Tell-Tale Leak Detection and Leak Collection System

1. Introduction

This paper provides a description of the construction of the steel tank shell, the original tell-tale system and its problems, and subsequent improvements that were made to the system.

2. Tank Shell Construction

In order to understand how the tell-tales work to detect and collect fuel that has leaked through the steel plates of the tank shell, it is necessary to understand how the tank shell is constructed. There are three distinct areas of the tank shell: the Upper Dome, the Barrel (cylindrical section of the tank), and the Lower Dome. The arrangement of reinforcing angles welded onto the back side of the shell plates is different in each of the three areas. The reinforcing angles are situated with one leg of the angle flush against the back side of the joint between shell plates to insure a full penetration butt weld. The other leg of the angle is embedded in the concrete that surrounds the tank shell so that it contains and controls the movement of fuel that leaks through the shell plates into the interstitial space between the back side of the shell plates and the concrete.

Upper Dome
The shell plates of the Upper Dome were welded together working from the back side of the plates. There are stiffener angles welded to the back side of the plates, but they do not obstruct the flow of leaked fuel down the back side of the shell plates to the base of the Upper Dome where it pools and moves laterally until it reaches a thru-shell penetration into a tell-tale pipe.

Barrel
The Barrel is made up of rectangular shell plates 19'-7-3/8" wide x 5'-0" and curved lengthwise to a 50' radius. The plates were butt welded together from the front side (the welders were inside the tank). For the vertical butt joints the backer bar on the back side of the joint is a 2-inch wide flat bar. For the horizontal butt joints the backer bar is a 2½" x 3" x 5/16" reinforcing angle, with one leg of the angle flush against the back side of the joint and the other leg embedded in the surrounding concrete. The embedded leg of the reinforcing angle behind the horizontal joint serves to isolate the back side of each 5-foot high ring of shell plates as a separate compartment. A fuel leak through the shell plate in the Barrel of the tank flows downward 5-feet or less until it reaches the embedded leg of the horizontal reinforcing angle, then it moves laterally along the angle leg until it reaches a thru-shell penetration into a tell-tale pipe.

Lower Dome
The shell plates in the Lower Dome were butt welded together from the front side. Both the vertical and horizontal joints between shell plates used 2½" x 3" x 5/16" reinforcing angles as the backer bar. The embedded legs of the reinforcing angles make the interstitial space behind each shell plate an individual compartment. A leak through any given shell plate must be "jumped" downward from plate to plate until it reaches the collector ring around the perimeter of the 20-foot diameter bottom plate at the center of the Lower Dome.

3. Original Design and Construction of Tell-tale System and System Operational Problems

Upper Dome and Barrel
The original construction of the tell-tale leak detection system consisted of 11 vertical pipes equally spaced around the perimeter of each tank. Starting from a point just above the base of the Upper Dome the pipes ran vertically down the wall of the Barrel inside the tank, penetrated the shell in the Lower Dome, ran through the concrete plug under the tank, and ended at a monitoring station in the Lower Access Tunnel near the skin valves for each tank. The top thru-shell penetration connected to the tell-tale pipe was located just above base of the Upper Dome to collect any leakage from the Upper Dome. The bottom thru-shell penetration connected to the tell-tale pipe was just above the horizontal joint between the bottom of the Barrel and the top of the Lower Dome. Between the top and bottom thru-shell penetrations, thru –shell penetrations located every 5-feet just above each horizontal butt-welded joint between shell plates were connected to the vertical tell-tale pipe. In this way the tell-tales pipes were designed to collect any fuel that leaked through a hole in a shell plate (or through a hole in a shell plate weld) into the interstitial space between the back side of the steel shell plates and the inner side of the reinforced concrete wall, and deliver the fuel to the Lower Access Tunnel to indicate the presence of a leak.

Lower Dome
The Lower Dome of the tank was served by 165 jumper pipes, a collector ring around the perimeter of the 20' diameter flat plate at the center of the tank bottom, and a single 12th tell-tale pipe that collected all

leakage from the Lower Dome and delivered it to the monitoring station in the Lower Access Tunnel. As noted previously, because the back side of each shell plate in the Lower Dome was an individually contained compartment, jumper pipes were needed to move the leaked fuel down from plate to plate until it reached the collector ring and the 12th tell-tale pipe.

Use of Tell-tales in Original Construction
During the original construction of the tanks, the tell-tale pipes were used in reverse, i.e., compressed air was introduced into the tell-tales in the Lower Access Tunnel and the tell-tales delivered the compressed into the space behind the steel shell plates. With water in the tank, any air coming through a hole in a shell plate or a hole through a shell plate weld manifested itself in the form of bubbles which could be readily detected and the hole(s) marked for patching.

Operational Problems
The tell-tale leak detection system worked, but there were several problems with its design that prevented optimal performance:

- The tell-tale pipes were only ¾" diameter and in the event of a tank leak could become plugged with the solid materials contained in the heavy fuel oil that was stored at Red Hill in the early years, thereby stopping the tell-tale pipe from identifying the leak. With the top of the tell-tale pipe at a level just above the bottom of the Upper Dome there was no way to access it to blow or flush out a blockage in the pipe without first draining, cleaning, ventilating, and scaffolding the tank to allow the tell-tale pipe to be cut, cleaned, and repaired.
- The tell-tale pipes were standard wall thickness and ran down into the very bottom of the tanks where they were exposed to corrosive salt water that settled out of the fuel. With no corrosion allowance in the relatively thin pipe wall, the tank bottom water eventually corroded holes through the pipe wall, thereby causing the tell-tale pipe to indicate a tank leak when actually it was a leak in the tell-tale pipe itself. It should be noted that from 1942 when Red Hill came into service until the early 1960s when the Chevron refinery at Barbers Point started producing fuel, all fuel was delivered to Red Hill from tankers mostly coming from the West Coast. As waves washed over the deck of the fully loaded tankers, sea water entered the tank vents and settled to the bottom of the cargo tanks until it was discharged along with the fuel to the Red Hill tanks..

4. Improvements to the Tell-tale System

Melvin Miller, the Fuel Department Superintendent from the late-1940s through early-1970s and Charles Boerner, the PACDIV engineer who oversaw the construction of Red Hill and served as the resident in-house expert from 1941 until he retired in the early 1970s, both understood the problems with the tell-tales and worked to correct them with two separate rehab projects.

FY-59 POL Conversion Project

In 1960-1963 the tell-tales were modified and improved in Tanks 17-20. Improvements included:

- Increasing the pipe diameter from ¾" to 1½" to prevent clogging.
- Increasing the wall thickness from standard to extra heavy to provide corrosion allowance.

The 1963 improvements to the tell-tales remain in Tank 19 only.

FY-70 Special Project R1-67
In 1971-1973 in addition to the design improvements made in 1963, two more improvements to the tell-tale design were installed in Tanks 5, 6, and 12.
They were:

- Extending the pipes up into the Gauging Gallery at the top of the tank where they could be readily accessed for flushing and cleaning.
- Relocating the point at which the tell-tale pipes exit the tank to well above the tank bottom so the pipes would not be exposed to the corrosive effect of tank bottom water.

Unfortunately, in the early 1970s Mr. Boerner retired and Mr. Miller died before he retired, so neither man was available to defend the improvements they made to the tell-tale design in Tanks 5, 6, and 12 when the design for MILCON P-060 to rehab Tanks 1-16 started in 1977.

Subsequently, a design decision was made that MILCON P-060 should remove the tell-tale systems from Tanks 1-16 altogether.

5. Problems Created by Removing Tell-tales

- Removed a tool for potentially identifying and locating leaks, and collecting leaked fuel before it migrates into the surrounding rock.
- Eliminated a way to drain off any rainwater that percolates down through the lava rock and finds its way into the space between the back side of the steel shell plates and the inner side of the concrete wall. The standing water could cause accelerated corrosion of the back side of the steel shell plate.
- Eliminated the ability to relieve the buildup of hydrostatic pressure outside the tank shell working to force leaked fuel through the concrete outer shell and into the surrounding lava rock.

OPNAV 5216/144 (REV. 6-70)
S/N 0107 778 8099

DEPARTMENT OF THE NAVY

Memorandum

Mr Miller
NSC-Fuel Dept.

DATE: 10 Mar 1972

705

FROM 48A1

TO 48
48A

SUBJ Red Hill Fuel Leaks

Ref: (a) NSC PEARL 090117Z MAR 72

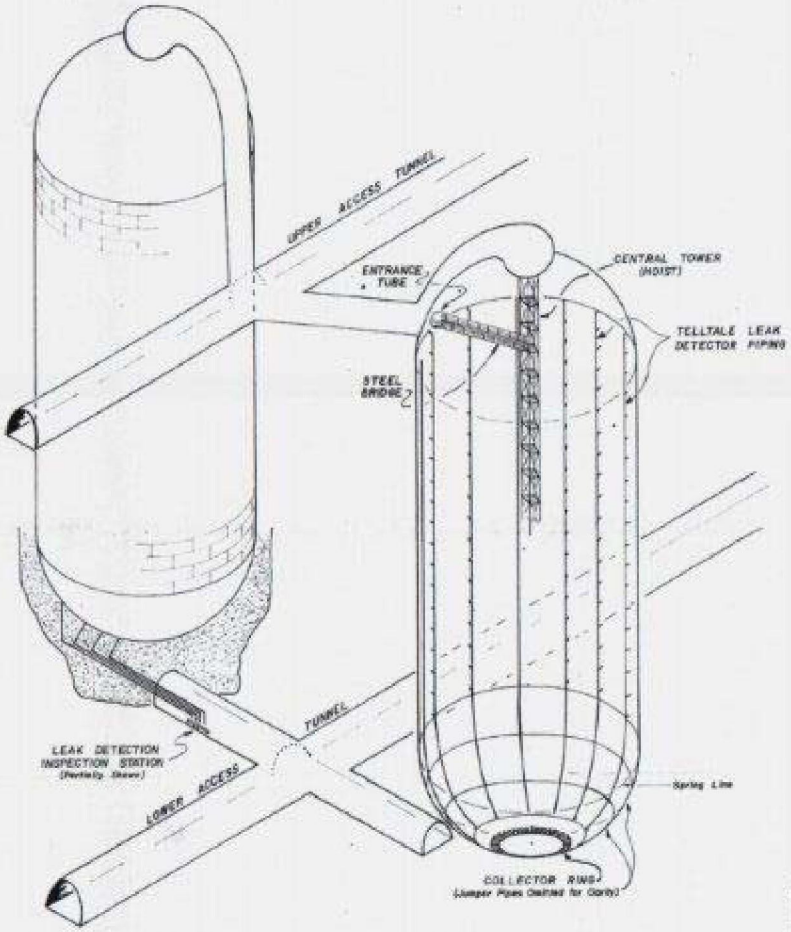
1. The suggested threat of potential pollution of the Red Hill potable water aquifer which lies less than 100' under the Red Hill tanks is real. This threat was one of the main reasons for the installation of the tell-tale piping system in each tank. This is also the reason why every effort should be made to continue the incremental funding for follow-on tank repair projects to keep tell-tales open and functioning.

2. The tell-tale system is the only real indicator of leakage in that a certain amount of the fuel is actually recovered as evidence of leakage. The new electronic gaging system is a highly sensitive and very accurate method of monitoring the fuel in the tank, but it does not compensate for the expansion and contraction of the fuel due to temperature changes. This temperature change is usually the cause for difference between tell-tale quantity and gaging quantity. (One degree change in temperature of full tank equates to 150 bbls of fuel). The tell-tale quantities will vary in accordance with quantity which might seep through concrete lining and gunite lining behind the plate lining and into the surrounding rock. However, precautions taken during original construction, and the extensive pressure grouting of the lining system and surrounding rock, made seepage of leaking fuel into the rock very improbable. This, however, is not the case if the tell-tales are not working or removed since a leak through the plate liner in the lower section of the tank, without tell-tale "relief", would subject the surrounding ground to up to 100#/sq.in. head pressures depending upon the height of fuel in the tank above the leak.

3. A recommended added precaution to protect the fresh water aquifer would be a series of two" diameter horizontally drilled holes into the porous rock under each tank to intercept and drain into the lower tunnel leaking fuel which may not have been picked up by the tell-tale system.

4. The above has been discussed with Mr. Miller, NSC PEARL.

C. H. BOERNER, PE



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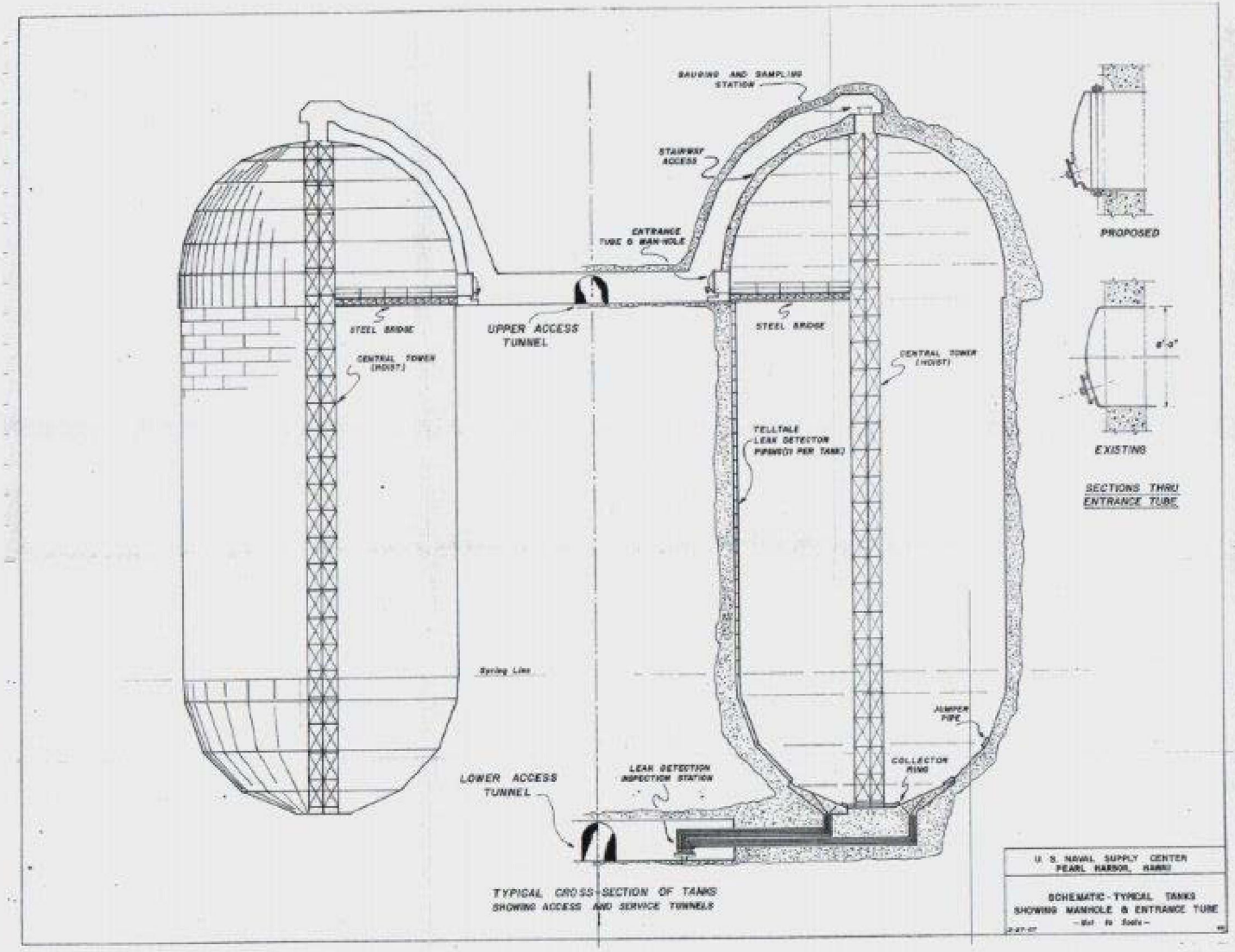
ISOMETRIC DEPICTING
INTERNAL DETAILS OF TANKS
—Not to Scale—


GAUGING AND SAMPLING STATION
STAIRWAY ACCESS
ENTRANCE TUBE & MAN-HOLE
STEEL BRIDGE
UPPER ACCESS TUNNEL
CENTRAL TOWER (HOIST)
TELLTALE LEAK DETECTOR PIPE(S) PER TANK)
Spring Line
JUMPER PIPE
COLLECTOR RING
LOWER ACCESS TUNNEL
LEAK DETECTION INSPECTION STATION
PROPOSED
EXISTING
8'-0"
SECTIONS THRU ENTRANCE TUBE
TYPICAL CROSS-SECTION OF TANKS SHOWING ACCESS AND SERVICE TUNNELS
U. S. NAVAL SUPPLY CENTER PEARL HARBOR, HAWAII
SCHEMATIC - TYPICAL TANKS SHOWING MANHOLE & ENTRANCE TUBE
- Not to Scale -

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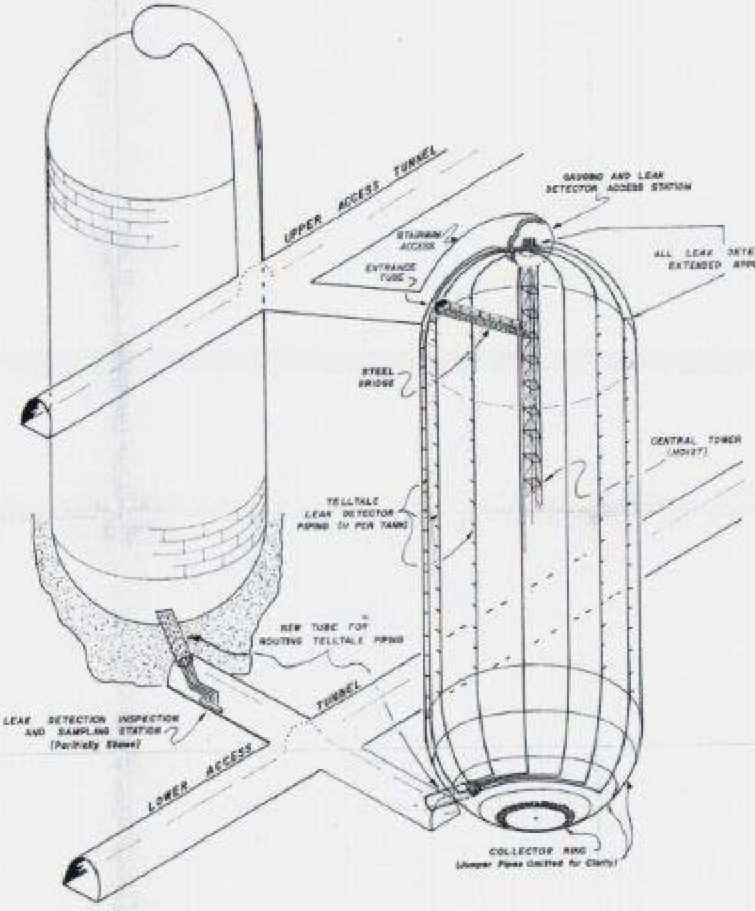

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PROPOSED TELLTALE SYSTEM
WITH ALL REQUIRED CHANGES

– Not to Scale –

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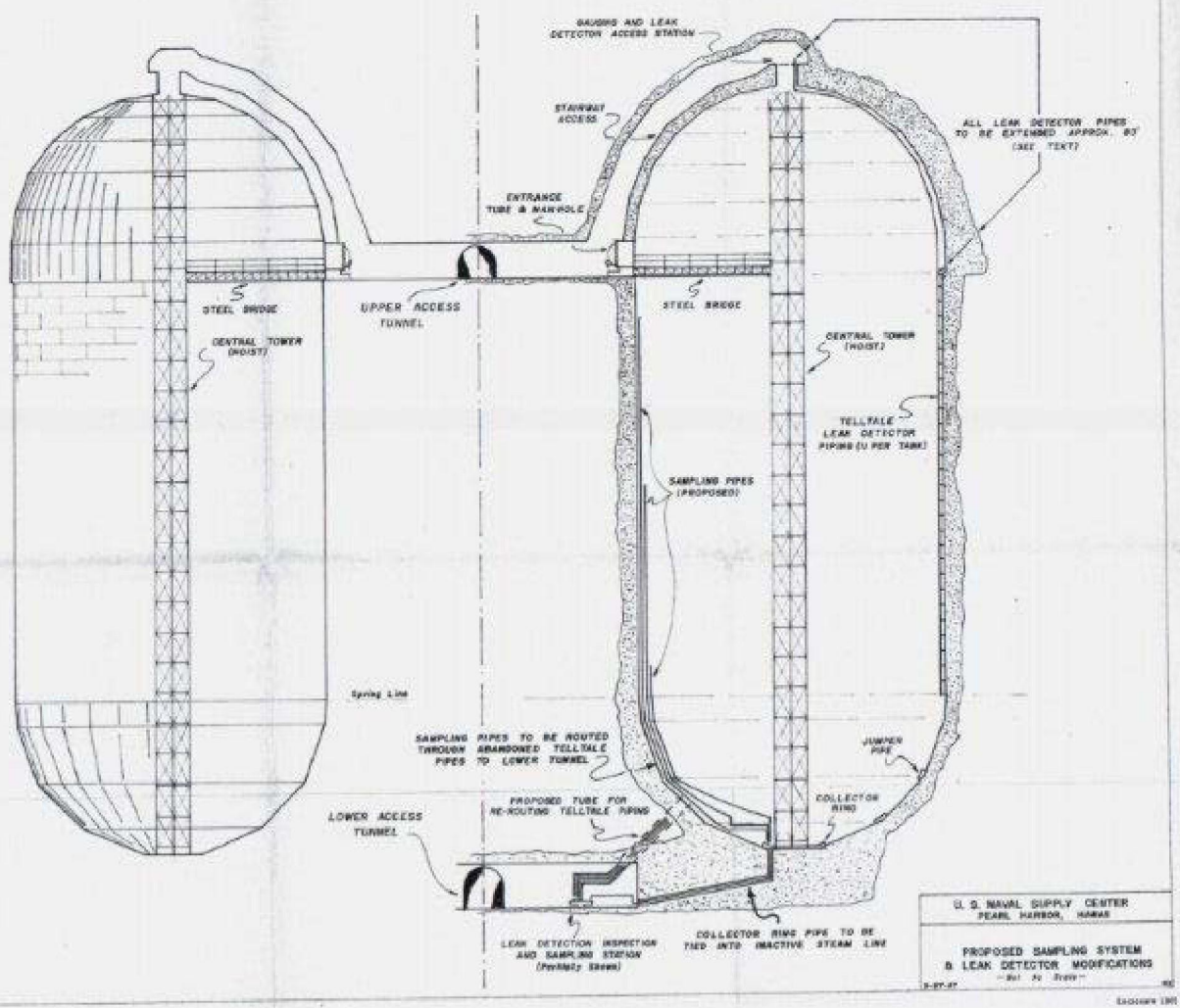
GAUGING AND LEAK DETECTION ACCESS STATION
STAIRWAY ACCESS
ALL LEAK DETECTOR PIPES TO BE EXTENDED APPROX. 83' (SEE TEXT)
ENTRANCE TUBE & MANHOLE
STEEL BRIDGE
UPPER ACCESS TUNNEL
STEEL BRIDGE
CENTRAL TOWER (HOIST)
CENTRAL TOWER (HOIST)
TELLTALE LEAK DETECTOR PIPING (U PER TANK)
SAMPLING PIPES (PROPOSED)
Spring Line
SAMPLING PIPES TO BE ROUTED THROUGH ABANDONED TELLTALE PIPES TO LOWER TUNNEL
JUMPER PIPE
COLLECTOR RING
PROPOSED TUBE FOR RE-ROUTING TELLTALE PIPING
LOWER ACCESS TUNNEL
LEAK DETECTION INSPECTION AND SAMPLING STATION (Partially Shown)
COLLECTOR RING PIPE TO BE TIED INTO INACTIVE STEAM LINE
U. S. NAVAL SUPPLY CENTER
PEARL HARBOR, HAWAII
PROPOSED SAMPLING SYSTEM & LEAK DETECTOR MODIFICATIONS

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