Health Consultation

BARRELS DISPOSED IN LAKE SUPERIOR BY U.S. ARMY

DULUTH, ST LOUIS COUNTY, MINNESOTA

EPA FACILITY ID: MND980679344

MARCH 14, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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Prepared By:

Minnesota Department of Health
Environmental Health Division
Under A Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

FOREWORD

This document summarizes public health concerns related to barrels containing wastes that were disposed in Lake Superior. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). For a formal site evaluation, a number of steps are necessary:

Evaluating exposure: MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. Rather, MDH relies on information provided by the Minnesota Pollution Control Agency (MPCA), the US Environmental Protection Agency (EPA), and other government agencies, private businesses, and the general public.

Evaluating health effects: If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. MDH's report focuses on public health— that is, the health impact on the community as a whole. The report is based on existing scientific information.

Developing recommendations: In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to pollutants. The role of MDH is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory to warn people of the danger and will work to resolve the problem.

Soliciting community input: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

Please write to: Community Relations Coordinator
Site Assessment and Consultation Unit
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OR call us at: (651) 201-4897 *or* 1-800-657-3908
(toll free call - press "4" on your touch tone phone)

On the web: http://www.health.state.mn.us/divs/eh/hazardous/index.htmls

Introduction

From 1959 through 1962 contractors of the US Army dumped a large number of barrels into Lake Superior. The barrel dump sites have been identified by the Minnesota Pollution Control Agency (MPCA) as site number MND980679344. While the Army has stated that the barrels contained "classified" parts from grenades, there have been reports and speculation about barrels containing other materials. The Minnesota Department of Health (MDH) receives questions about the barrels every few years. Questions are often related to the potential contamination of drinking water drawn from Lake Superior. Therefore, MDH reviewed files at the MPCA and from the US Army Corps of Engineers (US ACE), a citizen-compiled report, and numerous newspaper articles on the site. MDH conducted this review of available information to document questions and concerns, and to record recommendations. The Reference section at the end of this report is a list of many of the documents MDH reviewed.

Site Background and History

Given the standards applied to waste disposal today, it is somewhat surprising how wastes were disposed in the late 1950's and early 1960's. Disposal of wastes into Lake Superior is an environmental issue, but disposal of hazardous wastes with the potential for contaminating drinking supplies or accumulating in food could be a public health issue as well.

- From 1959 through 1962, 1400-1500 (described as: some 1440; 1450; 1400 or more; 1437; about 1400; approximately 1450; some 1437; in excess of 1400 barrels) were dumped into Lake Superior under the supervision of the US Army.
- Six loads of barrels were dumped on 7 days from 1959 to 1962 (MPCA 1985).
- The barrels contained material used by Honeywell, Inc. at the Twin Cities Army Ammunitions Plant (TCAAP) in Arden Hills, Ramsey County, Minnesota (NPL number: MN7213820908). In addition, 6 barrels were determined to have come from the Honeywell facility in Hopkins, MN (US Army Armament Material Readiness Command 1977).
- Other than the 6 barrels from Honeywell, Hopkins, there is no indication that the contents of any group of barrels was different from any other group of barrels.

On-shore investigations of barrel content

In 1977 the US ACE conducted an investigation into the barrels:

> The procedure for determining the content of the barrels was to obtain copies of the manufacturing contracts and specifications and to obtain sworn statements from knowledgeable personnel. The Records Retention Center in St. Louis, MO was visited and contract documents obtained. Technical specifications of the material dumped were obtained from various Army organizations. Sworn affidavits were obtained from as many persons as possible who had firsthand knowledge or had participated in the disposal action. (US Army Armament Material Readiness Command 1977)

The barrels were reported to contain classified materials from Honeywell, Inc.. Many, if not most of the barrels, were reported to contain classified grenade parts.

> The material that was dumped into Lake Superior was metal scrap produced under Contract DA-11-022-ORD-3019 and associated contracts. The items produced under this contract, dated 15 Dec 59, are listed in C-8 [of the 1977 report]. Manufacture of the top and base section assembly for the M32 Grenade and the succeeding family of grenades - notably the M40 - produced the majority of the scrap. The M40 Grenade differed from the M32 in diameter only and its metallic composition was identical. The metallic specifications for the M40 are listed as aluminum and steel. (US Army Armament Material Readiness Command 1977)

Honeywell occupied TCAAP Buildings 502 and 103 during the period of interest. Fuses were assembled in Building 103. Building 502 was used for machining, stamping and casting ferrous and non-ferrous metal parts (US Army Armament Material Readiness Command 1977). The following is a list "of facilities and special processes to be utilized by Minneapolis-Honeywell Regulator Co. at Twin Cities Arsenal Building 502" per contracts with the Army:

a) Chemical Analytical Laboratory.
   This laboratory will be utilized to ascertain that materials manufactured here or purchased outside comply with the applicable specifications per the Ordnance Drawing or Engineering Parts List. This laboratory will perform the control function on chemical processes utilized at this plant.
b) Meter Direct Reading Spectograph(sic).
   This special test machine is used to analyse metal alloys manufactured at this plant to ascertain that they meet specifications per Ordnance Drwg. or Engineering Parts list. The information derived by analysis on metal slugs serves as a control for their casting operations.
c) Phillips X-Ray Defraction(sic) and Flourescence(sic).
   Utilized in analysis of material as to structure and composition. This analysis is used as a basis of certification of material produced.
d) Radiographic X-Ray (100KV-1MA[])
   This equipment will be used to check weldments and castings in case of doubtful material as to porosity or inclusions, Minneapolis-Honeywell Regulator Co. are also contemplating attempting to evaluate visual standards for these type of defects.
e) Aluminum Alloy Heat Treatment Ovens.
   This equipment is to be used by Minneapolis-Honeywell Reg. Co. for the treatment of items produced on Contract DA-11-O22-ORD-3019
f) Metal Finish (Zinc Plate; Chemical Films for Aluminum Alloys; Dichramate(sic); Chemical Cleaning of Materials.)" (US Army Corps of Engineers 1991)

Six barrels from Honeywell Hopkins were dumped with the TCAAP barrels:

> The documents inclosed(sic) clearly show that, except for no more than six barrels, the material dumped into Lake Superior was classified aluminum and steel scrap. This residue from grenade production is non-nuclear, nontoxic, and non-hazardous. The material was dumped into Lake Superior because that was the most economical and secure disposal method available at the time. The six barrels that were not loaded in Building 502 came from the Honeywell Hopkins Plant and contain, to the best recollection of those interviewed, fiberglass tape impregnated with lithium chloride, potassium chloride, barium chromate,

> calcium chromate, and zirconium. This material was the scrap from a thermal battery used on a time fuze(sic). No reason has been found for their inclusion in the Lake Superior dumps. However, the composition of the salt mix impregnated on the tapes was classified. While the data collected on the six barrels is not conclusive, there is no reason to believe they contained anything other than what has been testified. These barrels had holes in them to insure their sinking and have had constant exposure to the water since 1959. In order to evaluate the potential impact on water quality of these barrels, a worst case situation was presented to the US Amy Environmental Hygiene Agency. Their evaluation is at C-24, which concludes that this disposal action will have a negligible effect on Lake Superior.
> (US Army Armament Material Readiness Command 1977)

According to records from the Atomic Energy Commission (AEC) and the Nuclear Regulatory Commission (NRC), Honeywell did not use radioactive isotopes at their TCAAP facility prior to 1967 (US Army Corps of Engineers 1991). 3M, another occupant of some TCAAP facilities, did have a license to use radioactive materials at TCAAP in 1961 (US Army Corps of Engineers 1991). This license may have been the license in effect from May 9, 1961 and May 2, 1967 for research and development into the production of uranium dioxide and thorium dioxide micro-spheres as nuclear fuel (US NRC 2000). By 1991, 3M operations with radioactivity at TCAAP had apparently expanded to include work on military gunsights and on civilian equipment for medical diagnosis and therapy. The primary isotopes used in 1991 included promethium (Pm) 147, polonium (Po) 210 and cobalt (Co) 137, with lesser amounts of strontium (Sr) 90, scandium (Sc) 46, niobium (Nb) 95, cerium (Ce) 141, and iodine (I) 125 (US Army Corps of Engineers 1991). There is no indication that materials from 3M were included in any of the barrels that were dumped in Lake Superior.

Additional information on dumping processes and events:

- Fifty-five gallon barrels must contain over 400 pounds of material for them to sink. According to eye-witness reports, some barrels contained concrete weight, and others floated and were flooded on site so that they would sink (US Army Corps of Engineers 1991).
- There is a persistent but unattributable news report that “a crew member who dumped the barrels saw a purplish sludge oozing from one container.”
- The tug used during the 1994 barrels-recovery operation, coincidentally, was one of the tugs used to tow barges of barrels during dump events. Onboard were records of the dump, which have been copied into the US ACE Report.

> Documentation found during the course of this study Appendix C,D & G yielded the following historical information:
>
> #1- 29 Oct 1959 - Date of first disposal,
> (two trips) Date from "Daily report of Operations" - Tug Ashland. In a memo dated 5/24/61 Mr. C. Wang described the dumping as having weighed 100 tons disposed of in two loads off flat barge #10 working with the Tug Ashland. (Estimated 300 barrels). Note that the daily report of the tug indicates "3 miles in lake".
>
> #2- 11 October 1960 - 50,000# scrap disposed using Tug Barlow for $500 cost. Date from "Daily report of Operations" - Tug Barlow….

#3- 9 June 1961 - "Daily Report of Operations" - Tug Lake Superior. Confirmed from Log entries found on Tug as site #6. 3 Barrels recovered.

#4- 18 October 1961 - Tug Lake Superior - 100-125 barrels.

#5- 25 May 1962 - 206 Barrels delivered and disposed…. Tug Lake Superior used.

#6- 25-26 Sep 1962 - 496 Barrels disposed using Tug Marquette off Knife River approximately 18 miles from Duluth Harbor (Date of disposal requires barrels found at Site #l and Site #7 to be from this shipment). 4 barrels have been recovered from these disposals. This may have been accomplished in two disposals.

It is also noted that Disposal #6 did not follow depth requirements requested by the Army as some barrels, bearing markings from 1962, were recovered in 150' of water despite the order for a minimum of 300' depth.

It should be noted that Dump #1 or #2 were reportedly dumped without sufficient ballast to sink the barrels. These barrels reportedly floated on the surface until holes were shot into the barrels to sink them. Side scan from the 1990 effort, figures 11, 12 and 13, show large diameter metallic soundings in shallower (110') water zones that could possibly be munitions disposal sites. These areas also correspond with the reports filed in 1968 by area fisherman placing a possible disposal site 1.5 miles east of the Duluth pumping station. Further investigation of these areas would be required to confirm or disprove this theory.

Three additional tugs have also been identified (Tug Marqueue, Barlow and Tender Ashland); however, the 1959-1962 log of the Marquette no longer exists. The US ACE recommended that "Logs for the Tug Barlow and Ashland should be located if additional search efforts are attempted in the future." (US Army Corps of Engineers 1994)

- Alternative methods of disposal of classified materials were investigated by the Army, and after the dumping in September of 1962, classified parts were melted in the furnaces at the US Steel facility in Duluth, MN.

  Mr. John G. Heren (C-13) states that the scrap was disposed of by dumping in Lake Superior because there were no smelting facilities cleared to handle classified material and that the volume of scrap produced was too large to store and safeguard. Appendices C-15 through C-23, dated Sep and Oct 59, show that alternate methods of disposal were being sought. These records also verify that the scrap was produced under Contract 3019 in Building 502 and that dumping was necessary due to the large accumulation of scrap material and the delay in arriving at another disposal method. The alternate method of disposal finally adopted was melting the scrap in the US Steel Corporation furnaces in Duluth. This was verified by Mr. Dennis Nylen of that corporation. (US Army Armament Material Readiness Command 1977)

Underwater searches, recovery and contents identification:

1968 -

"In 1968, a local fisherman, Mr. Stanley Severson, operating the vessel 'Hiawatha', reportedly netted several barrels while trawling in an area approximately 7 miles N.E. of Duluth, Minnesota. Newspaper accounts and letters written to the St. Paul District by the 'Save Lake Superior Association' several years later relate that the crew found a barrel weighing approximately 700 pounds containing 'metal parts, resembling buckshot.' The barrels were reportedly inspected onboard the 'Hiawatha' and dumped

back into the lake in shallower water in the same general area." (US Army Corps of Engineers 1991)

1976 -
In December 1976 about 20 barrels were located during a magnetometer search by a researcher from the University of Minnesota. (US Army Corps of Engineers 1991)

1977 -
Attempts to find barrels in 1977 were unsuccessful. Searches included a joint effort by the Army and the University of Minnesota researcher to relocate barrels identified in the 1976 magnetometer search. An underwater camera search of the area was not successful in locating barrels. (US Army Armament Material Readiness Command 1977)

1990 -
The US ACE located numerous barrels at the Talmadge area dump site in 1990 (See Attachment 1 for Talmadge area location, Site 1). Two barrels were retrieved during recovery operations in 1990. The barrels contained parts resembling gears, springs, timers and scrap metals consistent with grenade parts. Details of what was found in the 2 barrels is described (US Army Corps of Engineers 1991):

> On 27 November at approximately 1200 hours, MPCA tamper seals were removed from the barrels. By 1715 hours, the first of the two barrels when broken open by a backhoe after the exterior shell was sawn off using a carbide blade circular saw. The remaining concrete interior protected a series of tightly packed cardboard boxes containing small 1 7/8" diameter gear assemblies layered inside the cardboard boxes. While the barrel was estimated at weighing some 700 pounds, approximately 500 pounds of that weight was estimated to be concrete added to insure the barrel would sink when placed into the lake. Several parts were collected by OHM and placed in sample bottles, decontaminated, and displayed to the press which had gathered to observe the event.
>
> The second barrel was opened later that evening at 2145 hours. Contents resembled that of the first barrel, and on closer inspection, it was discovered that the parts contained in the first barrel were sub-assemblies of the parts found in the second barrel. Boxes contained in the second barrel were marked in the following manner:
>
> Confidential
> MH Part No. 550012
> 25 ea
> Scrap Assemblies
> For Destruction Only
> Confidential

1990 – Radiological Surveys
A statement by the submersible operator who dove on some barrels in October 1990, under contract with the US ACE, noted: "At 5:30 pm the sub made it's 3rd and final dive of the day. As the sub approached a barrel, the Geiger counter in the sub, began to register minute levels of radiation. The pilot aborted the dive and returned to the surface to report these readings. Other readings with another Geiger counter were taken on the

sub, the buoy line, the tug's anchor and anything else that was in the water, and the results were negative." Readings were estimated to be about 50 times the level of on-land solar radiation. No radiation was recorded on the Geiger counter during numerous subsequent attempts to verify this one-time reading. (US EPA 1990; US Army Corps of Engineers 1991)

The US EPA was asked to assist in locating any radioactive source near the same barrels. Their instrument was 200 times more sensitive than the Geiger counter on the submersible. Due to the absorption of alpha and beta particles by steel drums and water, likely findings of radiation would be limited to gamma radiation sources. In 1990, 15 barrels were monitored by a remote operated vehicle (ROV) towing an EPA radioactivity probe. One barrel was identified as having a source that was measurable, but only about $1/8^{th}$ to $1/10^{th}$ of the level of solar radiation measured on land. The source was not identified, but it was at an intensity that could be expected from a radium dialface, a small amount of thorium in the paint on the barrel, or a natural source beneath the barrel. (US EPA 1990)

1993 -

Between September 9 and 20, 1993 a side-scan sonar search of additional areas was conducted under contract from the US ACE. Five barrel disposal sites were identified. Three were verified by underwater video. 415 targets were identified by sonar, of which 249 were considered to have a high probability of being barrels. Appendix C from the report contains the exact locations of the identified targets. (Oceaneering Technologies 1994)

The 1993 search was the most effective effort to locate barrels. However, most of the barrels have never been located. Best estimates are that about 400 or so barrels have been located.

> The likelihood that the remaining "missing" barrels are located in the search area but escaped detection is extremely low. A small number of barrels may be so thoroughly silted over that they are essentially buried and thus "invisible" to sidescan sonar. The sonar images clearly indicate scour holes around targets, and the ROV video confirms that some drums are partially buried. Also, two barrels lying on the lake bottom next to each other could appear as a single target in the sonar images, and be counted as such. Nevertheless, these scenarios are unlikely and could only account for an insignificant number of barrels, not anywhere near the great number potentially missing.
>
> A more plausible scenario is that the remaining barrels are located outside the 45-square-nautical-mile area that has been searched. This scenario is supported by the location of a disposal site bordering the northeasternmost end of the search area east of Knife Island. High probability sonar targets were detected on the very last search line in that area. Because of the pattern of barrel disposal, additional strings of barrels may be just outside Zone C in the area of Line 1. Future attempts to locate additional disposal sites should consider this area for further investigation. (Oceaneering Technologies 1994)

1994 -
Recovery operations were resumed in 1994 and 7 barrels were recovered from 3 different locations. Pictures taken during this event are included as Attachment 2:

Table 1: Barrel Contents - 1994 Recovery operations

Talmadge Area (Attachment 1, Site 1)	2 barrels	Barrel 1: "The barrel held 11 neatly stacked boxes bearing the same markings and containing the same BLU3 grenade sub-assemblies as the bases recovered from this site in 1990… Some boxes yielded inspection slips dated 8/10/62." Barrel 2: "contained the same material."
Story Point Area (Attachment 1, Site 7)	2 barrels	"The barrels contained scrap ammunition sub-assemblies of a munitions type (M1A1 Mine fuse?) not identified at the time of printing. Inspection slips found in these drums were dated 8/62… An x-ray of the part was taken by TCAAP and shows the part contains a firing pin and a block of explosive material. The MH Part number is 510718."
Knife River Area (Attachment 1, Site A)	Sunken vessel	Later identified as a pleasure boat that burned and sunk around 1917.
Lester River Area (Attachment 1, Site 6)	3 barrels	"Barrels found at this site were nearly covered in sediment and divers had to struggle through chest deep mud/silt to get to each barrel… "The barrels … contained partially incinerated munitions scrap. The majority of content appeared to be molten aluminum lead and steel from an attempt at incineration as a means of permanent destruction of the ordnance. Examination of the content of these barrels showed that 90-95% of the material in the barrel had been reduced to unrecognizable metal slag, but remaining in the barrel were partially incinerated pieces of M32 grenade bodies which were readily identifiable from the manufacturing drawings included in the 1977 historical report. "Without achieving 100% destruction, we conclude that the incinerated scrap was not accepted as having been properly destroyed in accordance with classified material regulations and therefore was packed into barrels and shipped to Lake Superior for water burial. "Also mixed into the barrels were some general plant refuse such as a broken glass ashtray, stainless steel ladle, a padlock, fabric tape and a paper cup from a vending machine bearing the Minneapolis Honeywell logo."

"At the conclusion of this project effort the location of approximately 25-50% of the 1437 barrels reported sunk is now known. An exact count was not attempted. Nine barrels have been recovered and confirmed as containing classified munitions scrap." (US Army Corps of Engineers 1994)

Appendices to the US ACE Report (1994) contain the data sheets from chemical analyses of the contents of the barrels recovered in 1994. Below is an MPCA summary of the highest levels detected for a range of compounds:

Table 2: Maximum Chemical Concentrations – samples from 1994 recovered barrels

Barrel type	Sample type	Contaminant	Corp analysis (ug/L)	PCA analysis (ug/L)	* MDH Health Risk Limits (HRL; ug/L)	* EPA Maximum Contaminant Level (MCL; ug/L)
Parts	Water	Acetone	200		700	
Parts	Water	Arsenic	23			10
Ash	Ash/acid leach	Barium	0	2500	2,000	2,000
Parts	Water	Benzene	18		5	5
Parts	Water	n-Butylbenzene	0.8			
Parts	Water	sec-Butylbenzene	0.9			
Ash	Ash/acid leach	Chromium		37	100 (Cr VI)	100
Parts	Water		38			
Ash	Ash/acid leach	Cadmium	85	150	4	5
	water leach		13			
Parts	Water	Ethylbenzene	95		700	700
Parts	Water	4-Isopropyl-toluene	1.7			
Parts	Water	Lead	200			15 (action level)
Ash	Ash/acid leach		200	1100		
Parts	Water	Methylethylketone	16		4,000	
Parts	Water	Napthalene	1.3		300	
Ash	Ash	PCBs		590	0.04	0.5
Parts	Water	Tolulene	22		1000	1000
Parts	Water	1,2,4 Trimethyl-benzene	6.6			70
Parts	Water	Xylene	9		10,000	10000

(MPCA 1994)

* MDH HRLs and EPA MCLs are included for comparison purposes only, as drinking water criteria are not relevant in this context.
MCLs: http://www.epa.gov/safewater/contaminants/index.html#mcls
MDH Health Risk Limits: http://www.health.state.mn.us/divs/eh/groundwater/hrltable.html

1995 – Radiological Survey

In 1995, additional radiological surveys of the barrels were conducted. The results of the survey were reported in an EPA Report, "Radiological Survey of Drums Disposed into Lake Superior, July 18 – 22, 1995" (US EPA 1995). Twenty-four barrels from 3 different dumping areas were surveyed during this operation. (See Attachment 3 for locations) No radiation sources were found.

Discussion

Historical Context

In the 1950s and 1960s sewage disposal was accepted practice for most industrial wastes. Wastes that weren't disposed in this manner, including PCBs, pesticides and other highly toxic chemicals, were often disposed in uncontrolled dumps and landfills. Removal and transportation under Department of Defense guard for disposal into Lake Superior would have been expensive for unclassified wastes. Therefore, it is likely that industrial wastes do not make up a significant portion of any of the dumped barrels.

Movement of contaminants from barrels

It is important to consider the condition of the barrels in Lake Superior when planning environmental sampling, estimating risk from contaminants, or planning mitigation or recovery efforts. Appropriate activities with leaky barrels are likely to be different than those planned with sealed barrels.

If a barrel is sealed, the contents of the barrel may be the same today as when the barrel was dumped. If the barrel was punctured or damaged when it was dumped, or if the barrel has corroded enough over time to allow Lake Superior water to mix with the contents, contaminants from the barrel may have escaped the barrel. The disposition of the released contaminants would depend on the chemical properties of the contaminant. Water soluble contaminants would be expected to disperse soon after they are exposed to the lake water. Non-soluble contaminants like oils and other hydrophobic compounds would not move quickly in the aquatic environment, unless they are in buoyant droplets. If non-soluble contaminants are released from the barrels, they could have a toxicity-dependent and concentration-dependent impact on benthic species in the immediate vicinity of the barrel.

Soluble contaminants released into the lake can move easily in underwater currents. Soluble contaminants would be expected to dissolve in lake water when they become exposed, and dissipate quickly. Significant dilution would be expected to occur as the dissolved chemical moves away for the barrel.

A large portion of non-soluble contaminants will stay in an open barrel and will only slowly move into sediment as the barrel leaks or corrodes. Without a forceful current that can scour material, most non-soluble contaminants will stay with the source and become slowly covered by sediment deposition. Non-soluble contaminants will only dissolve slowly and reach very low concentrations in lake water. These concentrations will become further diluted as the contaminants move away from the barrels.

Barrel recovery and monitoring efforts in 1990 and 1995 reported that sedimentation was apparently occurring around the barrels. Therefore, the impact of non-soluble contaminants is likely to be limited to the immediate vicinity of the barrel. In addition, any contaminant impact would decrease over time as the barrels and contaminants are buried. The effect of storms on turbulence 100 to 400 feet below the surface is not well characterized, but the presence of sediment around the observed barrels suggests that any potential impact from resuspension of sediments is likely to be limited.

Polychlorinated Biphenyls

Some dumped barrels apparently contained small amounts of chemicals including PCBs. A letter from the MPCA to a Congressional Representative suggests that PCBs (and/or Mirex) may have been used in grenades (MPCA 1977-8). A large amount of PCBs disposed in Lake Superior would be a cause for health concern. However, MDH believes it is unlikely that barrels were used to dump large amounts of PCBs into Lake Superior, simply because it was much cheaper – and legal at the time – to dump waste PCBs into dumps and landfills.

It is likely that the PCBs found in chemical analyses were either residual in the barrels, residuals from manufacturing processes, part of the classified products that were disposed in the barrels, or residue from oils used when attempting to incinerate the parts.

Therefore, it is likely that the total amount of PCBs in the dumped barrels is limited, and that the largest impacts of this waste would be on aquatic organisms in a very limited region around the barrel itself. Diet averaging would suggest that fish feeding on organisms around a few barrels leaking small amounts of PCBs would lead to negligible or imperceptible impact on fish tissue concentrations.

Large amounts of PCBs in a number of barrels could have an impact on aquatic organisms close to corroded, contaminated barrels. But the natural covering of the barrels by sediments will decrease available contaminants. If data or modeling the potential uptake of local aquatic organisms suggests a localized impact on organisms, additional modeling or sampling could be used to determine any potential food chain impacts. While trickling small amounts of PCBs into the environment is bad for the environment and probably bad for aquatic organisms, the risk to people is likely to be extremely small.

Drinking Water

Of paramount concern to people who have asked MDH to investigate what is known about this site, is the proximity of the barrel dumps in relation to the Duluth public water supply intake. Maps in the reports show the shortest distance between water intakes and the boundary of a disposal area is about 2 miles. The barrel retrieved by the fisherman in 1968 was reported to have been 1.5 miles from the Duluth water intake. This is consistent with reports from the 1994 US ACE Report noting that barrels floated away from the barge during one dumping event, and had to be shot so that they would leak and sink. This would have caused a larger dispersal pattern for dumped barrels than would otherwise be expected.

In 1977, the US Army Environmental Hygiene Agency modeled the potential worst-case dilution of salts found in 6 barrels from Honeywell Hopkins plant (US Army Environmental Hygiene Agency 1977). If the volume of the contaminants is calculated from the mass of contaminant assumed to be diluted in the evaluation, it is possible to reconstruct a portion of the analysis. Apparently, in their evaluation, the US Army Environmental Hygiene Agency assumed that all of the barrels could contain a very high proportion of any of the 5 listed chemicals (lithium chloride, potassium chloride, barium chromate, calcium chromate, and zirconium). Worst-case evaluation of each contaminant was independent of the evaluation of every other contaminant. This aspect of the evaluation is very conservative. While the total amount of each contaminant was restricted to a portion of 6 barrels, the total amount of all modeled contaminants was over 22 barrels containing pure chemical. Therefore, summing of the diluted concentrations or risks is not appropriate.

The US Army Dept of Environmental Hygiene predicts dilution 1 mile from the broken barrels to be about 60,000-fold (ratio of source mass to concentration at 1 mile; US Army Environmental Hygiene Agency 1977). While this assumes uniform dispersal, it is likely that dilution of dissolved contaminants in a current would still be extremely high. In addition: potential releases would be intermittent as barrels corrode; barrels and non-soluble contaminants are being covered by sediment with time; and the concentration of non-soluble chemicals (e.g. PCBs) would be further limited by their low solubility.

Non-soluble chemicals are most often discussed as chemicals of concern. The primary human exposure pathway of concern for PCBs and other non-soluble chemicals is the fish consumption pathway and not through drinking water. Not only will dilution limit the concentration in water as you get further away from the source, but the solubility of the chemical will limit the concentration in water close to the the source.

The maximum concentration of PCBs dissolved in water near any PCB source is limited by its' poor solubility to about 400 times the concentration of concern for drinking water. This maximum concentration can only be reached over relatively long periods of time in a closed system or chamber. In the open environment of a lake the maximum dissolved concentration near the barrels will only be a small fraction of their theoretical solubility. As you move away from the contamination source, the chemical is diluted and the concentration in water will drop from this maximum. The maximum solubility of Mirex, another chemical raised as a potential contaminant, is only about 12 times the concentration of concern for Mirex in drinking water. Similarly, the solubility of chemicals like arsenic, cadmium, lead would limit their dissolved concentration, even near the barrels. A much larger source of contaminants than has been identified would be needed for Lake Superior water to reach elevated concentrations as you move even small distances from the barrels. Therefore, it is extremely unlikely that contaminants from the barrels could reach the Duluth Public water intake at concentrations approaching levels of concern.

The measured PCB concentration of liquid in the barrels (Table 2) is 20 to 500 times the solubility of most important PCB congeners (4-6 chlorines). Therefore, it is likely that the analyzed sample included oils, particulates or colloids to which PCBs were attached. The size of the particulates would limit the movement of PCBs from the site, unless there is sufficient current to keep them suspended.

It is expected that industrial barrels could contain waste that exceeds drinking water guidelines. However, the potential for human exposure or consumption without considerable dilution by Lake Superior waters is minute. In addition, water from Lake Superior is filtered and treated prior to distribution through public water systems. Therefore, there is nothing to suggest that any contaminant from the barrels could reach the general public through the public water supplies. Any potential impact from toxic contaminants would likely be in close proximity to the barrel and would be limited to aquatic organisms.

Additional information on the Duluth Public Water Supply can be found at: http://www.duluthstreams.org/understanding/drinking.html . MDH Source Water Assessments for Duluth and other public water supplies can be found at: http://mdh-agua.health.state.mn.us/swa/pdwmain.cfm .

Purplish Liquid

An unconfirmed, but persistent report says that one barrel that did not sink during a dumping event was punctured with an axe and leaked a purple liquid (MPCA 1995; news reports). Potassium permanganate is a strong oxidizer that becomes a purple liquid when it is dissolved in water. Potassium permanganate solution is frequently used to precipitate dissolved materials from solution. Precipitates can then be filtered and recovered. Very little of the dissolved chemicals will remain in the potassium

permanganate solution. There is no information confirming the presence of a purple liquid in a barrel; suggesting that potassium permanganate was used at TCAAP; or showing that radioactive compounds were used by Honeywell at TCAAP until 1967. Disposal of a purple liquid is not evidence of the disposal of radioactive materials.

It is somewhat puzzling why potassium permanganate would have been in the barrels. Even though many chemicals were disposed of in sewers in the 1950s and 60s, down-the-drain disposal of a colored liquid like potassium permanganate may have been considered inappropriate. Therefore, it is conceivable that potassium permanganate was in a barrel that was dumped. It is unlikely that any water-soluble liquid would remain in a barrel that was punctured and sunk into Lake Superior 50 years ago.

Radioactive wastes

In the late 1950s and early 1960s, disposal of radioactive wastes was not as restricted as it is today. It appears that accepted practice was for sewage disposal of low level wastes; on land burial for solid wastes; or sea disposal of leaktight concrete casks for solid wastes. A report from an international conference on radioactive waste disposal in 1961 stated:

> the impression is that liquid radioactive wastes are divided into three categories, in both the USA and Britain, viz.: 1) high-level wastes, with concentrations of the order of tens of curies per liter and higher (these solutions are buried in special storage tanks); 2) medium-level wastes, with concentrations of the order of millicuries or fractions of a curie per liter; these wastes are usually subjected to chemical processing, and concentrates of high activity are routed to burial sites, in some cases (notably in the case of Britain) being dumped at sea; 3) low-level wastes, in which the content of radioactive isotopes exceeds the accepted level for drinking water by several orders of magnitude; these wastes are diluted with water down to levels set by medical stipulations and are then transferred to open reservoirs. (Spitsyn and Kolychev 1961)

Some low-level radioactive wastes from 3M TCAAP operations were buried near Kerrick in Pine County at about the time that the Lake Superior dumping was occurring (US NRC 2000). According to the Nuclear Regulatory Commission, 3M acquired a radioactivity license in May 1961 for research and development into the production of uranium dioxide and thorium dioxide micro-spheres as nuclear fuel. Radioactive materials used under this license are presumed to be the materials buried in Kerrick.

None of the available information suggests that radioactive materials were disposed in the barrels. However, to conclusively demonstrate that there were no radioactive materials dumped, all barrels would have to be raised and their contents analyzed. Only a small number of the barrels have been found, but barrels from 3 of the 6 or 7 dump sites have been raised and their contents inspected. By and large, the contents appeared to be what had been reported to have been dumped. These results provide some additional confidence that the barrels from these dumping events do not contain radioactive materials.

Conclusions

The contents of each barrel dumped have never been documented. Therefore, it is doubtful that we will ever know all of items and chemicals in these barrels. However, some reasonable assumptions can be made about the chemicals or products that would have been likely candidates for dumping.

Dumping into Lake Superior would have been an expensive means of disposal. In the late 1950s and early 1960s there were few restrictions on materials that could be buried. Typically, chemicals and industrial wastes, like oils and sludge, were either landfilled, burned or reused. This includes pesticides, waste oils, and heavy metals. In the 1950s and 1960s, metals like mercury and arsenic, and pesticides like DDT and organophosphates were commodities and would have been sold, landfilled or burned. PCB-containing oils were not treated differently than other oils. Therefore, it is unlikely that any of these chemicals were candidates for disposal in the Lake. Radioactive materials were not licensed for use at TCAAP by Honeywell until 1967. 3M was licensed to use radioactive materials at TCAAP in 1961, but there is no information showing that any materials from 3M TCAAP operations were disposed of in the barrels.

Chemicals and other materials that could not be landfilled, burned or reused would have been candidates for disposal in Lake Superior. This would have potentially included classified parts, classified materials, and possibly some materials for which there was no easy method of disposal. The contents of the recovered barrels confirm initial reports that the barrels contained classified parts and materials.

Despite one unexplainable and unconfirmed report of radioactivity near the barrels, there is no reason to believe that the barrels contained radioactive wastes. Furthermore, it is unlikely that there would be a completed human exposure pathway for hazardous wastes in the barrels.

The location of 25-50% of the barrels may be known. Many of these barrels are partially buried in sediment and some are corroding. In addition, it is likely that some barrels sunk in areas outside the target areas and may be difficult to locate.

MDH has not conducted a cost-benefit analysis of continuing the investigation of the Lake Superior barrels. However, it is obvious that the costs of additional investigation are very high and it is MDH's judgment that the risks of detrimental exposures to people from these barrels are unquantifiable, but low. MDH has not evaluated the potential risks to the environment, or the damages to natural resources incurred by the barrel dumping.

Available information about this site suggest No Apparent Public Health Hazard as defined by the Agency For Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/COM/hazcat.html).

Recommendations

If additional resources are going to be used investigating the barrels dumped in Lake Superior between 1959 and 1961, MDH suggests that the work is focused on:

- Searching tug boat records and internal Department of Defense, TCAAP and Honeywell documents to assure that all available information about the dumped barrels has been acquired.
- Locate and record exact location and condition of as many barrels as possible. Record observations on corrosion and holes in each barrel and sedimentation around each barrel.
- Focus any risk analysis on the potential risks to aquatic species. These communities are more likely to be impacted than people.
- If risks to aquatic species are significant, subsequent analyses can be performed to identify potential risks to people.
- Further assurances that contamination from the lake does not impact public water supplies could be accomplished by conducting underwater video or photographic surveys of the area around the water intakes (e.g. within a couple thousand feet). Chemical analyses of water or sediment samples in this area is not recommended, unless there is some indication that there is a significant source of contamination in the area.

Public Health Action Plan

MDH plans no additional action related to this site. MDH will review new information on this site if there is additional investigation.

This consultation was prepared by:

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CERTIFICATION

This Lake Superior Barrels Health Consultation was prepared by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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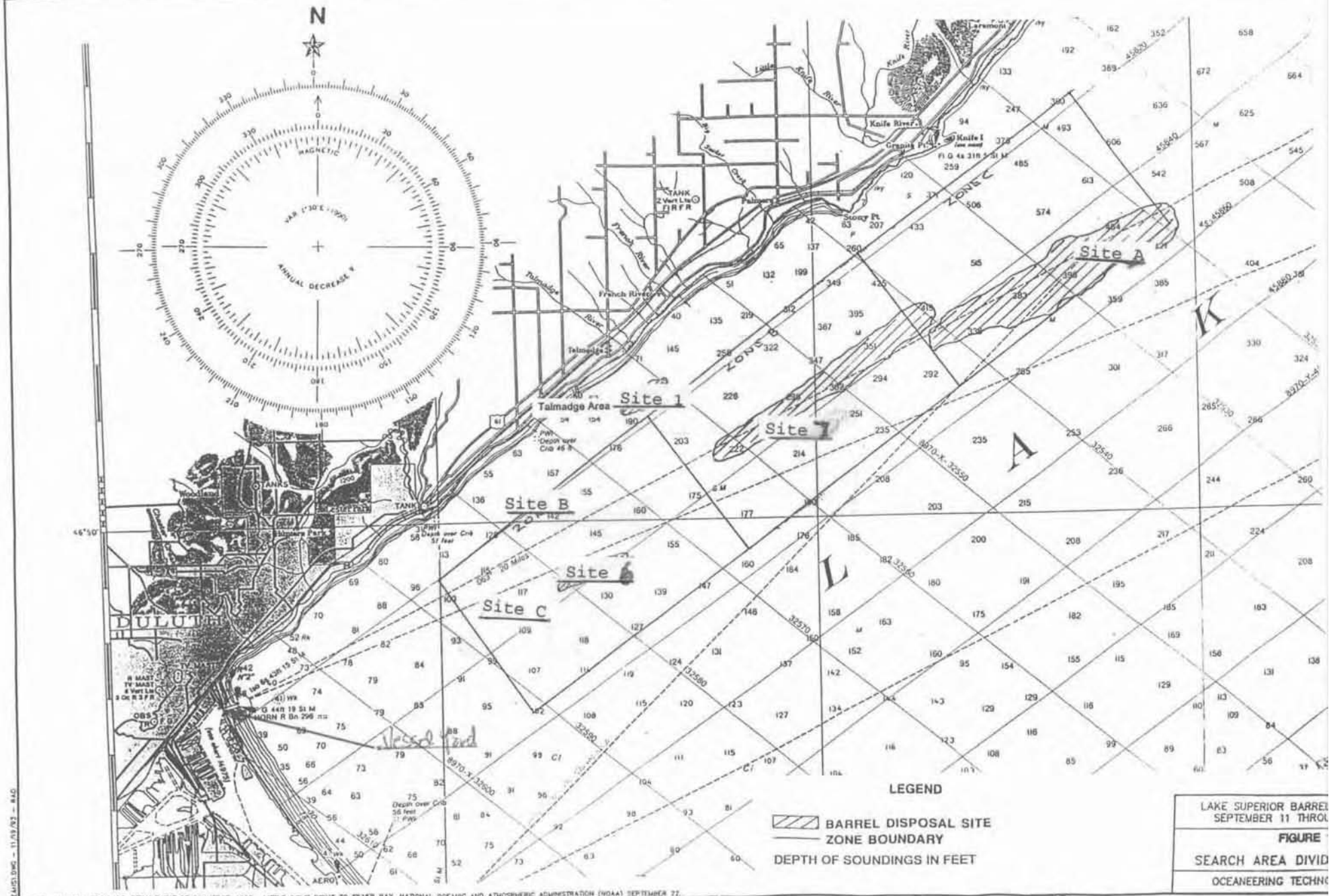
Team Lead, CAT, CAPEB, DHAC, ATSDR

Attachment 1



Site Map

Lake Superior Barrel Sites

Attch #1

Attachment 2

Photo 13- Recovering Barrel @ Site 6

Photo 14- Scrap from opened barrel – Site 6 – Recovered from 125' depth

(US ACE, 1994)

Attachment 2

Photo 3- Barrel recovered from Site #7 – Note concrete plug.

Photo 3A - Navy Torpedo Recovery ROV recovery of barrel from site 7.

(US ACE, 1994)

Attachment 2

Photo 1- Opened Barrel From Site #1

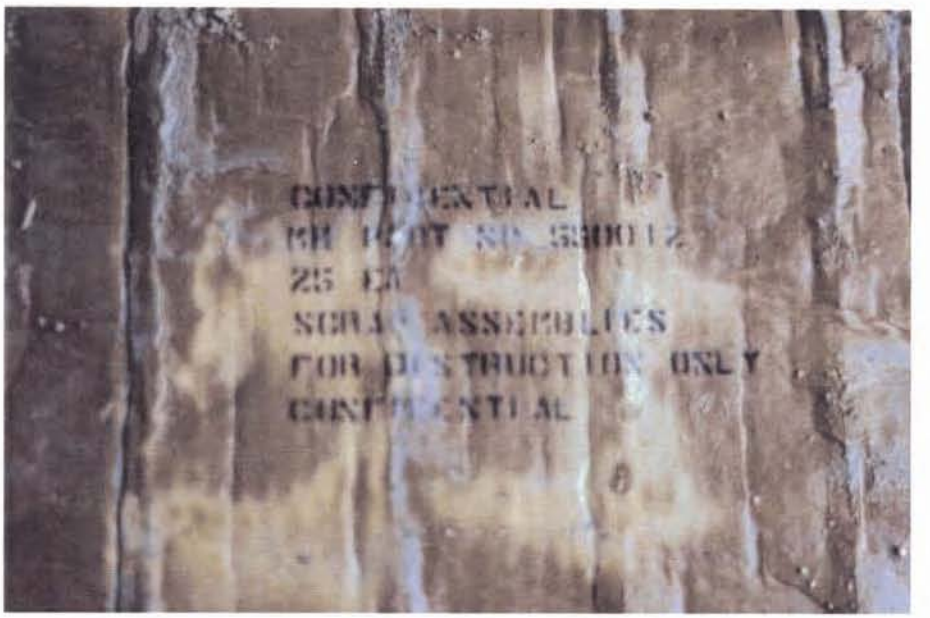


Photo 2- Box Top From Barrels recovered at Site #1 – Talmadge River 155' depth

(US ACE, 1994)

Attachment 2

(US ACE, 1994)

Attachment 2

(US ACE, 1994)

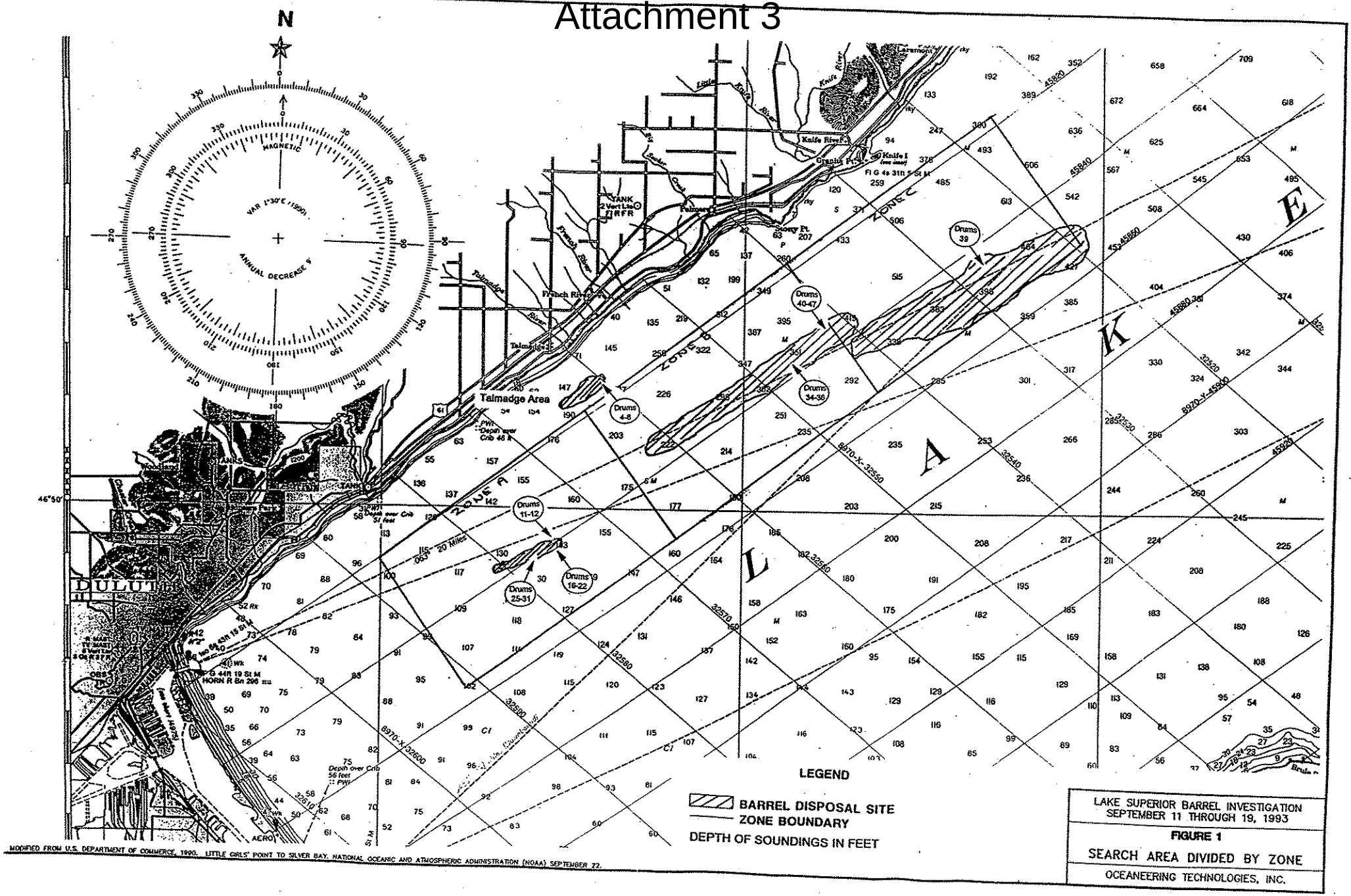


Figure 1. Location of Drums Surveyed During July, 1995