 1 pump station.) It had 2 concrete smokestacks 180' high. Shortly after a 25 year contract with Utah Power and Light was signed in 1912, the Magna steam generating plant was shut down and later dismantled. [Arrington, 1963]

The plant was constructed of steel, brick and concrete [Utah Copper, 1939]. The boiler room contained twenty 600 hp water tube boilers, fired with mechanical stokers. Five generators were driven by cross-compound, condensing, reciprocating engines. The total capacity was 8500 kw. Power was transmitted to a central mill substation 1/2 mile away at 4000 volts. After 6 years this supply became inadequate to service the mine and mill. In order to service the power needs, electricity was imported from Utah Power and Light to a central switching station constructed with switches, circuit breakers, transformers and oil circulating pumps. Each mill had its own substation.

Kennecott [1997] indicates the wastes produced included fly and bottom ash which was likely disposed of in the adjacent tailings pond. After removal of all transformers containing PCBs in 1992-3, remaining structures were removed shortly thereafter. Asbestos abatement was done by Thermal West. Brick and concrete was disposed of in the Tailings Impoundment Landfill. Scrap steel went to Atlas Steel for recycling. Footings and walls below grade were left in place and covered with 18 inches of top soil. The site was sampled in 2001 and metal concentrations were low. No further action was taken. The site was closed out by the North End ROD in Sept 2002.

NEW POWER PLANT (facility #100)

The impending threat of WWII resulted in an increasing demand for electricity to supply the growing numbers of defense industries coming to Utah. To meet this urgent demand, the government requested that Kennecott build a 100,000 kw electric generating plant to supply the needs of the Utah Copper Division. Work on the plant was started in May 1941, but the first unit was not placed into operation until Feb, 1944. When finally completed, the cost of the plant amounted to $8 million. A third generating unit was added in 1947, raising the plant capacity to 110,000 kw; the added cost brought the total investment to $12.5 million. The need for additional power at Utah Copper became evident in 1950 when the Utah refinery was built, and even more so with the purchase of the Garfield smelter in 1959. Therefore, the power plant was expanded to 175,000 kw in 1960 at a cost of $18 million. [Arrington, 1963]. The plant is coal fired, but it has the capacity to operate on natural gas [SAIC, 1991] Normally coal is used in the summer and natural gas in the winter. It has been retrofitted with low Nox burners over the last few years.

The power plant consists of two 25 megawatt units, a 50 megawatt unit, and a 75 megawatt unit. Each unit has 3 coal pulverizers, boiler, turbine generator, electrostatic precipitator, emission stack, transformers, controls, and auxiliaries. This plant can burn either coal or natural gas. Coal combustion generates wastes in the form of fly ash and boiler bottom ash, both of which are disposed of in the tailings pond. Based on an annual rate of 200,000 tons coal per year with an ash content of between 8 - 10%, some 18,000 tons per year of ash are generated. [BPMA, 1988]

Kennecott [1997] currently uses low sulphur coal from Southern Utah and burns about 500,000 tons of coal during the summer months. In the winter the plant consumes natural gas, about 40,000 million cubic feet per day. Power generation is at 13,800 volts and is transmitted at 44,000 volts. With cogeneration potential at the smelter, the plant serves about 75% of Kennecott's power needs. The rest is purchased from UP&L.

Wastes generated at the power plant include silica slag, flue dust, and fly ash. As the slag is generated, it is accumulated in a side dump rail car at the plant. As of late 1987, the rail car was being picked up and dumped at various locations long the Kennecott ore transport rail system. The flue dust and fly ash are piped off as slurry to the Magna Tailings pond for disposal. There have been allegations of on-site disposal of fly ash and flue dust at the power plant facility. The location and occurrence of this disposal is unproven to date. A site visit report contains a photograph of a fenced area that is identified as an abandoned coal slag disposal area, but it is unknown if this area has been sampled. [SAIC, 1991]. Kennecott [1996] reports that no inorganic concerns have been found at the power plant (but is silent on the organics).

A Kennescope article [1956] indicated that boiler tubes required acid cleaning for the first time. Approximately 6 tons of sludge including iron oxide, copper, phosphorus, and others were removed. The tubes had been damaged by these deposits. Routine acid cleaning procedures were adopted after this discovery. The location of the waste products generated during this process was not specified. The boiler tubes were again repaired and cleaned out in 2001.

Kennecott [1997] indicates that the fly ash is slurried to the tailings impoundment and the bottom ash is trucked to the landfill. Some silica slag was used at the rail graveyard site to enhance drainage [Kennecott, 1997].

POWER STATION (facility #100.01)

Schroedl [1993] refers to a power station greater than 50 years old located near Kennecott Gate 40. The structure is still in use. The exterior is stucco and the roofing material is shingles; the building does not have any apparent alterations. It may be eligible for the National Register of Historic Places because "it retains its integrity and represents a distinctive architectural style". It was built after 1945 but before 1952. The street address is about 2400 South 7400 West, Magna. This was later identified as Pump Station 21 and is located south and west of the Magna Tailings Pond.

BLACK ROCK CANYON (facility #139)

Black Rock Canyon is located about ½ mile SW of the Kennecott smelter on the north end of the Oquirrh Mountains. Black Rock is a geological feature along the shores of the Great Salt Lake at the mouth of the canyon. The area was originally settled by ranchers. The first homesteader was Charley White who had a cattle ranch at Black Rock in 1849 and was also engaged in salt boiling. He claimed to produce 300 lbs of salt/day with his 6 - 60-gallon kettles. In the 1860's Heber Kimball built a ranch near Black Rock. His barn also doubled as a stage coach stop. During this time (1868), the area became known as Pleasant Green.

In September, 1944, two WWII planes crashed into the Oquirrh Mountains in Black Rock Canyon. The bodies of the crew members were retrieved, but the wreckage of the planes was left. Due to media coverage of this ill-fated flight in 1999, two trespassers were caught by Kennecott security trying to make off with artifacts. The artifacts were confiscated by Kennecott security. Later the artifacts and the wreckage were given back to the Air Force who retrieved the wreckage in Oct. 1999.

The ecological risk soil samples indicated that lead values averaged 176 - 235 ppm and arsenic values averaged 71.5 - 94.8 ppm. Invasive plants include Kentucky bluegrass, cheatgrass, scratchgrass and tall wheatgrass. Forbs included curlycup gumweed, white top, dalmatian toadflax and milkweed. There was a small area of submontaine shrub including mountain lover, scrub oak and rubber rabbitbrush.

Vegetation in Black Rock Canyon was also devastated by smelter emissions. There was at least one mudflow in the Canyon that wiped out the railroad tracks at the foot in 1899. Revegetation efforts are underway. Progress is unknown. A recent ecological assessment indicated that plant taxa in Black Rock Canyon indicates reduced numbers of native species relative to Coon Canyon. Coon Canyon was 73% native plants; Black Rock Canyon was 61% native.

In 2000, Kennecott proposed to lease a part of Black Rock Canyon for use in a sand and gravel operation. A full characterization is planned before operations begin to insure that hazardous materials do not go off site along with the sand and gravel. This part of the canyon was previously used as a sand and gravel borrow area by UDOT during the project when I-80 roadbed was elevated due to rising Lake levels in the early 1980s. Monroc (the lessor) is required to reclaim the site as excavation proceeds. Kennecott also required a surety from Monroc to insure the reclamation is conducted. In 1999, prior to leasing the area to Monroc, Kennecott characterized the surface soils in the area of the lease. (It is unlikely that this was native surface because the area had previously been used as a borrow area by UDOT.) The maximum arsenic in the soil (floor of lower canyon) was 76.6 ppm, averaging 24.9 ppm. The maximum lead was 202 ppm, averaging 64.9 ppm.

GARFIELD TOWN SITE (facility 136.01)

The Garfield Town Site is the footprint of the old town of Garfield. The highest concentrations were 190 ppm As, 1000 ppm Pb, 5.6 ppm Cd, and 70 ppm Se. Although the first house was erected in the Garfield area about 1857, the town of Garfield was founded in 1905 by ASARCO, Boston Consolidated, and Utah Copper to provide housing for smelter and mill workers [DN 12-5-06]. The town was owned by the Garfield Improvement Co, a subsidiary of ASARCO and Kennecott. Jones [1995] indicates that the northern part of the original townsite plan was buried by tailings. The RR depot in Garfield also had to be relocated in 1917-9 when the tracks were realigned around the tailings pond expansion of 1918. There were two floods recorded; one in 1926 covered the lawns with mud and damaged the RR tracks; one in 1930 was caused when the Utah and Salt Lake Canal washed out its banks, washing out the tracks and leaving 2.5 feet of mud in the town. By the 1950's, Garfield had a population of 2000 with a school, swimming pool, library, post office, and businesses. The townsite was sold in 1955 to Galbreath Realty along with Copperton and some houses near the Magna and Arthur mills [DN 12-15-55]. Involved in the sale were 217 houses in Copperton, 90 houses in close proximity to the Arthur and Magna Mills and 394 houses in Garfield. In Garfield, residents were allowed to buy their homes if they could be moved to a different location. 60% moved their houses to Kearns [DN 8-28-56.]

Contemporaneous accounts give several reasons for the town to be abandoned. (1) Workers no longer had to be close to the smelter and mills with the advent of automobiles. (2) Kennecott wanted to get out of the landlord business. (3) Another reason was "the contamination problem from industrial gases" [DN 12-15-55]. A newspaper editorial stated..."the site itself can never be made a desirable one due to the fumes from the copper refinery, the smelter, and the Western Phosphate plant, all close by." [DN 12-16-55] (4) Company officials also noted that the housing in the whole town was substandard, not just the additions made in WWII. [DN 12-16-55]. The moving of the Garfield houses and residents was completed at the end of 1957 [SLT 8-16-57]. Kennecott now owns the vacant land.

The area was described in 1995 as an area of 42 acres about 40% was vegetated with Russian Olive and Cottonwood trees with the remainder being grass.

In 1995, Kennecott was using the area for stockpiling materials including some top soil from a downtown Salt Lake City construction project. It also had a parking lot for refinery workers and a batch plant. In 1995, Kennecott characterized the soils at the Garfield town site. None of the soils exceeded the action levels for the North Facilities Soils removal action (industrial levels). No removal activities were necessary but there was some reclamation performed at the site. Roads, curbs, gutters, parking lots, etc were demolished and the exposed soils were sampled and revegetated by tilling and seeding with native plants. Several roads were left in place to provide access to the area.

MAGNA SOILS (facility #137)

Testing conducted on soils in the Kennecott North Area have yielded results indicating high levels of contamination in a park and residential section of the town of Magna. The contaminants found in surface soils within the town included elevated levels of copper, lead, and arsenic. The portion of the town identified with the contamination is in the northwest portion of the Magna area, which is the older residential area. This area is immediately south of the Magna Tailings Pond and east of current Kennecott property. The pattern of metal concentrations decreasing with depth in the area seem to indicate a possible historical wind deposition of the site contaminants. [SAIC, 1991]

Also there was a flood in 1930 which transported water and mud throughout the town. The mud came from Little Valley. Several homes on 1st and 2nd west were carried away. The waste canal on 9200 W was a river and overflowed its concrete sides. The Saucer Dam north of Magna Cemetery was constructed as a WPA project in the 1930's to control flooding [Hulse, 1964]. (Another flood in Magna in 1922 was caused by a flood in the Utah and Salt Lake irrigation and process water canal.)

Kennecott suggests that there are many potential sources of metals in the Magna soils, some of which are: (1) emissions from smelters; (2) phosphate plant; (3) Magna tailings pond; (4) windblown dust or runoff from the Diving Board tailings; and (5) emissions from motorized vehicles. A previous study suggests that smelting fallout is responsible for Cu and As contamination, and Pb, Cd, and Zn came from auto exhaust. [Kennecott, 1991]

EPA, using the BOR with an Interagency Agreement, collected about 400 samples in the settled portions of Magna to determine if a removal action in this area was necessary. Few samples were found to exceed typical action levels, and no removal action was recommended.

LITTLE VALLEY (facility #138)

Vegetation in Little Valley (near the Bonneville crusher) was devastated by smelter emissions in the early days of the older ASARCO smelter. Revegetation efforts began in the 1930's by residents of Magna. The area, denuded of vegetation, was prone to flooding. One such flood roared through downtown Magna.

Winsor [1964] indicated that Little Valley produced a flood at the same times as the floods in Garfield, one of which filled up the large culvert under the Bingham-Garfield railroad tracks with boulders. Afterwards the culvert was cleaned and a drop inlet above it was made to prevent clogging of the culvert. Also the WPA built two dikes across the stream bed above the tracks and one below the tracks above Magna. Winsor suggests that the one above Magna saved the town from flooding several times. In 1945, a flood knocked a bad break in a 36" water pipe to Garfield and Magna. After pipe repair, an overshot was built at the spot to carry future food waters over the pipe.

Revegetation has been continued by Kennecott and now the land is leased for grazing. A flock of sheep was there in the summer of 1993. Bare spots now exist on some of the hillsides surrounding the valley. A recent ecological risk assessment indicates that there were reduced numbers of native species relative to Coon Canyon. Coon Canyon had 73% native species; Little Valley had 54% native species. The predominant plant species in Little Valley was wheat from the use of straw.

Ecological studies showed that the lower levels (grass-submontane shrub) had many invasive plant species at this elevation including: Kentucky bluegrass, winter wheat, curlycup gumweed, scrub oak, western ragweed, pila fescue, dalmatian toadflax, big-tooth maple, yellow sweetclover, and cheatgrass. Higher elevations contained some coniferous forest vegetation including Douglas fir, white fir, and mountain maple.

The soil concentrations were surveyed as a part of Kennecott's ecological risk assessment. Average lead values were 136 - 209 ppm; arsenic averaged 46.3 - 58.2 ppm. The ecological risk study also suggested that grazing pressure was responsible for habitat reduction for voles and shrews. Grazing by livestock has been discontinued in Little Valley [Kennecott, 1997]. This is being reexamined.

There are several pockets of wastes which have settled in the bottom of drainages downgradient of the Bonneville Crusher. These waste pockets are recognizable because they do not support vegetation. The wastes originated from the ore storage area at Bonneville Crusher and are essentially fine grained size particles of ore which had washed off the pile. This area was studied as part of the North End Soils removal, but the waste did not have concentrations exceeding the action level. No removal was slated. However, in 2001, the Utah Division of Water Quality requested that Kennecott remove these wastes because the state was concerned that they might contaminate the underlying ground water with sulfate. The wastes from Little Valley Wash were removed in 2001 and placed in the tailings pond.

Little Valley Wash has a Kennecott permitted discharge to it, Outfall SW3, covering stormwater. Kennecott indicates that stormwater from the area southeast of the North Concentrator may flow into the wash during a significant storm. Little Valley Wash has not been classified by the state.

70. COBALT LEACHING FACILITY - Garfield Cobalt Refinery (facility #70)

The site of the former Garfield Cobalt Refinery lies west of Garfield on the southern shores of the Great Salt Lake in Tooele County just to the west of the Salt Lake-Tooele county line. It is located just off I-80 at Lake Point Junction about 1/4 mile SW of the junction of I-80 and Hwy 201. The land for the site was originally purchased from ASARCO and Union Pacific. It is unknown if they had any facilities on the site prior to the Cobalt Refinery operations.

The Garfield Cobalt Refinery was designed and constructed by Chemical Construction Company (Chemico), a subsidiary of American Cyanamid Company. Chemico designed and built the refinery for Howe Sound Company and its subsidiary Calera Mining Company to refine cobalt concentrates from Calera's Blackbird mine and mill in Lemhi County, Idaho [SAIC, 1994]. Construction of the refinery began in 1950 and was completed in 1952. The initial equipment was plagued with corrosion problems and several changes in the process were needed. Chemico took over operation during 1954 and 1955 and upgraded the process and equipment.

Calera's mill in Idaho produced a concentrate containing:

Co	17.5%
Fe	20.0%
As	24.0%
S	29.0%
Ni	1.0%

The concentrate was shipped to Garfield by rail in 50 ton lots. After assay, the lots were blended to achieve the optimum As/Fe ratio. Water was added to create a slurry (25% solids), and screened to remove debris. Oxidation of the concentrate slurry was accomplished in a horizontal pressure vessel (40 feet long, 6 feet diameter). This process was done at high temperatures and pressures (375°F, 500 psig). Oxygen was added via compressed air; concentrate, process solutions and recycled materials were added continuously. The chemical reaction was exothermic producing an oxidation slurry of free acid, cobalt, nickel, iron, and copper as sulfates, and minor ammounts of arsenic in solution. Calcium sulfate and iron arsenate were insoluble residues. [This operation was particularly prone to mechanical difficulties due to excessive corrosion and wear of pumps, valves, etc. Titanium piping and fittings were found to help considerably.]

The oxidation slurry was filtered following neutralization of the slurry with limestone and lime. Filtering was done using drum filters. The iron arsenate-gypsum residues were "discarded to waste".

The process solution needed further purification to remove residual iron, arsenic, and copper. This was done in a batch operation by adding lime, anhydrous ammonia, and air, producing insoluble gypsum, iron hydroxide and minor amounts of iron arsenate. These insoluble materials were removed by filtration. Because this material contained cobalt also, it was recycled through the oxidation step.

The process solution then went to another batch operation to remove copper, by introducing cobalt powder. The sludge produced was a copper cement sludge. Later the sludge was further processed to separate the cobalt and copper.

The process solution was then reduced in a vertical autoclave where anhydrous ammonia was added to form a complex cobalt amine. Then hydrogen was added in the presence of a catalyst. This process was done at 375°F and 750-800 psig and produced a fine cobalt powder. Some of the cobalt plated out on the inside of the autoclaves and this had to be removed by acid leaching. The cobalt still contained too much sulfur so the cobalt powder was washed with water. The wastewater still contained cobalt and this was treated with ammonium or sodium sulfide to produce cobalt sulfide which was recycled back to the oxidation step.

The remaining sulfur was removed from the cobalt powder in an arc furnace. The material was charged into a 'Lectromelt Furnace, and melted in the presence of a high lime slag. The molten metal was poured into water to form granules. The granules were dried, polished and put in steel containers for shipment [Mitchell, 1956]. In 1957, Calera replaced the final reduction step of the original process by adding an electrolytic step to produce higher quality cobalt.

Production figures were given in the Mineral Yearbook for each year:

Year	lbs. of Co
1953	591,500
1954	631,400
1955	1,616,300
1956	2,355,000
1957	2,681,000
1958	3,061,000
1959	1,121,000
TOTAL	12,146,200

The Cobalt Refinery was originally built with support from the U. S. government to provide a domestic source of this strategic metla. However, by 1959, domestic cobalt production was not deemed important for national security anymore, and the cobalt contracts with the Defense Department were not renewed. Foreign suppliers, mainly from the Belgian Congo and Belgium, provided most of the nation's cobalt needs. After fulfillment of the government contracts for the cobalt [U.S. Defense Minerals Exploration Administration], the Calera mine closed in June 1959, and the Garfield Refinery closed in September 1959.

Since the concentrate contained about 17% cobalt when it arrived at the refinery, the rest of the concentrate became waste. This would amount to 59,304,000 lbs of waste from the concentrate itself. In order to neutralize the sulfuric acid produced, lime was used. At least 26,700,000 lbs of Calcium would have been needed for this process. Oxygen to make sulfates would also add to the tonnages of wastes. There was no evidence that any of these wastes were removed from the site at the time of closure.

Following closure of the Garfield cobalt refinery, the property was sold to Minerals Engineering Company and Susquehanna-Western. The plant was converted to produce vanadium pentoxide. The companies signed a 5 year contract with FMC in May 1960 to provide raw material, a vanadium-bearing ferro-phosphorus slag from treatment of phosphatic ores from Idaho and Montana. Actual output began in 1961. Prior to 1960, vanadium was produced as a by-product of uranium processing, but declining uranium production made a new source of vanadium attractive.

The original design of the process was calculated to produce 1,000,000 lbs. per year of vanadium pentoxide, also known as "red cake." Susquehanna-Minerals received a preconcentrated slag containing 15-16% vanadium pentoxide. The vanadium pentoxide product was produced from the concentrate by salt-roasting, leaching, and stripping from solution by solvent extraction. FMC reported in their response to a 104e request that the process involved mixing the preconcentrated slag with salt and roasting it at 650 - 800° C for 25 - 30 minutes. The resulting product was extracted with water and filtered. The solution extract, containing sodium pyrovanadate was then mixed with ammonium chloride to produce ammonium vanadate. This was then fused to release the ammonia producing a product of vanadium pentoxide with 95 - 100% purity. The waste products from the filtration step contained tailings composed of phosphate, Cr, Fe, and SiO2. The plant was shut down in May 1962. The parties sued each other shortly thereafter.

If the full production capacity were achieved, approximately 750,000 lbs of vanadium pentoxide would have been produced from 5,000,000 lbs of slag concentrate. At a minimum, at least 4,250,000 lbs of wastes would have been produced.

In 1974, the property was sold to Chad White and his relatives who have operated a plumbing supply company on the site. The tailings from the historic operations cover less than 10 acres and are located just west of the main building. Tailings appear to be 10 - 20 feet deep at the northern boundary, shallower to the south. The site is used by motorcyclists, 4 wheel drive vehicles, and horses. Surface water usage is confined to recreation at Great Salt Lake beaches [PA, UDEQ, 1987].

A PA was conducted in March, 1987, and completed in April, 1987. An environmental assessment was conducted by UDEQ in fall 1994 to determine if this area should be an OU at the

Kennecott North Zone site. EPA has given UDEQ a cooperative agreement to collect samples at this site to determine if action is necessary. Kennecott does not own the site.

The UDEQ study indicated high levels of arsenic at the site, some radionuclides, tanks and barrels with unknown contents. There was evidence of off-site migration of tailings material. Local sources indicate that some off-site tailings could have been purposeful, occurring during pump failures. Others could have been enhanced from a spill of sulfuric acid from a rail car derailment on the siding adjacent to the site. [The derailment story, from a local source, could not be confirmed through government sources.] The EPA OSC for the site was Duc Nguyen. This site was administratively segregated from the overall Kennecott site for a separate removal action.

The main body of remediation work at the site began in May 1997 and was completed during October 1997 under an Unilaterial Administrative Order (UAO) issued by EPA on August 15, 1996.

Interim measures as required by the UAO were completed in the fall of 1996. These measures included the lime stabilization of the upper nine inches of the spilled tailings deposit in the Low Area; the construction of a sedimentation basin to prevent arsenic-bearing sediments transported from the refinery area by stormwater runoff from flowing into less affected areas during the winter of 1996-7; and the application of asphalt emulsion to the non-vegetated portions of the tailings pond dike as an erosion control measure.

The work in the Low Area consisted of chemical/physical stabilization and removing from the site all visible tailings as well as all contaminated soils exceeding the action level of 200 ppm As or a maximum of 18 inches below grade. Cement kiln dust was used as a stabilization agent. During the progress of the work, it was discovered that the contiguous tailing deposit extended eastward 500 feet beyond the initial expected limits of excavation. Visible tailings were excavated to depths sometimes exceeding three feet resulting in nearly 15,000 cy of in-place soils/tailings being stabilized. The stabilized material was shipped by rail to East Carbon Development Corporation (ECDC), a subtitle D landfill located in Carbon County, Utah. A total of 20,058 tons was shipped. The wastes in the tailings pond exhibited some unusual leaching behavior. When tested using organic acid in the TCLP, some metals did not leach for some samples., but did leach using distilled water of Great Salt Lake water.

Work in the Refinery Area consisted of the removal and off-site shipment of all asbestos-containing material; the removal to the tailings pond of contaminated process equipment, waste piles and debris; and the excavation and removal of contaminated soils to the tailings ponds. The material was disposed of at the Waste Control Management Landfill located at 1300 South 8000 West in Magna Utah. A total of 570 cy of waste from the Refinery Area was placed in the tailings pond for disposal.

Work in the Tailings Pond area consisted of placement of waste pile debris and contaminated soils/tailings and ditch sediments into the tailings pond and the construction of a permanent cap over the pond. The cap consists of a 5 inch bentonite amended clay layer covered with 1.0 feet of fill material and 6 inches of top soil. Wind blown waste material in ditches and on adjacent flats were also excavated.

Both surface water and ground water at the site are being monitored over the next five years. Four monitoring wells have been installed, two down gradient of the Low Area and two down gradient of the tailings pond. These wells are being sampled and tested quarterly for dissolved arsenic. Surface water samples are being collected from the two ponds located between the site and the Great Salt Lake. The structural integrity of the tailings pond cap are being inspected yearly each spring for the 10 years following remediation.