



Understanding the Significance of

Breaches to and Sediment Buildup in Finished Drinking Water Storage Tanks

Bob Clement, Environmental Engineer M.S., Microbiologist EPA Region 8, April, 2016

The views expressed are those of the presenter and do not necessarily reflect the views of the EPA

*In the more than
6 years
of inspecting
storage tanks
at PWSs,
I have never
visited one that
was up to par*

Anonymous



This presentation will cover:

- How differences in perspective can effect one's ability to assess a waterborne disease outbreak.**
- The very best practices for sanitary integrity, from EPA's September 2015 Learners Guide for inspections, vents, overflows, hatches, drains, roof-to-sidewall connections that collectively can avoid a waterborne disease outbreak.**
- A direct cause-and-effect link between a carcass and a waterborne disease outbreak**
- How the failure of best practices, breaches, sediment buildup and a rare washout event can lead to a waterborne disease outbreak.**



Perspective: Why does seeing the same physical flaw in a tank evoke such a broad range of responses from different people?
Can one's perspective be the key to the action that either prevents or allows a waterborne disease outbreak to manifest?



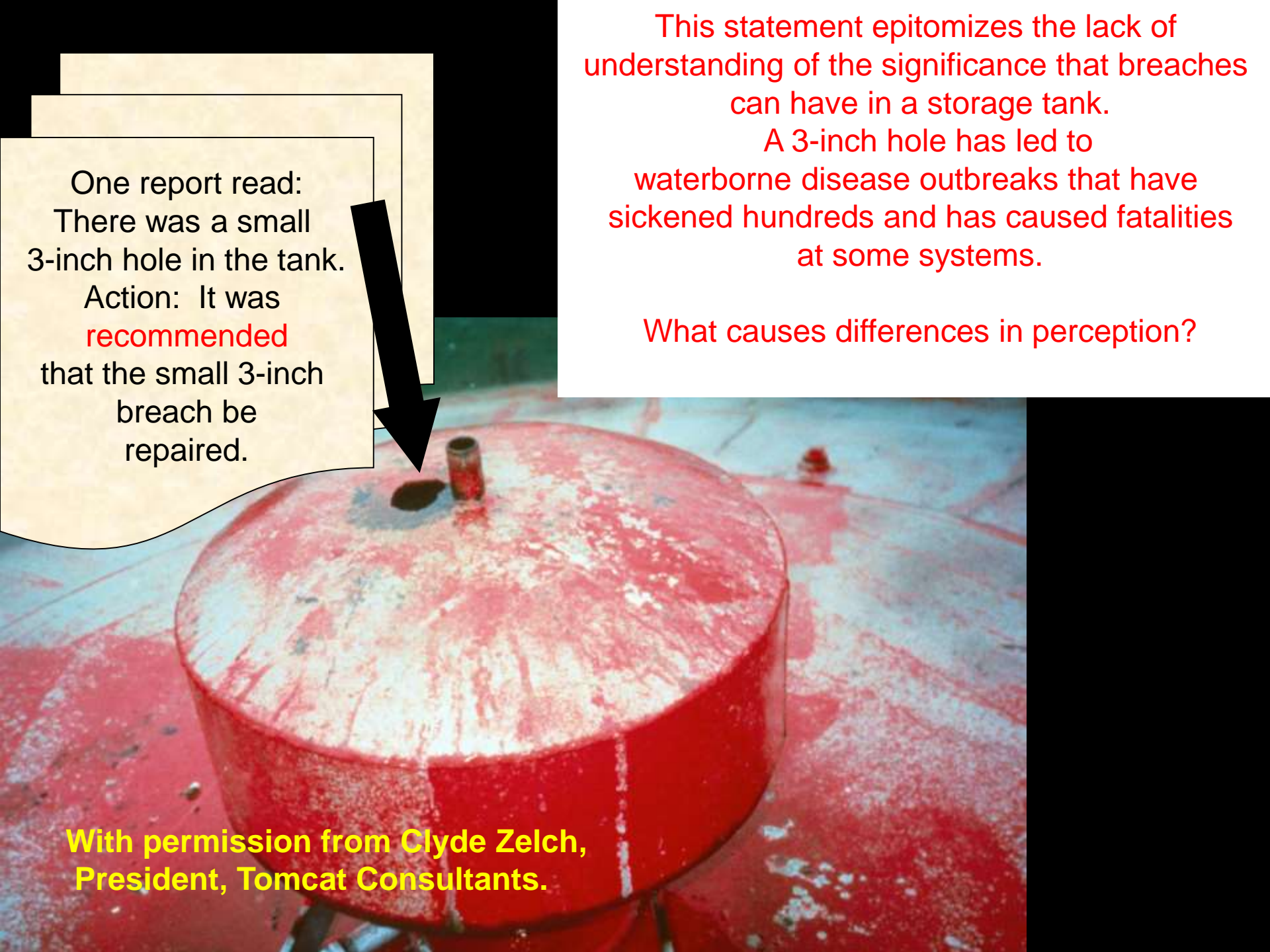
One report read:
There was a small
3-inch hole in the tank.
Action: It was
recommended
that the small 3-inch
breach be
repaired.

This statement epitomizes the lack of understanding of the significance that breaches can have in a storage tank.

A 3-inch hole has led to waterborne disease outbreaks that have sickened hundreds and has caused fatalities at some systems.

What causes differences in perception?

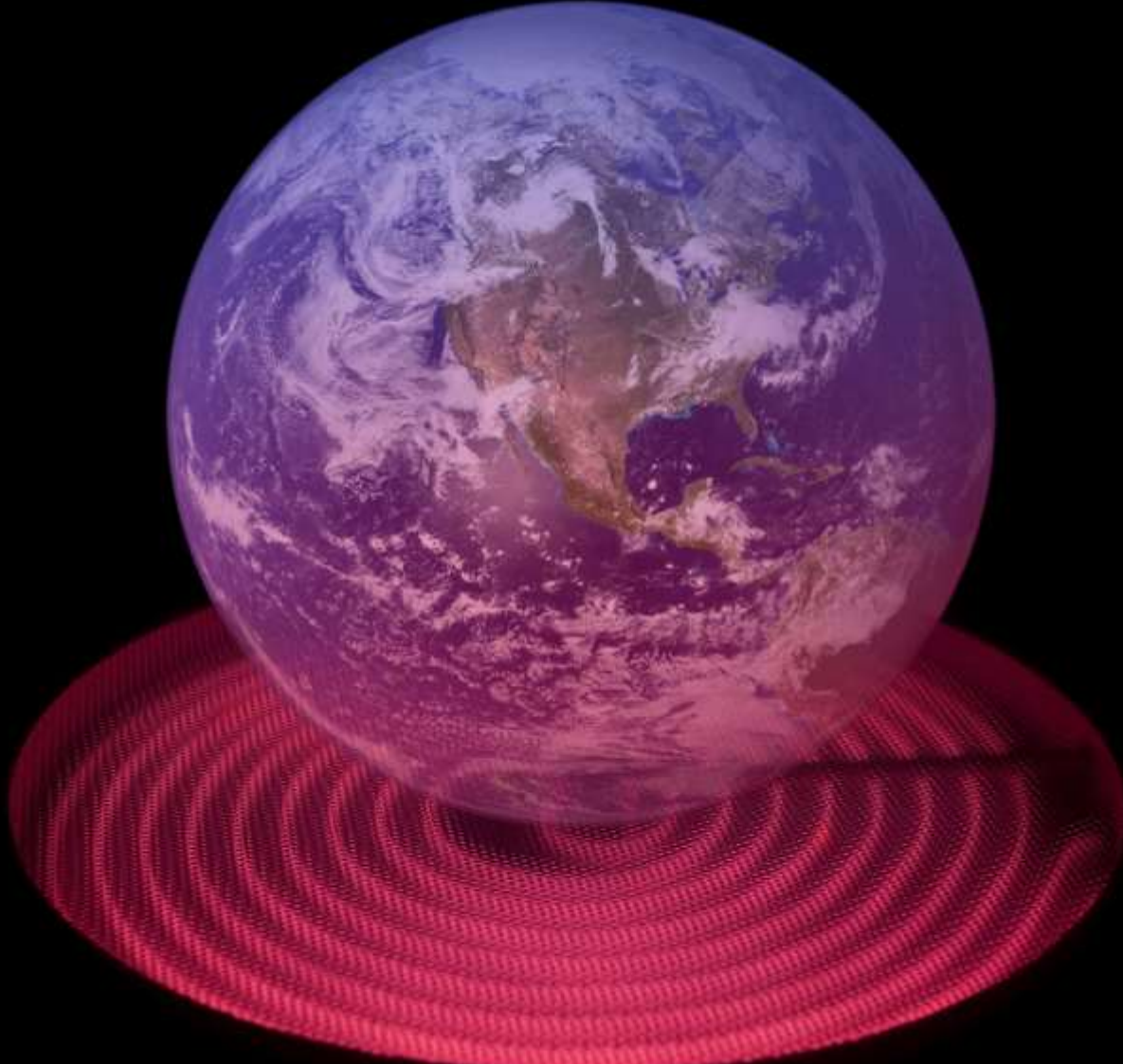
With permission from Clyde Zelch,
President, Tomcat Consultants.

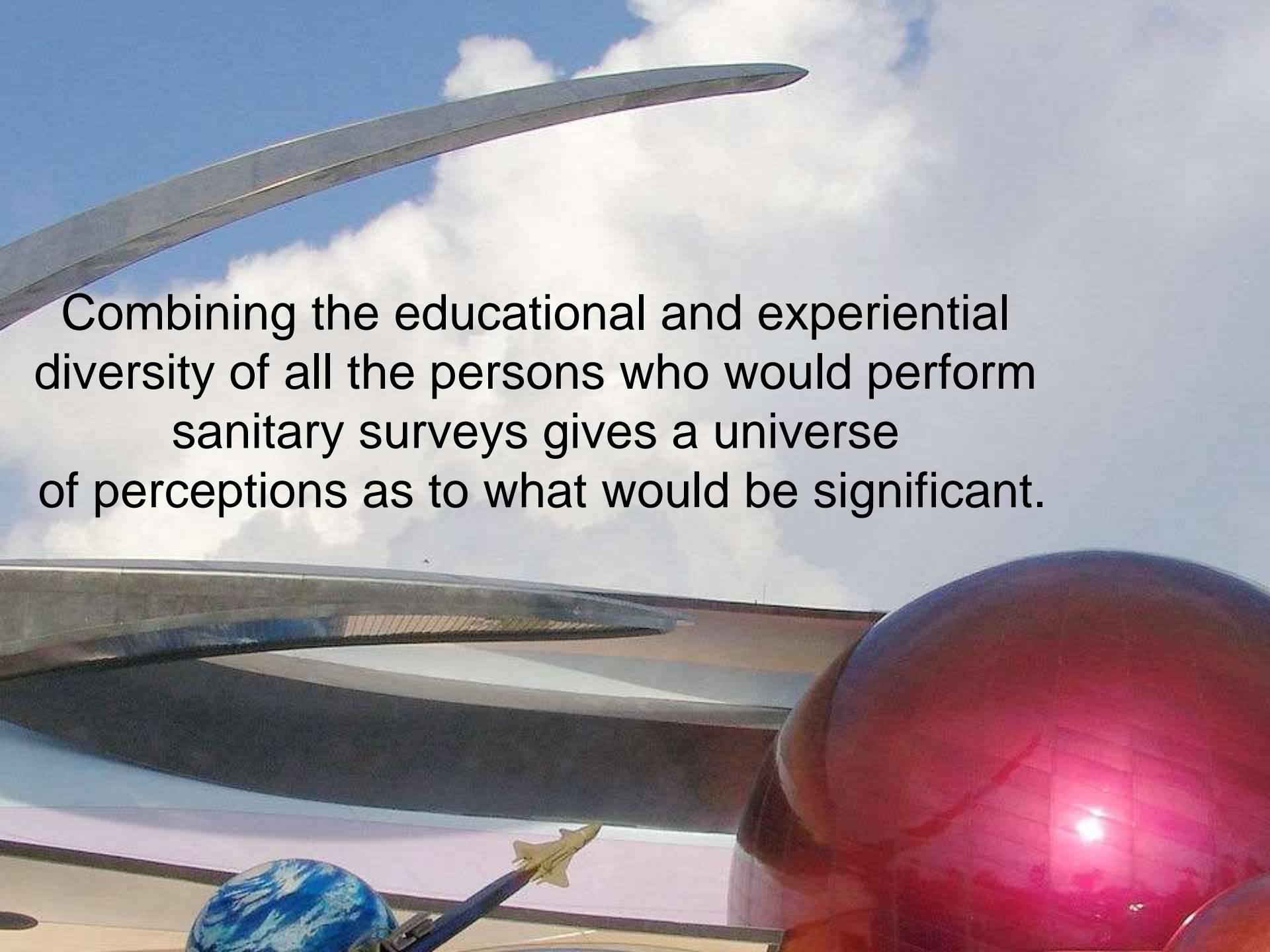


The first challenge is the tremendous educational diversity of persons performing sanitary surveys: from Chemical Engineering to Public Administration



The second challenge is the world of career paths that we apply our education to and the experience we gain.





Combining the educational and experiential diversity of all the persons who would perform sanitary surveys gives a universe of perceptions as to what would be significant.

The operator often has an even greater diversity in education (from high school degrees to PhD's) and work experience (from working in the oil fields to career water plant operators). Given this diversity, we cannot expect that either party (surveyor or operator) to have the same motivation for understanding the significance of breaches to storage tanks.



Let's take an example from the perspective of the person performing the sanitary survey

Degree: Microbiology, Biochemistry

Work: Federal employee (mostly desk work)

Visits a system

that has a knot hole missing in a board covering a spring collection box. Action:

requested that the boards be removed to investigate further.




Degree: Engineering

Work: State employee (significant field work) Visits a system and sees a tank in poor condition and inquires about it.

The operator said we'll be taking that tank off line in six months when the new treatment plant is online. Both walked on and investigated no further.





**Look
what just a missing
knothole in a board can
let into your finished
drinking water**

03.03.2010 18:12



**At least 3
bloated mice**

At least 7 snakes

**The operator, a retired
PhD chemist, was certain
that the 6 months of fecal coliform
results were due to EPA's bad
test methodology.**

For the system with the storage tank in poor condition, six months later a waterborne disease outbreak occurred



DENVERPOST.com

Thursday, March 04, 2010
Denver, CO

NEWS

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Denver Post, The (CO)

**111 in Alamosa hit by outbreak of salmonella
Officials expect more cases and are distributing free bottled water. How the wells were tainted is a mystery.**

March 21, 2008
Section: DENVER AND WEST
Page: B-01
Katy Human The Denver Post

An outbreak of salmonella poisoning in **Alamosa** spread Thursday, with 111 people likely sick from the dangerous bacteria that appears to have

WATERBORNE
SALMONELLA OUTBREAK
IN ALAMOSA, COLORADO
MARCH AND APRIL 2008

OUTBREAK IDENTIFICATION,
RESPONSE, AND INVESTIGATION



Safe Drinking Water Program
Water Quality Control Division

Prepared by:
Ron Falco, P.E.
Sharon Israel Williams, P.E.

November 2009

The Colorado Department of Public Health and Environment issued a Final Report on the Waterborne Salmonella Outbreak in Alamosa, Colorado in November 2009. It can be found at:



Colorado Department
of Public Health
and Environment



www.cdphe.state.us/wq/drinkingwater/AlamosaOutbreak

We have no regulations to lead us toward consistent implementation. We have only guidance and recommendations, and prior to 2015 that guidance has been inconsistent.

**In general,
regulations are able to achieve more
consistent implementation across the 50 states.**

Guidance and recommendations

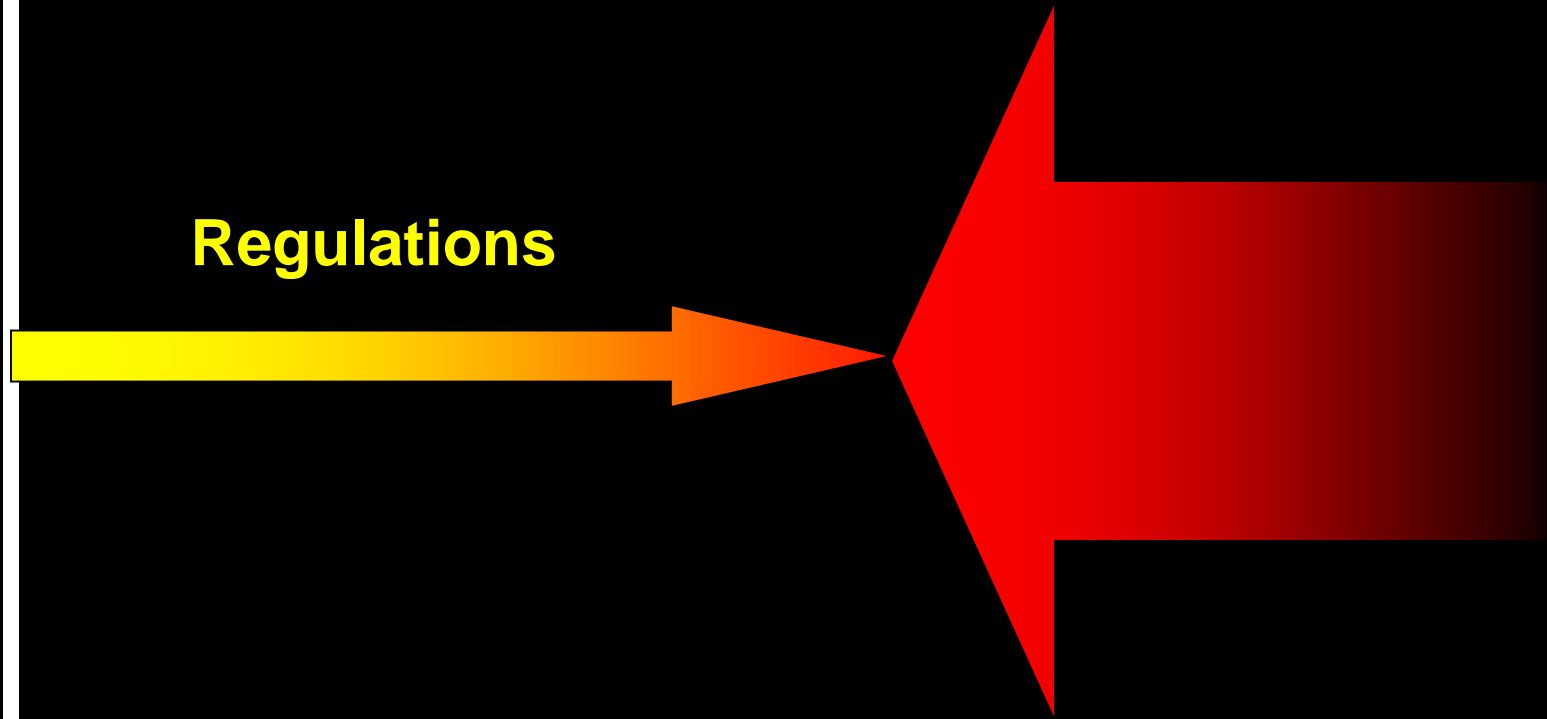


Regulations



Increasing consistency in implementation

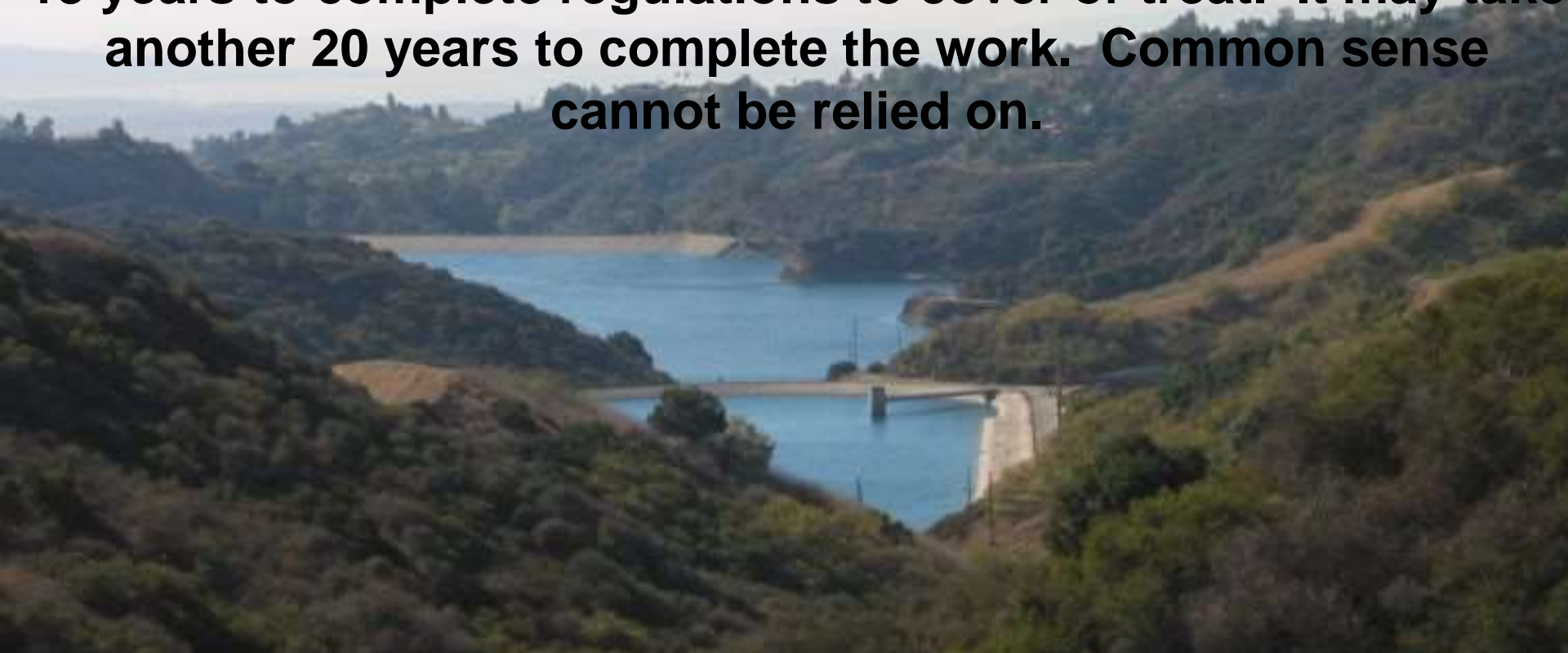
**Even when there are regulations,
the complexity, cost, or even increased workload
can decrease the consistency of implementation**



Increasing consistency in implementation

Can we rely on simple common sense?

This is an open finished water reservoir in a major city. In the decades it has been in use, common sense never prevailed to cover this reservoir. In fact, it never prevailed at ~150 open reservoirs serving tens of millions in some of America's largest cities. EPA had to create regs to protect people from the hazards of open reservoirs. But EPA moves slowly. It took 13 years to complete regulations to cover or treat. It may take another 20 years to complete the work. Common sense cannot be relied on.







Perspective aside, one thing we all can agree on is, water is a magnet for all things living from rodents, insects and bacteria and is used for the purposes of drinking, breeding or cell division.



Prior to 2015, guidances that discussed the sanitary integrity practices for tank components (vents, overflow, hatches, drains) not only contradicted each other but even contradicted themselves.



How to Conduct a Sanitary Survey of Small Water Systems
A Learner's Guide



03 04 2015

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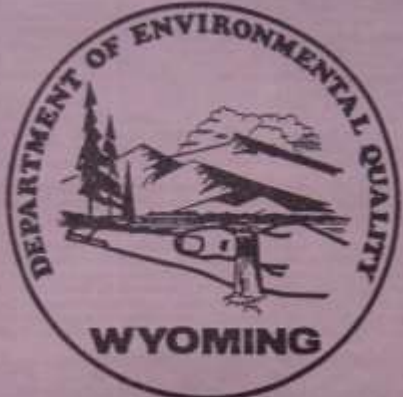
Recommended Standards for Water Works

2007 Edition

Policies for the Review and Approval of Plans and Specifications for Public Water Supply

A Report of the Water Supply Committee of the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers

03 04 2015



Water Quality Rules and Regulations

Chapter 12

03 04 2015



One example of inconsistency was in Ten State Standards where it stated ground level tanks must have a #24 mesh screen (since 1962) and elevated tanks must only have a #4 mesh screen.

The Ten State Standards committee made a decision that insects could not fly to the height of an elevated tank as the justification for a #4 screen (1/4 inch openings) on elevated tanks and overflows.

Joseph Conlon, the American Mosquito Control Association's Technical Advisor stated, insects have been found on Mount Everest.

Many states adopt Ten State Standards verbatim perpetuating this uninformed decision for decades.

Finally, as of October, 2015,

we have a guidance document that, for the first time ever in the history of storage tank guidances, describes very best sanitary integrity practices

for all tank components in one guidance document that will provide the best public health protection for finished water as it passes through a drinking water storage tank.



How to Conduct a Sanitary Survey of Drinking Water Systems



{Section 10 Finished Drinking Water Storage Tanks}



A Learner's Guide

DESIGNED TO ASSIST IN THE DELIVERY OF A
SANITARY SURVEY TRAINING COURSE

2015 Draft Edition as of September 2015



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.1 Vulnerability} On the average, the leakage of water out of distribution pipes is about 10%. Tanks protect against the non-potable water outside of the pipe from entering, by always forcing water out... Although tanks protect against contamination from entering the network of distribution pipes, the positive pressure they create does not protect the tanks themselves, because the pressure goes to zero at the air/water interface. This makes tanks the most vulnerable part of the distribution system, not only because there is zero pressure at the top, but also because there are designed openings to the atmosphere via vents, overflows, hatches, roof-to-sidewall connections, appurtenances entering tanks and unplanned openings.

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Finished water in storage tanks has no “defenses” like the distribution piping it supplies pressure to.



Drinking water pipes are placed in a hostile environment.

Sewage and storm pipes are always leaking.

Although sewage pipes are supposed to be laid below drinking water pipes, high water tables can bring this contaminated water in direct contact with drinking water pipe.

But, drinking water in a pipe has a very effective defense.

High-pressure water is almost always being forced out. Even bacteria that try and grow into the pipe are dislodged.

The importance of ensuring that all tank components have the very best sanitary practices in place and are checked on a daily to twice a week basis is realized when we understand just how vulnerable our finished water is in a storage tank.

Once water leaves the treatment plant the finished water is enclosed by the walls of the distribution system pipes at all times except in a storage tank. In a tank we have a small lake in an enclosed space where it is continually being exposed to air through the vents and overflows.



**Given this inherent
vulnerability what
must we ensure that we
keep
out of our finished
drinking water storage
tank?**





How to Conduct a Sanitary Survey of Drinking Water Systems



{Section 10.4.1 Vulnerability} To keep rodents, birds, bats, rodents, snakes, and insects and any diseases they may harbor, there must be no hole larger than that afforded by a #24 mesh screen or 0.027 inches (wire diameter 0.014 inches).

{Section 10.4.10, #14 Air Vents, b (1st paragraph)} Also, the tank must protect against rain, snow and minimize light and dust from entering.

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Desert dust storms disperse ~2.4 billion tons of soil annually.

1 gram of desert soil contains ~ 1 billion bacterial cells.

During dust storms in the Sahara Desert, dust can drift across the Atlantic in just a few days.

Historically, scientists believed that several days of UV would kill microbes traveling in dust clouds.

On 24 of 40 days that dust was sampled, viable amounts of bacteria and fungi were found.

It doesn't matter where the research is done, 20 to 30 % of the microbes in dust are known pathogens to some animal on the planet



**Insects carry a myriad of diseases,
one of which is, Salmonella.**

**There are more than 2,000 varieties
of Salmonella. It is ubiquitous.**

**Salmonella can survive for weeks in a dry
environment and months in a water environment.**



How to Conduct a Sanitary Survey of Drinking Water Systems



{Section 10.4.8 Components} Minimized degradation of the water in a tank occurs when all of the components work together as a system. A storage tank designed to work as a dynamic system, where each component is dependent upon all of the other component, has the best sanitary protection and most efficient operation. Relying on one component meeting the best sanitary protection requirements, while ignoring the other components, will lead to failure.

SANITARY SURVEY TRAINING COURSE

2015 Draft Edition as of September 2015



No tank component acts in isolation. Every tank component is dependent on several other components. A storage tank is truly a dynamic system.

A common argument is, you can't put a #24 mesh screen on an overflow it will clog. With what? The only thing in that tank is water and that easily goes through a #24 mesh screen. It will clog with floating leaves, feathers, dead insects - the screen component will take care of that. It will clog with bits of rust - the 3-5 yr minor coating repair component will take care of that. It will clog with sediment - the sediment is at the bottom the overflow is at the top (wrong application of logic) - the 3-5 yr cleaning of sediment will keep sediment down to a minimum, etc.

Only when the best practices are applied to all tank components and are continuously inspected is a tank operating as an efficient and effective dynamic system.



Vent

Hatch



Daily inspections



Overflow



I also have never inspected a tank that met all of the best sanitary integrity practices for tank components .

We are going to use the storage tank in my neighborhood and apply all of the best practices in the 2015 Learners Guide and see how this storage tank stacks up.



Drain

We are going to go through a lot of specific criteria on tank components and it will be difficult to remember all those specifics! That's why it's important to include all of these specifics in the sanitary survey template so we don't have to remember.

But there are other reasons these components are not inspected or poorly inspected.



We could fix that with different designs

A common reason elevated tanks are not reviewed is because it's just plain scary climbing them!



1994

Baloney

Drains:

Is it downturned? **NO**

or horizontal with flapper? **YES**

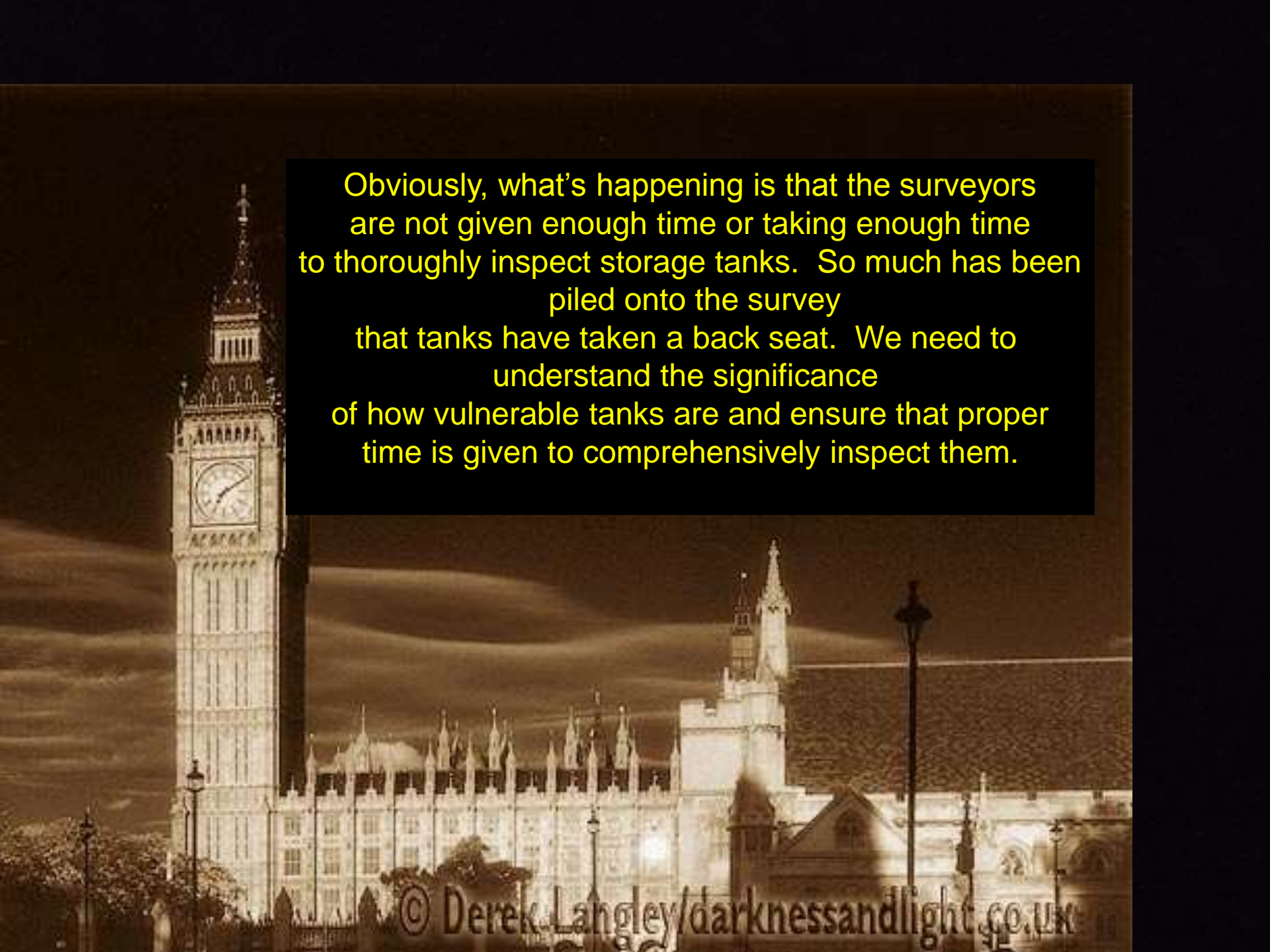
Does it have a # 24 screen? **YES**

Does it terminate at least
12 inches above splash plate? **YES**

**Sometimes surveyors don't visit each
storage tank and some
are in remote locations.**



**This concrete structure has been in
place way before the last survey. Yet
the last surveyor reported that it was 12 inches
above the splash plate when it's at most
just a couple of inches**



Obviously, what's happening is that the surveyors are not given enough time or taking enough time to thoroughly inspect storage tanks. So much has been piled onto the survey that tanks have taken a back seat. We need to understand the significance of how vulnerable tanks are and ensure that proper time is given to comprehensively inspect them.



Hands down the most important component of all of the tank components is daily to twice a week inspections





How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.1, Vulnerability of storage tanks (5th paragraph)} Water systems must also thoroughly inspect the inside of their tanks every three to five years. Many systems do not have this expertise and will need to hire an outside company to perform the inspection. If excessive sediment or other issues are detected during inspection, the operators will need to take the tank offline for cleaning and make any repairs which may include stripping the old coating and resurfacing with a new coating.

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How to Conduct a Sanitary Survey of Drinking Water Systems



{Section 10.4.10 #12, Cleaning and inspection(2nd paragraph)} In between these comprehensive inspections, operators must also conduct daily to biweekly (twice a week) inspections to observe the key components of the tank, like the vent and overflow, and look for holes in the tank. Systems need to conduct quarterly inspections for elevated tanks to observe the infrastructure, by climbing the tank.

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Daily inspection report for the 100,000 gallon Clarkson finished water storage tank

Date	Vent	Hatch	Overflow	Drain	Roof-to-side wall	Appurtances	Initials of inspector
Friday July 1, 2015	OK	OK	OK	Rodents nesting - set live traps	OK	OK	BR
Saturday July 2, 2015	OK	OK	Leaking - check telemetry	OK	OK	OK	BR
Sunday July 3, 2015	Birds roosting - set bird spikes	OK	OK	OK	OK	Antenna connection - needs to be re-caulked	CS
Monday July 4, 2015	OK	Bolt cutter marks on lock - install video	OK	OK	OK	OK	BR
Tuesday July 5, 2015	OK	OK	OK	OK	Spalling concrete SE corner - concrete patch	OK	CR

For continuous monitoring of tank components consider installing cameras to view the vent screens, hatches, overflows and entire tank area.



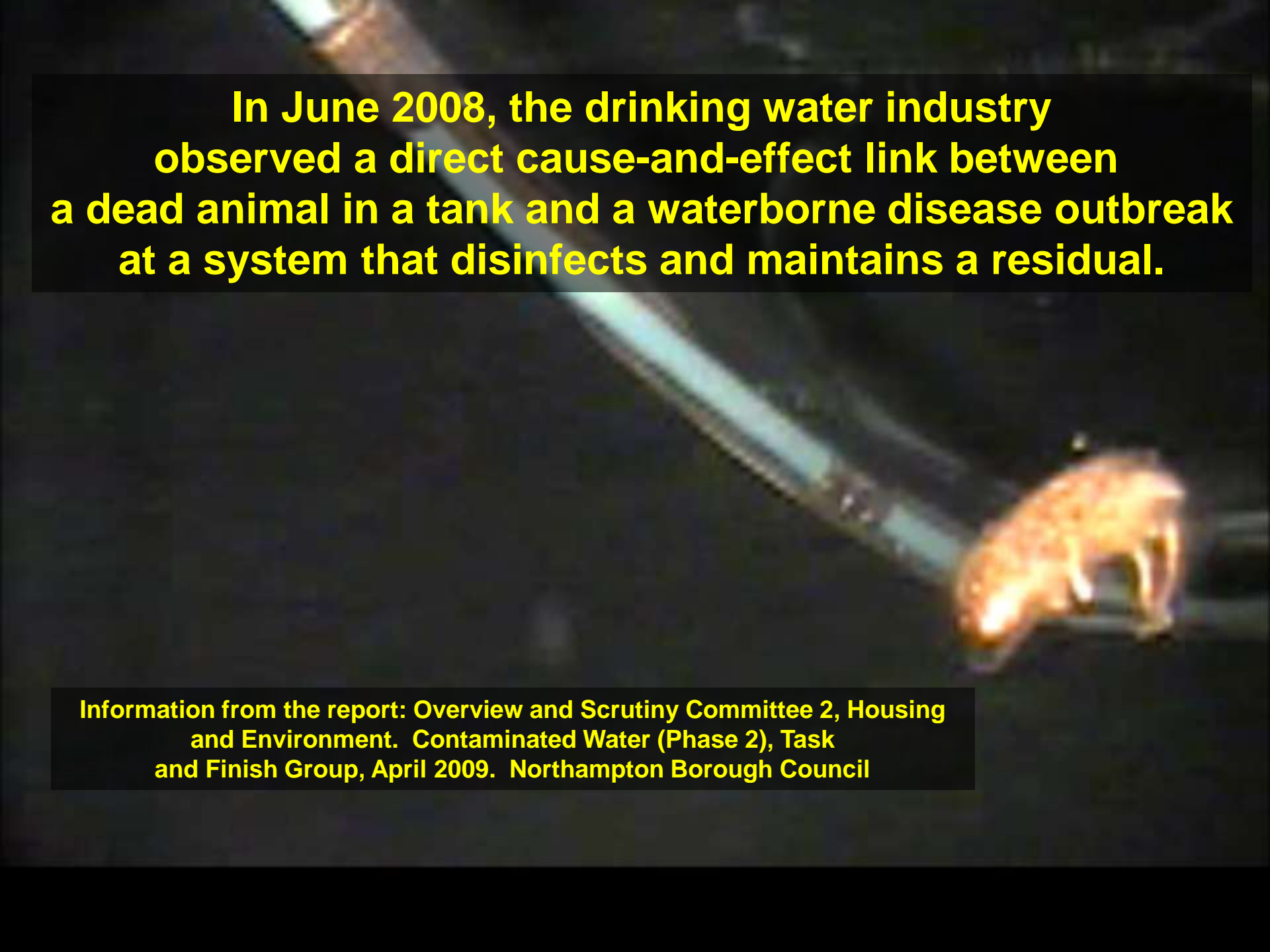
But cameras should not take the place of on-site inspections.



The reason that daily to twice a week inspections are the most important of all tank components is you will be able to catch breaches as they are developing and avoid holes, damaged screens, open hatches and repair them before insects, rodents and birds can enter and potentially lead to a waterborne disease outbreak.

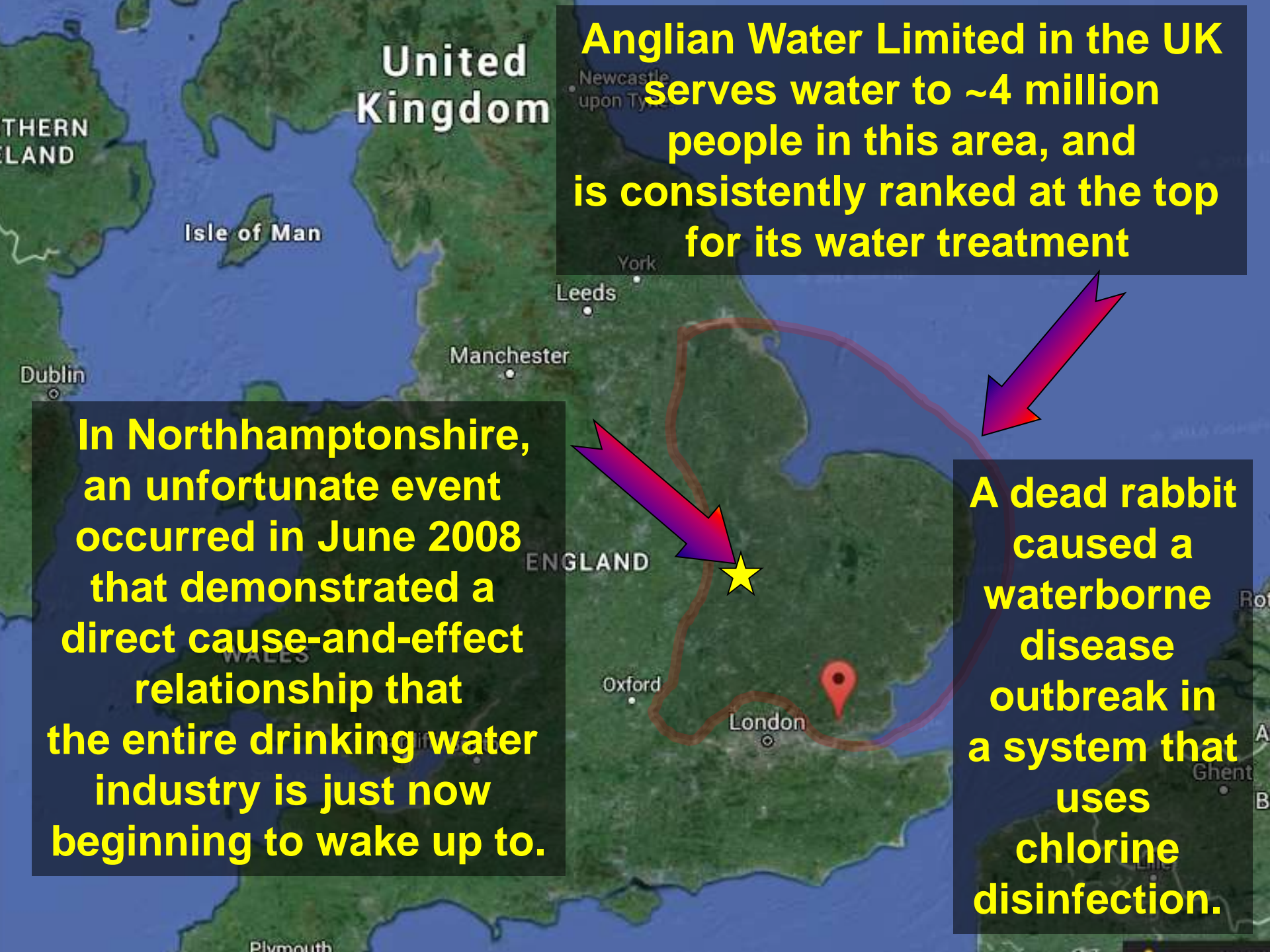


If daily/twice a week inspections are not performed on tanks you risk disaster-like an animal entering through that breach.



In June 2008, the drinking water industry observed a direct cause-and-effect link between a dead animal in a tank and a waterborne disease outbreak at a system that disinfects and maintains a residual.

Information from the report: Overview and Scrutiny Committee 2, Housing and Environment. Contaminated Water (Phase 2), Task and Finish Group, April 2009. Northampton Borough Council



United Kingdom

Anglian Water Limited in the UK serves water to ~4 million people in this area, and is consistently ranked at the top for its water treatment

In Northhamptonshire, an unfortunate event occurred in June 2008 that demonstrated a direct cause-and-effect relationship that the entire drinking water industry is just now beginning to wake up to.

A dead rabbit caused a waterborne disease outbreak in a system that uses chlorine disinfection.

Pitsford WTP, one of the WTPs with Anglian Water, continuously monitors for crypto by analyzing a cartridge filter every 4 days.

In the early evening of 6/24/08, the lab reported that the filter from 9:29 a.m. 6/19/08 to 11:50 a.m. 6/23/08 had levels of

6 oocysts in 11,848 liters (0.0005 oocysts/L).

These were highly unusual results. Crypto had only been detected occasionally in raw water, never in the finished water (874 samples since 2000).

The next filter was pulled at 8 p.m. on 6/24/08 (20 hrs. later) and the lab reported in the early hours of 6/25/08 they had levels of 418 oocysts in 5,064 liters (0.08 oocysts/L). The decision to issue a boil water notice was made by 3 a.m. and the press was alerted by 5:30 a.m. on 6/25/08 and lasted till 2 p.m. on 7/4/08. Warning cards were delivered by the evening of 6/25/08.



Consumer crypto sampling began from the Pitsford WTP, and fanned out into the storage tanks and the distribution system on 6/26/08 and lasted for 12 days, for a total of 342 crypto samples. Oocysts were detected at both the tanks and distribution system.



Investigations on the source began on 6/25/08. No oocysts were found in the raw water.

Samples were taken after each major unit process but the only places that positive samples were found were at the outlet of the GAC and disinfection contact basin.

Inspection revealed that vent screens were missing on the GAC backwash tank.

The disinfection contact basin was isolated and drained. Internal inspection of the basin found one relatively fresh rabbit carcass.

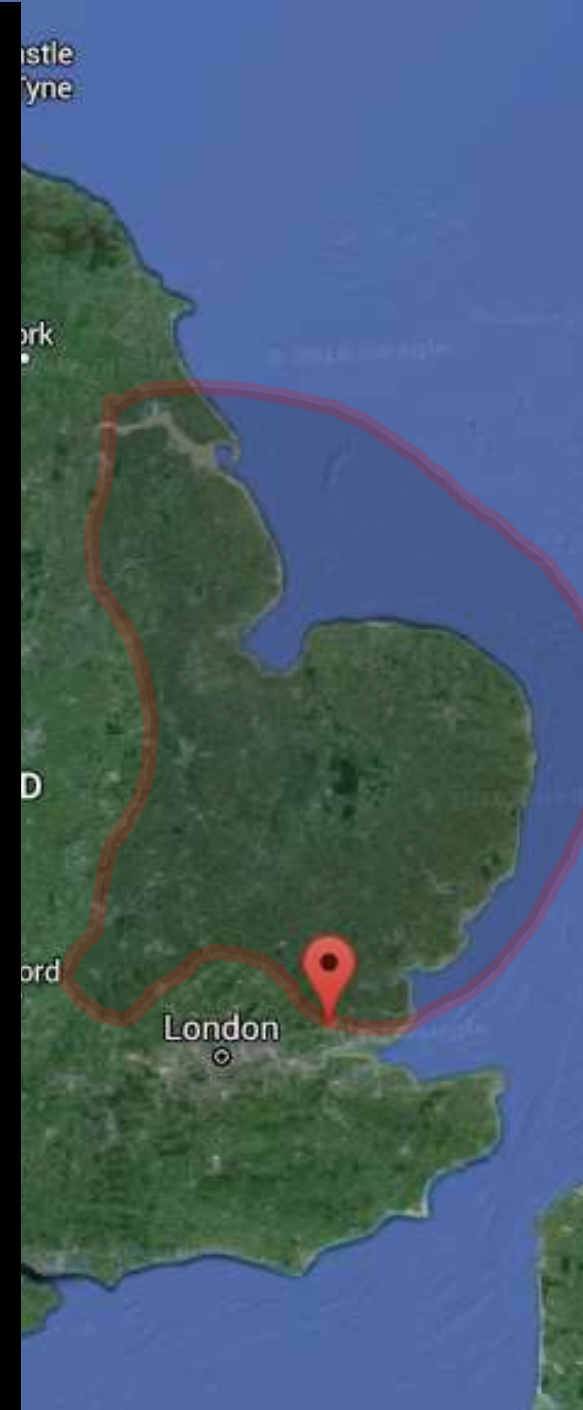
The carcass was removed and sent to a lab for analysis.



The UK Reference Laboratory typed oocysts from 7 water samples from the distribution system, the rabbit carcass and stool samples from 9 residents and reported these as all belonging to the same rabbit genotype.

A paper was published by the Journal of Water and Health 12/1/14 and demonstrated that this genotype caused disease in humans.

This had never been shown before, and the excitement in the research community was focused on this aspect, but it missed the bigger direct cause-and-effect link that a single rabbit carcass caused 22 confirmed cases of cryptosporidiosis.



Anglian Water Limited demonstrated the best way to clean and remediate its tanks and distribution pipes by systematically and unilaterally draining and cleaning its tanks then flushing the distribution system.

As this cleaning and flushing work progressed, a steady reduction in oocyst numbers were evidenced in samples collected from the tanks and consumers' taps.



Are there any regulations that require a PWS to report to the state or EPA (Wyoming and Indian Country) when a carcass is found in your tank? EPA Office of General Counsel stated yes; the regulations provide the authority in the Public Notice rule to address this situation. But there is no requirement that states use that authority for this particular case-by-case situation.

The public notice rule states in *Table 1 to 141.202-Violation Categories and Other Situations Requiring a Tier 1 Public Notice*:

(9) other violations or situations with significant potential to have serious adverse effects on human health as a result of short-term exposure, as determined by the primacy agency either in its regulations or a case-by-case basis.

This is a situation that can have a short-term adverse effect on human health .

The other question is, does a PWS have to report if a carcass is found in its finished drinking water storage tank within a certain timeframe of learning of this situation. In 141.202 (b)(2) it states, *Initiate consultation with the primacy agency as soon as practical, but no later than 24 hours after the public water system learns of the violation or situation, to determine additional public notice requirements; and...*

Gulf of California

Gulf of Mexico

Cuba



In EPA Region 8's annual mailing for 2016 to all Wyoming and Tribal PWSs it included the following language:

SITUATIONS WHEN YOU SHOULD NOTIFY EPA: It is very important to notify EPA Region 8 as soon as possible for certain situations or sample results at your water system, to protect public health and remain in compliance.

One of these situations include:

- When animal contamination is present in finished water storage tanks (see Newsletter article) : <http://www.epa.gov/region8-waterops/wyoming-public-water-systems-newsletter-2016>***



Newsletter article: *Animal Contamination In Your Storage Tank? We Need To Know About It Within 24 Hours!*

Excerpts: *Animal contamination in finished water storage tanks presents a serious public health risk as it can carry microbial pathogens, which can cause a waterborne disease outbreak after just a short-term exposure through drinking water. Animal contamination refers to either live animals (e.g. rodents or birds), dead or decomposing animal carcasses, or animal-related debris (feathers, skin, fecal matter, etc)...*

... When any animal contamination is found in storage tanks, EPA will presume that the potential for serious, adverse human health effects exist from short-term exposure to drinking water. In such situations, we expect you to provide public notice and to consult with the EPA as soon as practical, but within no more than 24 hours.

Anglian Water Limited has provided the drinking water industry with an invaluable cause-and-effect link that a carcass can cause a waterborne disease outbreak even at a system that chlorinates. So as embarrassing as it may be to find a carcass in your tank, it is very strongly recommended that you contact your state immediately.

The most important reason is because the state may want you to have the carcass tested for pathogens by someone at CDC. So treat the carcass as evidence of a potential waterborne disease outbreak. In addition, the state will want to talk with you about the best way to clean (drain and power wash – not divers) and remediate the affected tank and distribution system. Lastly, the state may want to have you on a boil water notice until remediation is complete.

CDC contact to have a carcass analyzed for pathogens:

Lihua Xiao, DVM, PhD

**Division of Foodborne, Waterborne and
Environmental Diseases National Center for
Emerging and Zoonotic Infectious Diseases
Centers for Disease Control and Prevention**

Mail Stop D66, Bldg 23, Rm. 9-168

1600 Clifton Road

Atlanta, GA. 30329-4018

Tel: 404-718-4161 E-mail: lxiao@cdc.gov



If a carcass has been found in your tank, the best way to clean and remediate the affected tank and distribution system involves the following steps:

- 1) Isolate the tank while maintaining pressure in dist. system.**
- 2) Find and permanently fix all holes in the tank.**
- 3) Completely drain and scour all surfaces with a high-pressure stream of clean water.**
- 4) Disinfect the tank according to AWWA standards**
- 5) Perform unilateral flushing**

Yes, that may mean if you find carcasses during a cleaning event using divers, you will need to conduct a second cleaning using the drain and clean method. There is a way to avoid two successive cleanings.





If you cannot absolutely and unequivocally verify that the tank you are about to clean has NO HOLES, then you can confidently hire divers. But if you cannot verify there are no holes then be conservative and hire a company that uses the drain and clean method. Finding a carcass in your storage tank is a great, great failing of the sanitary practices that the industry has put in place to protect human health.

Typically, if divers are used to clean a tank, they will report the number of carcasses that are found on the floor of the tank.

Carcass





Carcass

**Carcass
about to be
vacuumed out**

**And they will report on the
number of carcasses that are found floating
on the surface.**



Carcass

Carcass

**And they will vacuum
the carcasses floating and lying on the floor of the tank.
The carcasses are potential evidence
of a waterborne disease outbreak. They should be preserved
on ice and shipped out to CDC to be investigated
to see if there are pathogens in their intestinal tissues.**

Vacuumed

**Not
Vacuumed**

**Cleaning by divers does a good
job of cleaning these sediments
off the floor so the floor
can be inspected for rusting, etc.**





**The stains
that the carcass
leaves on the floor
need to be scrubbed.**



When carcasses are found, the tank must be isolated. The next step is to find and permanently repair all holes. If something like this flashing is blocking your view of any holes, it must be removed so the roof-to-wall joint can be directly viewed.

Divers do not typically clean the walls—you can see the difference between the walls and the floor. As a carcass disintegrates, microscopic pieces of its flesh float away, some are carried out in the water column to potentially be ingested, some other pieces of flesh adhere to the walls of the distribution system pipes, and other pieces of flesh adhere to the walls and floor of the storage tank. That's why the tank must be drained, so the walls and floors can be scoured with a high-pressure stream of clean water. Then the tank can be disinfected, and then the distribution system can be unilaterally flushed.



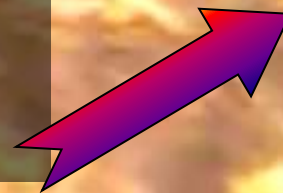
Wall

Floor

A wisp of sediment was dislodged as the diver brushed his glove against the wall. This sediment on the walls potentially may have animal flesh and pathogens adhered to it and can be released back into the water column.

This is the finished product from diving. This is not sufficient when you are dealing with animal carcasses.

The diver purposefully and gently brushed his glove against the wall here.



The holes can be verified by closing the hatch and looking for light. Those are the holes where the rodents entered.





By draining the tank, the walls and floors can be power washed and scrubbed, if necessary. All contaminants and water used in power washing are pumped out of the tank.



With a drain and clean method, all sediment and pieces of flesh from the decaying carcass are removed from walls and floor. This is the process that Anglian Water used to clean its tanks and it correlated with decreasing cryptosporidium levels.

Drain and power wash method

Diving method

Wall

**The difference in methods
is self-evident**

**Floor with carcass
stains**





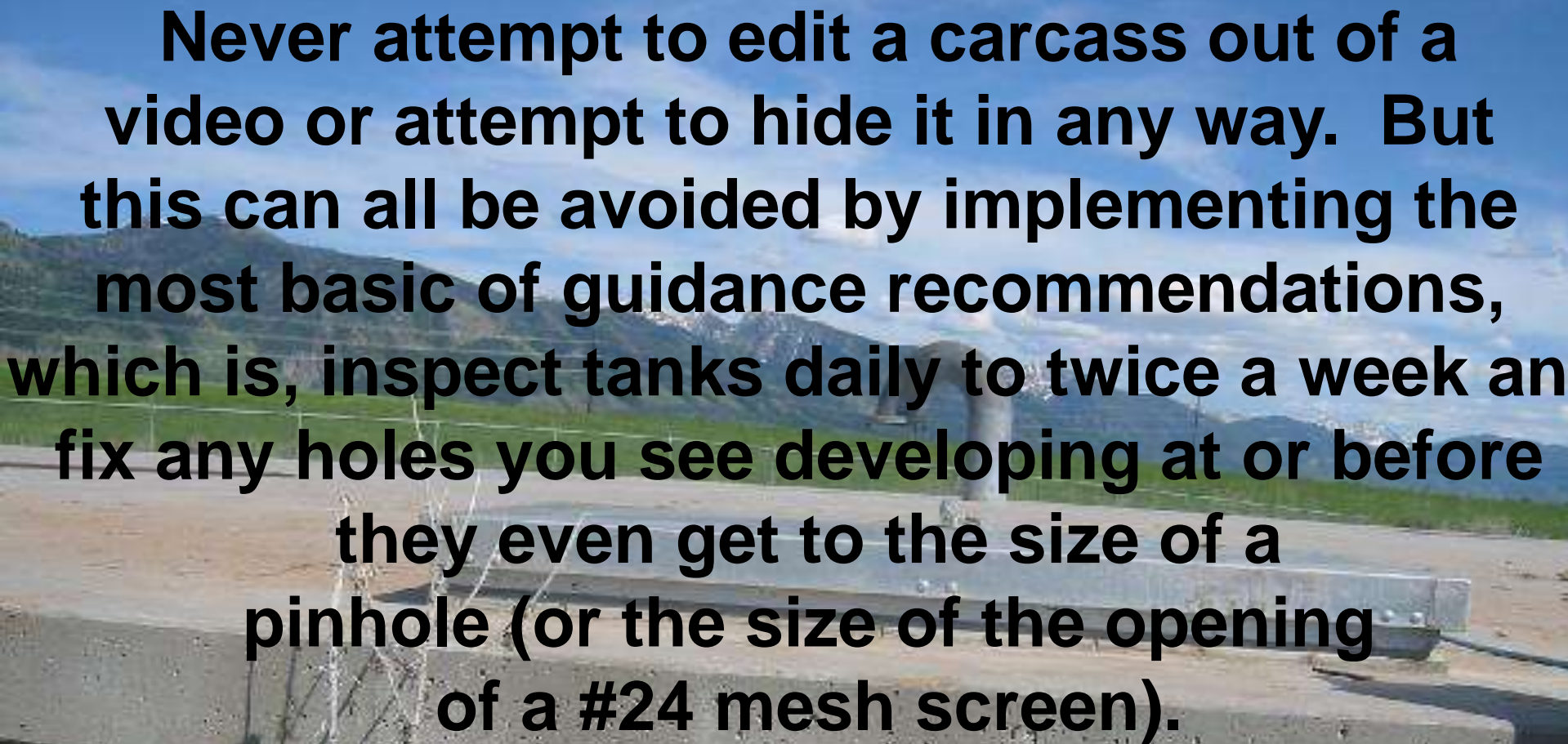
The drinking water industry has been given a very fortunate gift from this example. If the rabbit had drowned in a storage tank where there was no continuous crypto monitoring, we would not have this cause-and-effect link. Luckily, it occurred in a tank at the WTP and Anglian had a very proactive policy of continuously monitoring its finished water for crypto.

The report stated, “a small relatively fresh rabbit carcass was found”. This provides other vital pieces of information. If an infected animal drowns, the pathogens are released soon after, when it is in a relatively fresh or intact state. Also a small rabbit produced enough crypto to produce positive results in the storage tanks and distribution system. It only takes one dead animal to cause a waterborne disease outbreak.

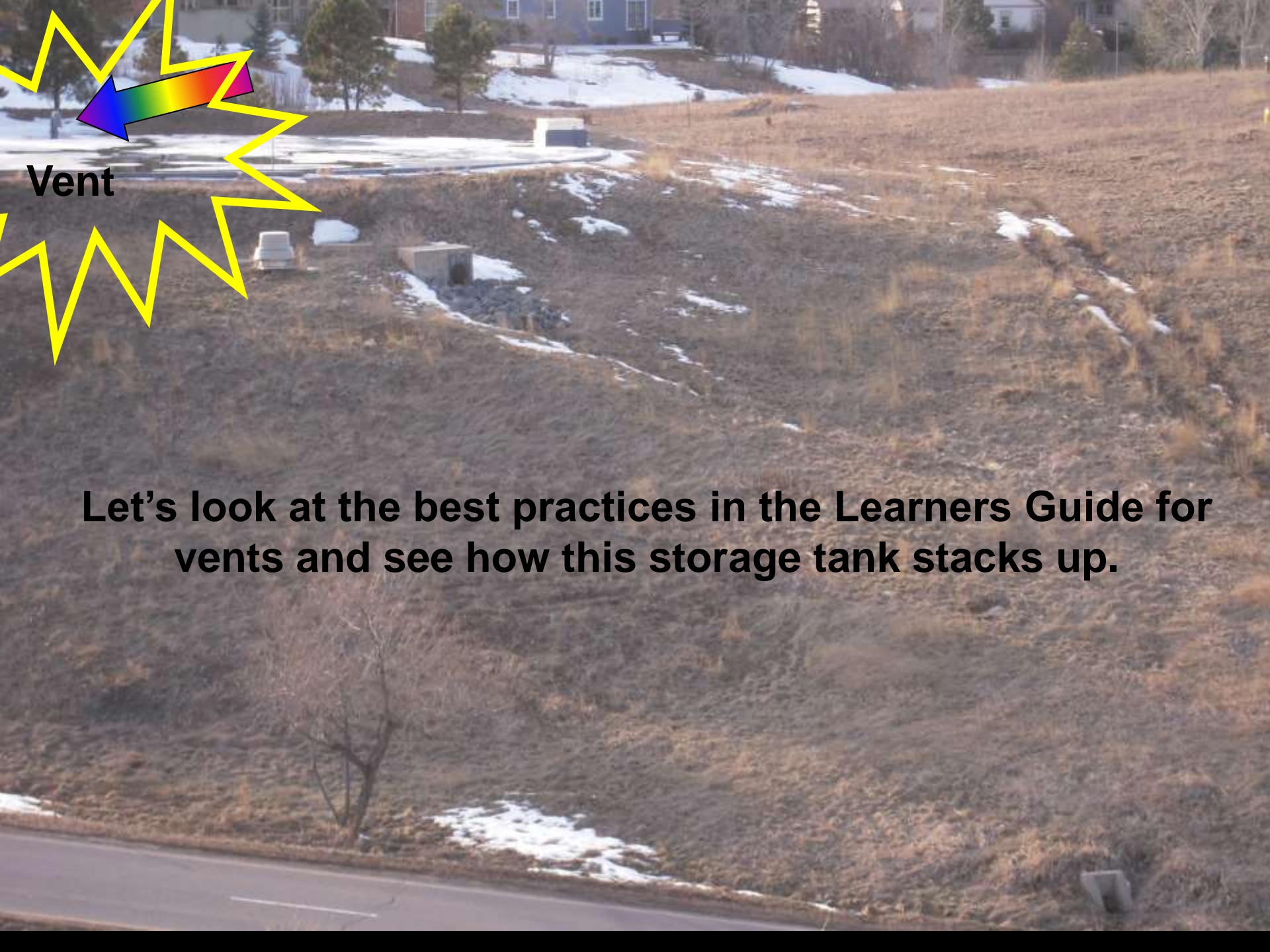


Typically, carcasses are found during tank cleaning events. Anglian Water in the UK has set a very high bar for doing what is right and acting quickly. Although it is different because we find the carcass first, then search for pathogens but that is no reason to be not be as equally responsible. If animals have been drowning over time, the release of pathogens will be episodic and there may be no clear indication of a waterborne disease outbreak. It only takes two people getting ill from the same water source to be classified as a waterborne disease. For that reason, CDC states that waterborne disease outbreaks are grossly underreported.



A photograph of a concrete wall with a metal mesh screen attached to it. The screen is made of thin metal wires forming a grid. The wall is made of large concrete blocks. In the background, there are green hills and mountains under a blue sky with some clouds. The text is overlaid on the image in a bold, black, sans-serif font.

Never attempt to edit a carcass out of a video or attempt to hide it in any way. But this can all be avoided by implementing the most basic of guidance recommendations, which is, inspect tanks daily to twice a week and fix any holes you see developing at or before they even get to the size of a pinhole (or the size of the opening of a #24 mesh screen).



Vent

Let's look at the best practices in the Learners Guide for vents and see how this storage tank stacks up.



How to Conduct a Sanitary Survey of Drinking Water Systems

The examples that follow will relate to the part of the paragraph that is outlined in red.

{Section 10.4.10, #14 Air Vents, a} All vents (ground and elevated) must have a #24 mesh screen, to keep living organisms down to the size of insects, and any pathogens they may harbor out of the tank. Metal elevated tanks must have a pressure/vacuum relief mechanism (e.g., movable palette, flexible inner screen, low pressure/vacuum relief valve, etc) to prevent tank damage. Extreme vacuum events must not be able to draw the screen into the tank, as well. Also see, Section 10.4.8 Components

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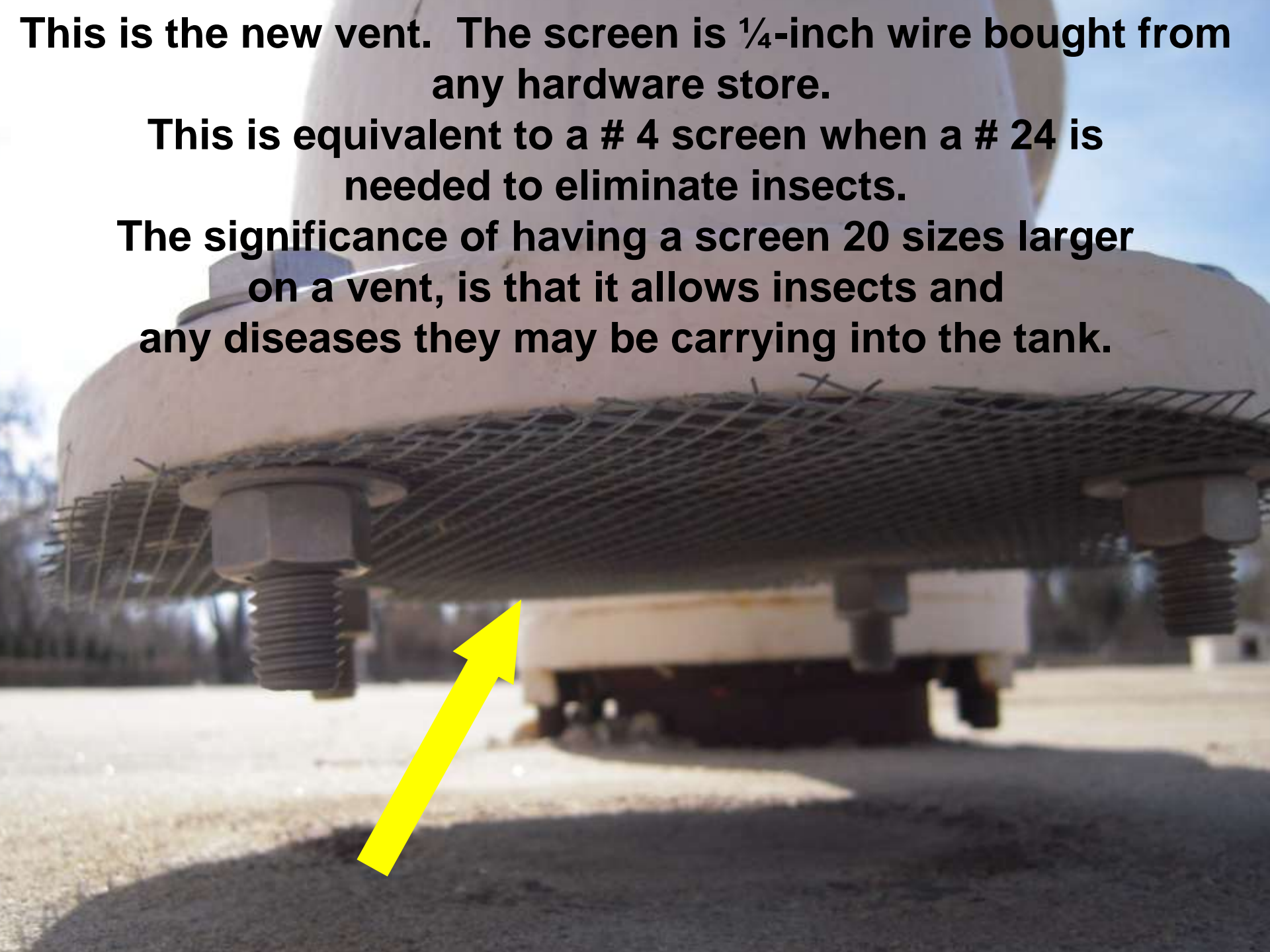
Understanding the significance of this vent opening wasn't realized until the tank was cleaned. The snakes, rodents & soil in the tank were coming from a vent opening too close to the ground and with too large of openings. These vents were sealed and moved to the top.



This is the new vent. The screen is ¼-inch wire bought from any hardware store.

This is equivalent to a # 4 screen when a # 24 is needed to eliminate insects.

The significance of having a screen 20 sizes larger on a vent, is that it allows insects and any diseases they may be carrying into the tank.



These 1-inch by ½-inch screens typically found on elevated tanks will allow all types of insects into the tank.



The myth is that insects can not fly to the height of an elevated tank. That myth is easily disproved in talking with entomologists

Elevated tanks may have blinking lights on top so planes don't fly into them. The lights can attract a high concentration of flying insects around a vent that is inadequate to prevent them from entering.

This vent is not down turned and does not minimize windblown dust rain, snow, or sunlight.

This an elevated tank and undeniable proof – insects can fly to the height of an elevated tank. Entomologists will tell you that insects have been found higher than Mount Everest. Without a #24 mesh screen insects can enter the tank. Insects in our finished water is simply unacceptable. The thousands of insects in this tank are wasps.



**With permission from Clyde Zelch,
President, Tomcat Consultants.**



This is a #24 mesh screen and will keep all insects and any diseases they may harbor out of the tank. A heating coil was added to ensure it did not freeze.





How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #14 Air Vents, a} All vents (ground and elevated) must have a #24 mesh screen, to keep living organisms down to the size of insects, and any pathogens they may harbor out of the tank. Metal elevated tanks must have a pressure/vacuum relief mechanism (e.g., movable palette, flexible inner screen, low pressure/vacuum relief valve, etc) to prevent tank damage. Extreme vacuum events must not be able to draw the screen into the tank, as well.

Also see, Section 10.4.8 Components

This is a typical design for a vent for new elevated tanks. It is designed to eliminate

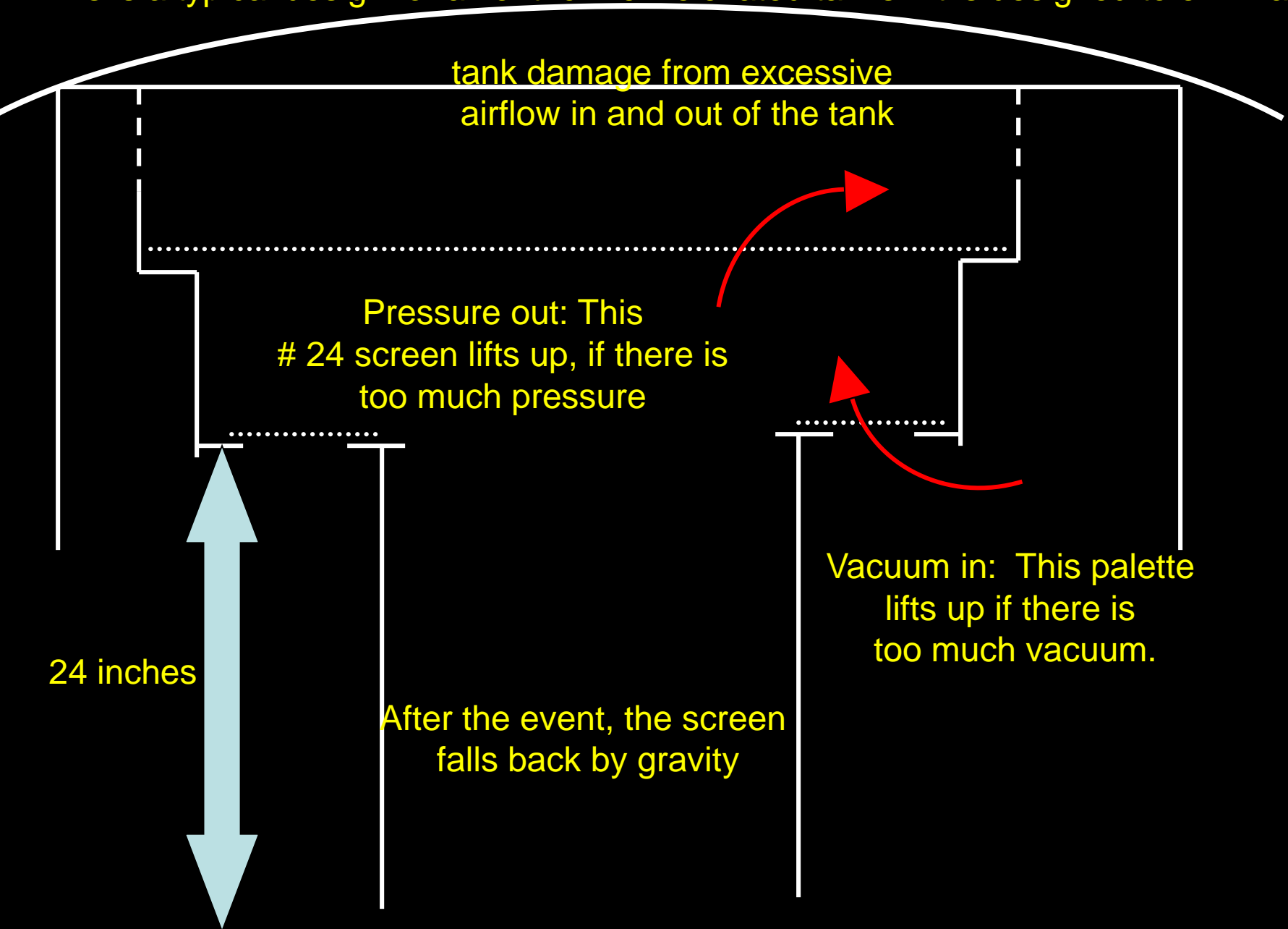
tank damage from excessive
airflow in and out of the tank

Pressure out: This
24 screen lifts up, if there is
too much pressure

Vacuum in: This palette
lifts up if there is
too much vacuum.

After the event, the screen
falls back by gravity

24 inches

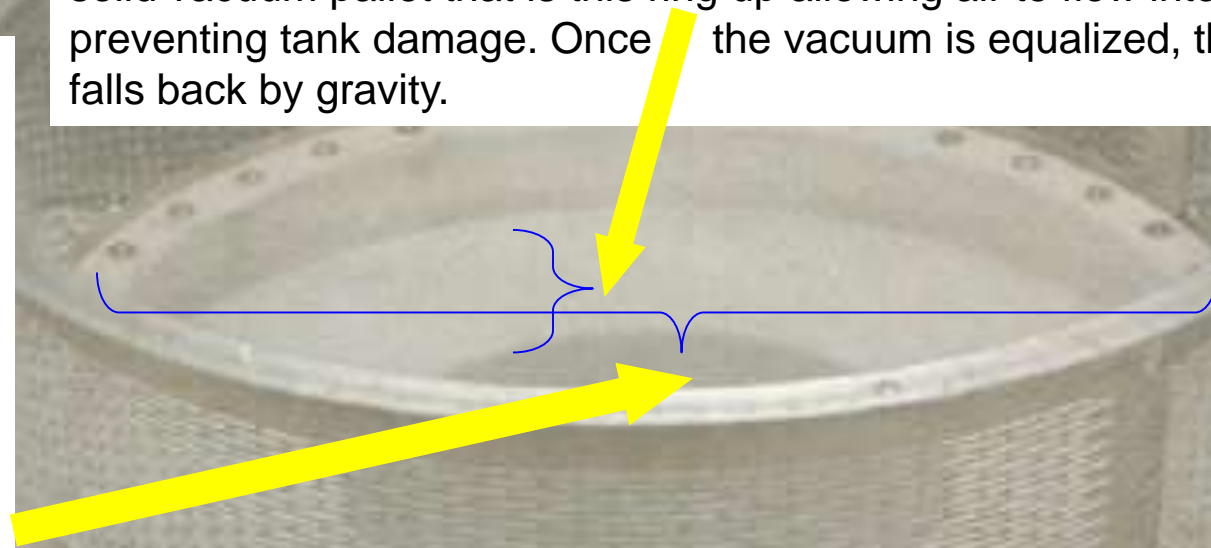


In a vacuum event, the air pressure outside the tank becomes greater than the air pressure inside the tank. This pressure difference lifts the solid vacuum pallet that is this ring up allowing air to flow into the tank preventing tank damage. Once the vacuum is equalized, the pallet falls back by gravity.

In a pressure event the air pressure inside the tank becomes greater than the air pressure outside the tank. This pressure difference lifts the #24 mesh screen pressure pallet up allowing air to flow out of the tank through the coarse exterior bird screen preventing tank damage. Once the pressure is equalized, the pallet falls back by gravity.

Under normal operating conditions these pallets will not move. A #16 mesh is what comes standard, but simply ask for #24 mesh. The air flow difference between a #16 and #24 is small, but check that the square inches of area for a vent is at least $\frac{1}{2}$ the square inches of area of the largest pipe. Or you can check calculations with the vent manufacturer or engineer.

Like any moving part, maintenance includes checking to see if the pallets lie flat and is not warped. Warped pallets need to be replaced.





For a flexible screen vent, ask that the flexible inner screen be #24 mesh. The flexible screen is typically wrapped twice, the vertical seam needs to be sealed. When frost builds up on the flexible screen, vacuum and pressure will move the screen breaking up frost buildup.

A bird screen fits over the flexible screen to protect it against being torn apart by birds.



The solid water tight cover is placed over the bird screen and comes down at least to the bottom of the #24 mesh screen.

This is a vacuum/
pressure
relief valve for low
pressure tanks like
drinking water tanks.



2010B

It is simply ridiculous to think that elevated tanks cannot have the same level of protection from insects as ground-level tanks (#24 mesh since 1962). Because elevated tanks are thin walled tanks they need an additional component -- a vacuum/pressure relief mechanism along with the #24 mesh screen.



Even if you have put a #16 mesh screen on your elevated tank and you have not also installed a vacuum/pressure mechanism you have put your elevated tank at risk of damage - like this tank. Since all finer screens must be utilized with a vacuum/pressure relief mechanism and there is very little air flow difference between a #16 and #24 than, use the #24 to also keep out all insects.

10 11 91



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #14 Air Vents, b (1st paragraph)} Vents breathe air in and out of the tank and can inhale contaminants into the finished water; therefore, the screen must be at least 24 inches (ground or elevated) above the roof or ground. The vent must also protect against rain and snow, and minimize light and dust from entering. If the vent is down-turned, it must face the ground (inverted U).
Also see, Section 10.4.8 Components

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The height can easily be fixed by adding a pipe extension here or rotating it 180 degrees

What about the height?

The 24 inches would not be measured from the ground but rather the closest horizontal surface to an inhalation hazard where bird and animal excrement may be inhaled.

Bird spikes can be added to horizontal areas near the vent.



**The vent is only 3 inches high!
It needs to be at least 21 inches higher.**

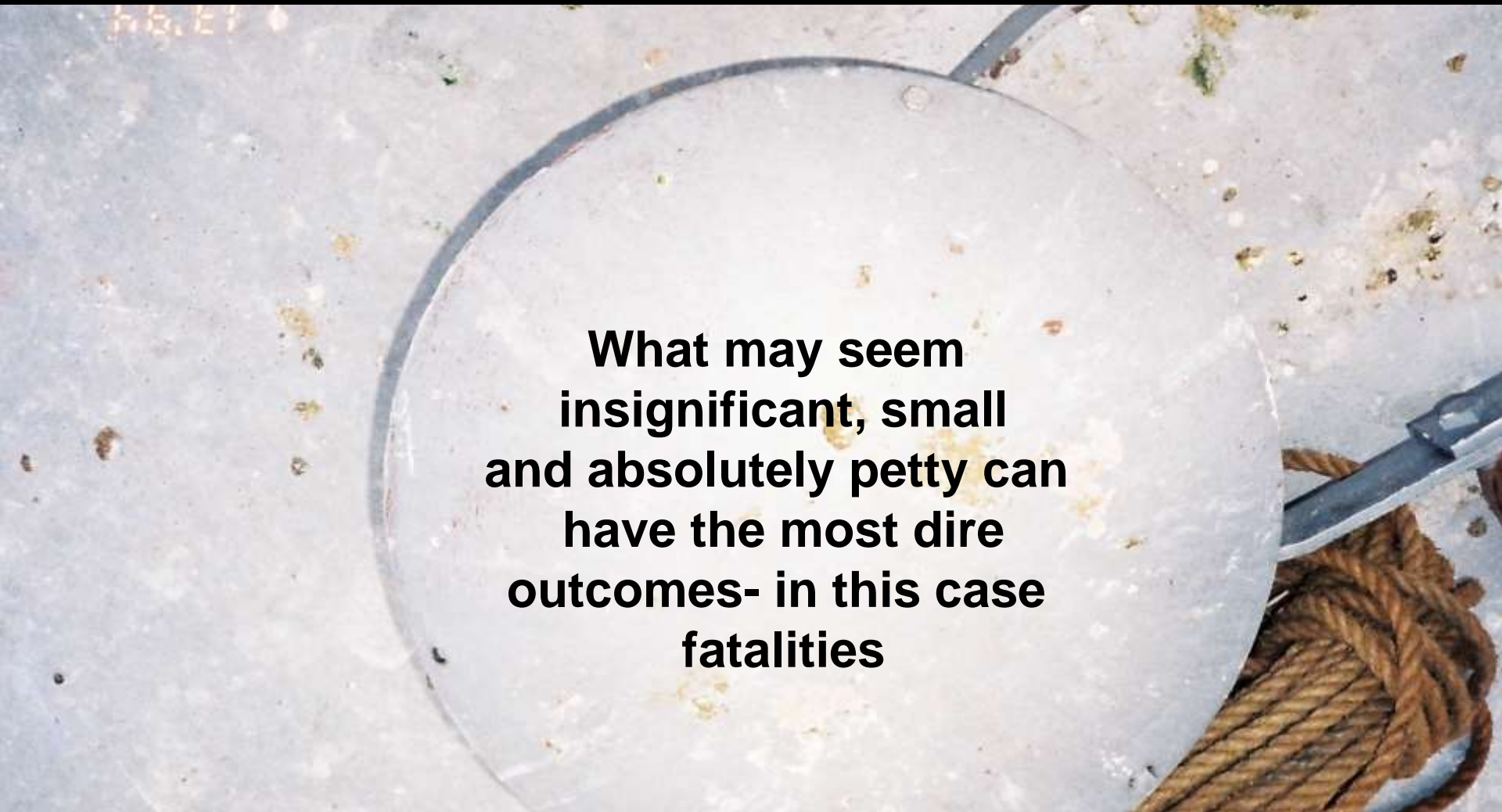


The significance of having a vent so low to the ground is it can inhale contamination from the ground and that contamination may contain salmonella.




Vents are an inhalation hazard. If the vents are at least 24 inches above the ground, there is a large enough volume of air surrounding the vent so that inhalation from contamination on the roof won't be pulled inside the tank

This is the vent for Gideon, Missouri one of the cities that had a major waterborne disease outbreak. You can see the pigeon droppings and the vent very low to the roof which will inhale these Salmonella laden droppings into the tank.

A photograph showing a circular vent on a light-colored roof. The vent is surrounded by numerous small, brownish droppings, likely from pigeons. A metal pipe and a coil of brown rope are visible to the right of the vent.

What may seem insignificant, small and absolutely petty can have the most dire outcomes- in this case fatalities

A blue vent stack is mounted on a concrete base, which is surrounded by a thick layer of gravel. The vent stack has a rounded top and a flat base. The background shows a vast, flat landscape under a clear blue sky, with distant mountains visible on the horizon. The text is overlaid on the upper part of the vent stack.

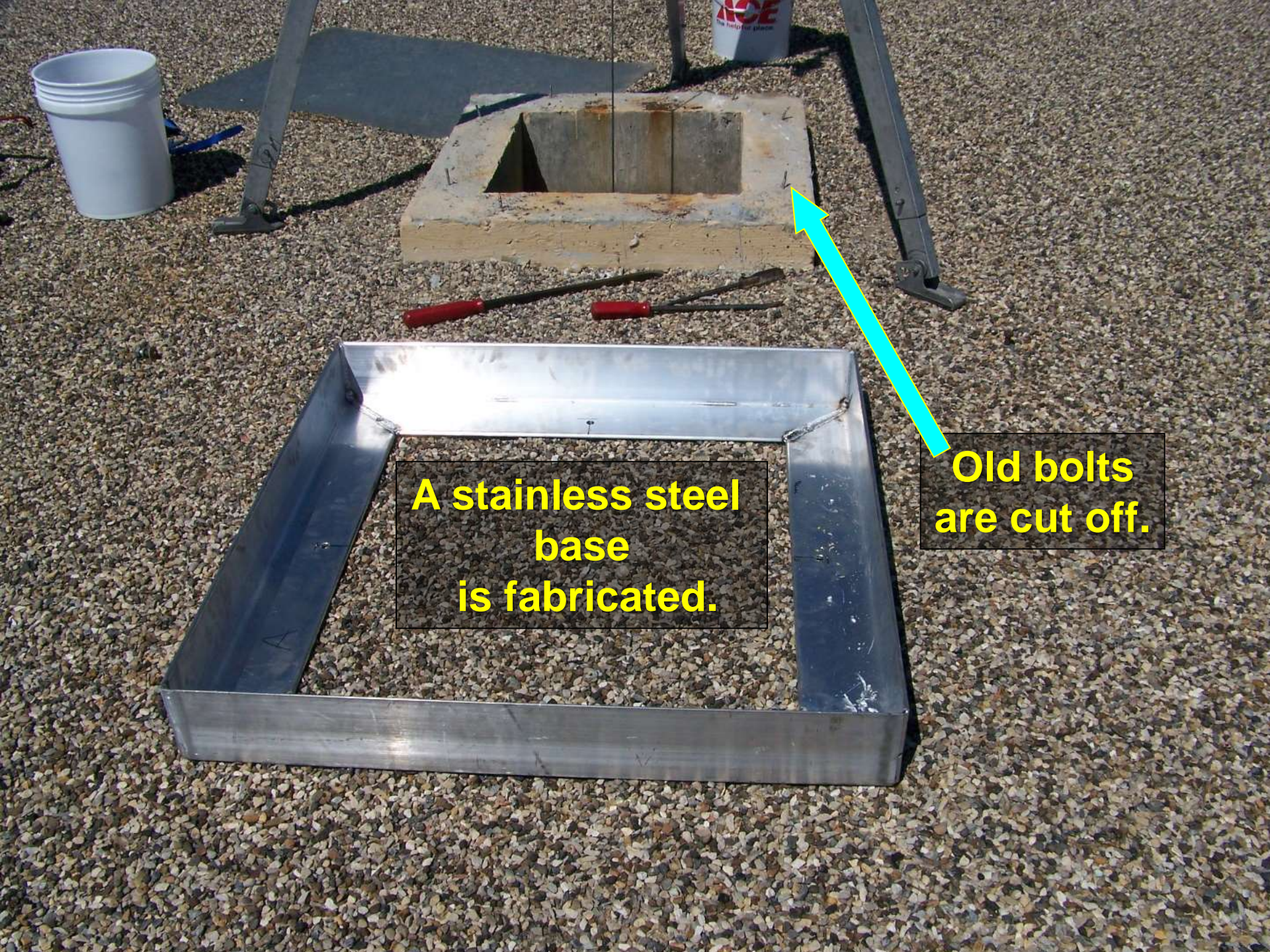
Some vents may seem impossible to raise to at least 24 inches— but let's see how one system raised their vent.

A blue metal vent top is shown from a top-down perspective, resting on a gravel surface. The vent top is a square-shaped metal frame with a mesh screen attached to its inner edge. The mesh screen is made of a silver-colored metal and is held in place by several metal brackets or bolts. Inside the vent top, a wooden board is visible, likely used for access or repair. The vent top is slightly raised from the gravel, and the overall appearance is that of a well-maintained but possibly aged piece of equipment.

Vent top is removed

A tripod is placed above the opening and the plywood is pulled tight against the bottom of the opening to prevent contamination from entering during vent replacement.





**A stainless steel
base
is fabricated.**

**Old bolts
are cut off.**



**New holes are drilled
in the concrete to match
the base.**

Anchor rods are glued into the concrete.



**Sealant is placed along
the rough concrete base
to create a good seal.**

Anchor bolts installed.




Rubber seal is placed over the sealant.



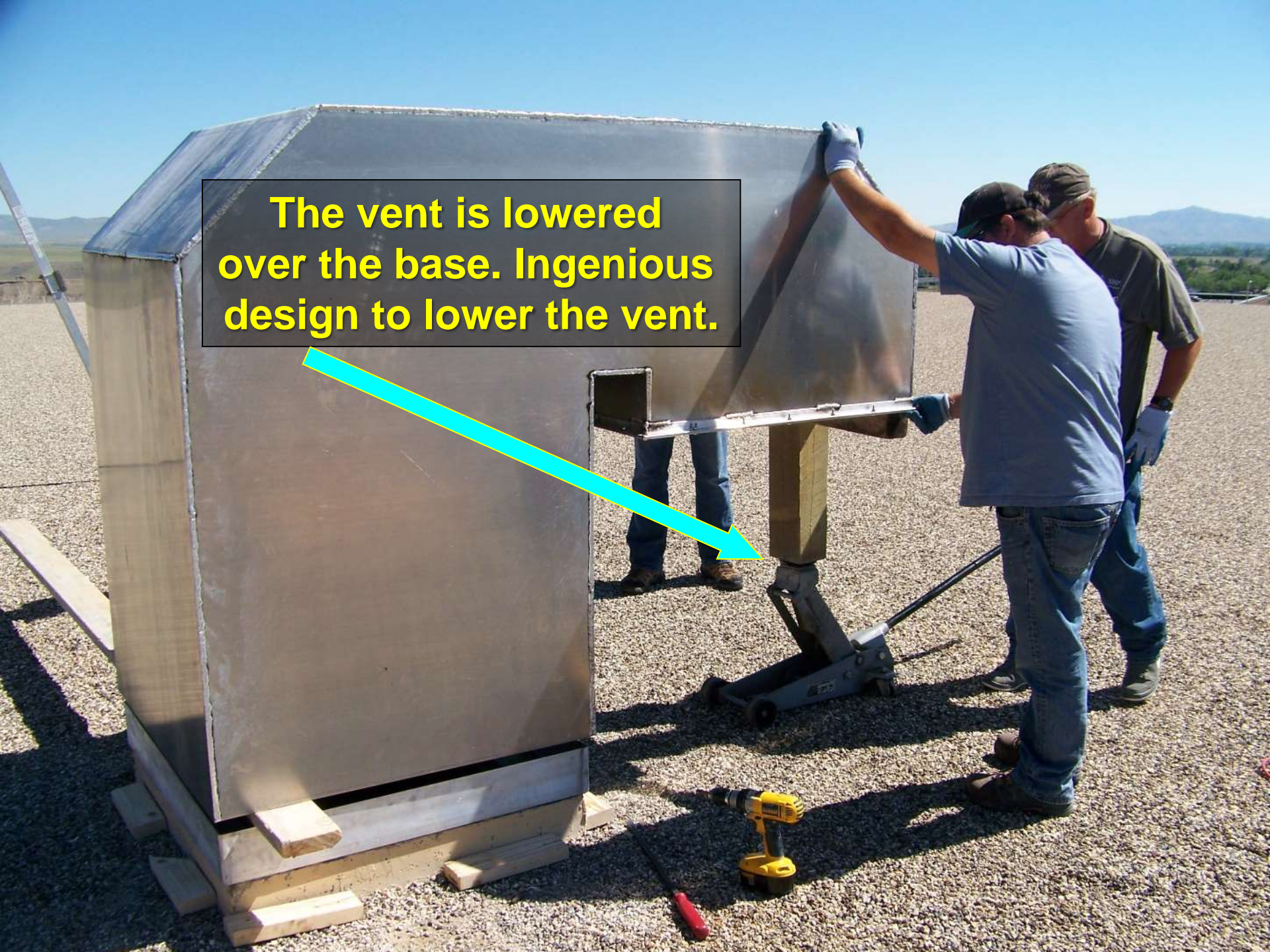
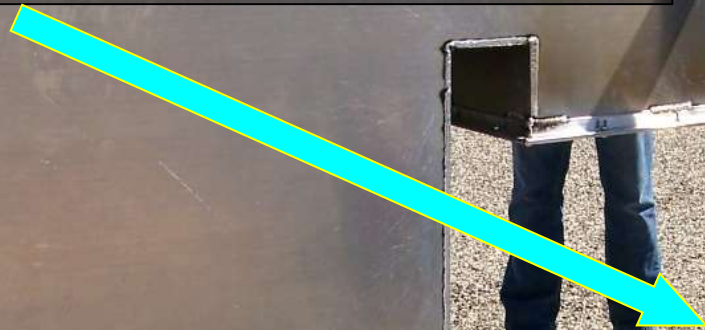


Stainless steel base is bolted to the concrete base making a tight seal between the concrete and rubber gasket and the gasket and steel base.

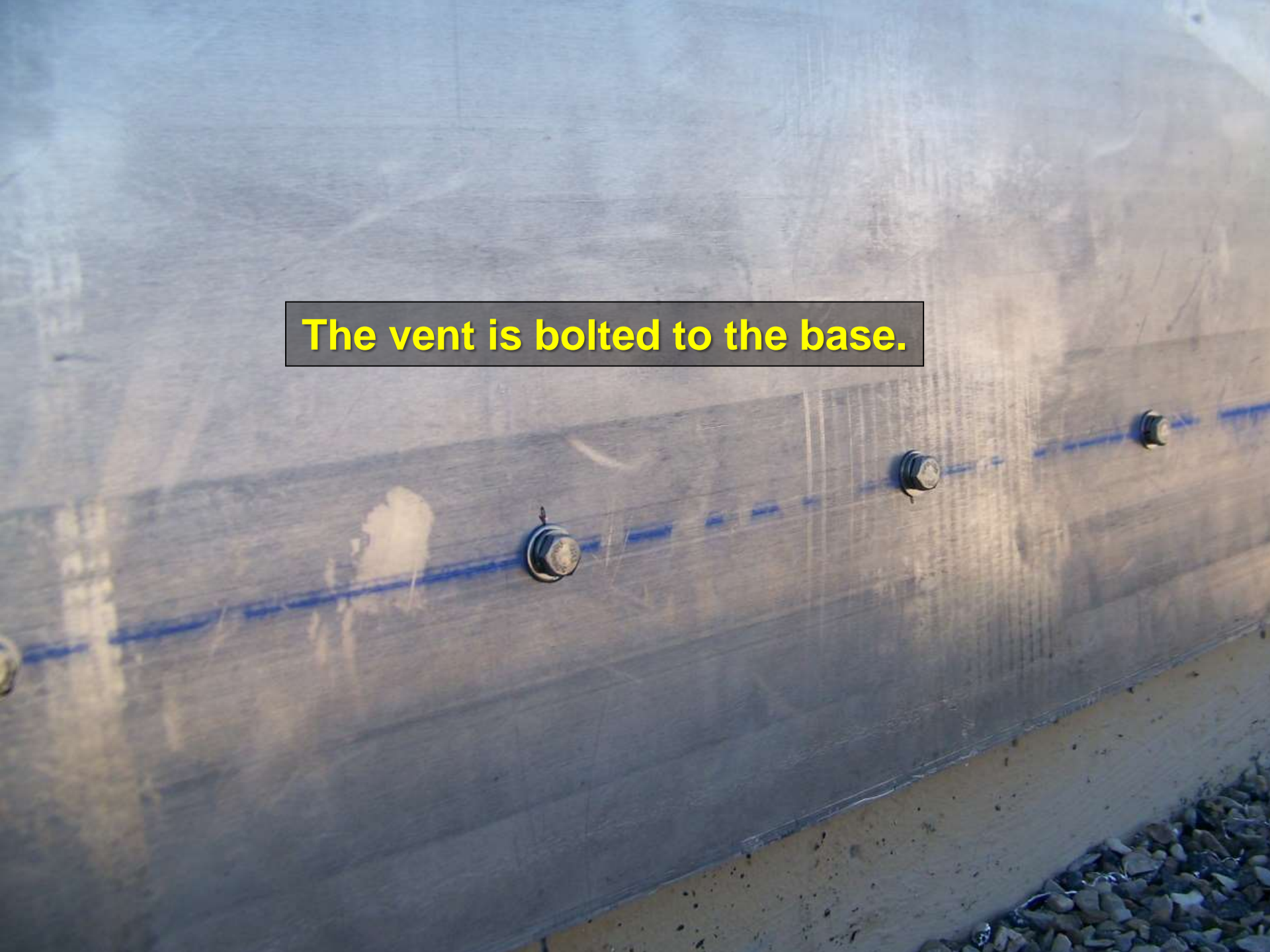
A photograph showing two men in blue work clothes and caps working on a large, rectangular metal vent base. The base is a heavy-duty metal frame with a hinged lid that is currently open, revealing a dark interior. The base is supported by four wooden blocks on a gravel surface. One man is on the left, leaning over the base, and the other is on the right, also leaning over it. In the background, there is a gravel area, some tools, and a landscape with hills under a clear sky. A text box is overlaid on the image, containing the text:

Base is installed and ready for the fabricated vent

The vent is lowered over the base. Ingenious design to lower the vent.



The vent is bolted to the base.



The #24 mesh vent screen is flat and placed between a rectangular flange.

INDIALEA
6061 T651
ASTM B221 / A12
00-A12

The inhalation hazard is mitigated permanently. Vent is at least 24 inches above the roof and is easily able to be inspected.



Raising the vent was quite possible. The 24 inch requirement has been known to PWSs since the very first revision of Ten State Standards in 1962.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #14 Air Vents, b (1st paragraph)} Vents breathe air in and out of the tank and can inhale contaminants into the finished water; therefore, the screen must be at least 24 inches (ground or elevated) above the roof or ground. The vent must also protect against rain and snow, and minimize light and dust from entering. If the vent is down-turned, it must face the ground (inverted U).
Also see, Section 10.4.8 Components

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An inverted U type of vent will eliminate light (it's completely dark inside of the tank with a U shaped vent). It will also minimize rain, snow and dust and the microbes they harbor.



Vent is facing the ground



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #14 Air Vents, b (2nd paragraph)} If the vent is not down-turned, it must have a water-proof cover down to the bottom of the #24 mesh screen. The best configuration for a screen on a pipe is between two flanges, which brings the screen inside the pipe and protects it against vandalism. Operators may need to add screening or other deterrents to prevent birds from nesting on a horizontally placed screen or to protect flexible screens.

Also see, Section 10.4.8 Components

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A non-down turned vent with a cover that comes down to at least the bottom of the #24 mesh screen will minimize rain, snow, light and dust from entering the finished water.



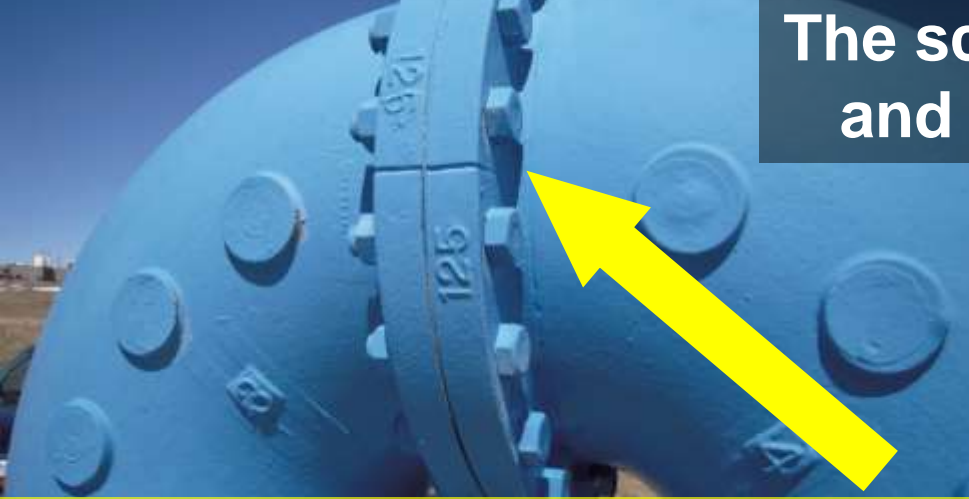
How to Conduct a Sanitary Survey of Drinking Water Systems

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The screen is well within the pipe and guards against vandalism



When a screen is set between two flanges it sits flat, creating a very good seal.



A screen wrapped around the pipe is a poor seal.





How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #14 Air Vents, b (2nd paragraph)} If the vent is not down-turned, it must have a water-proof cover down to the bottom of the #24 mesh screen. The best configuration for a screen on a pipe is between two flanges, which brings the screen inside the pipe and protects it against vandalism. Operators may need to add screening or other deterrents to prevent birds from nesting on a horizontally placed screen or to protect flexible screens.

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Without a bird screen this horizontal vent becomes a nesting spot for birds?



Pathogens from the bird nest and bird droppings directly enter the finished drinking water.





Vent

How did the vent in our example stack up to these best practices in the Learners Guide?



Vent



Inverted U but...

**This is a # 2 screen.
22 screen sizes
larger than a # 24; insects
are free to enter**



**Only 17 inches
high, it's
7 inches short**



**The vent opening
is 1/2 inch
in diameter**



Failed!

Vent



Overflow



Let's look at the best practices in the Learners Guide for overflows and see how our storage tank stacks up.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, a (1st paragraph)}

Overflows allow air in and out of the tank just like the vents but through a longer pipe, unless it is overflowing with water, which should be a rare event. All overflows (ground level or elevated) must have a #24 mesh screen to keep living organisms down to the size of insects and any pathogens they may harbor out of the tank.

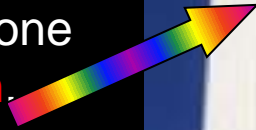
Also see, Section 10.4.8 Components



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One system had a small-diameter overflow like this one with **no screen**.




Mice crawled up, fell in, and drowned.

The significance of this breach was only discovered when the tank began to overflow through the vent because the overflow clogged.

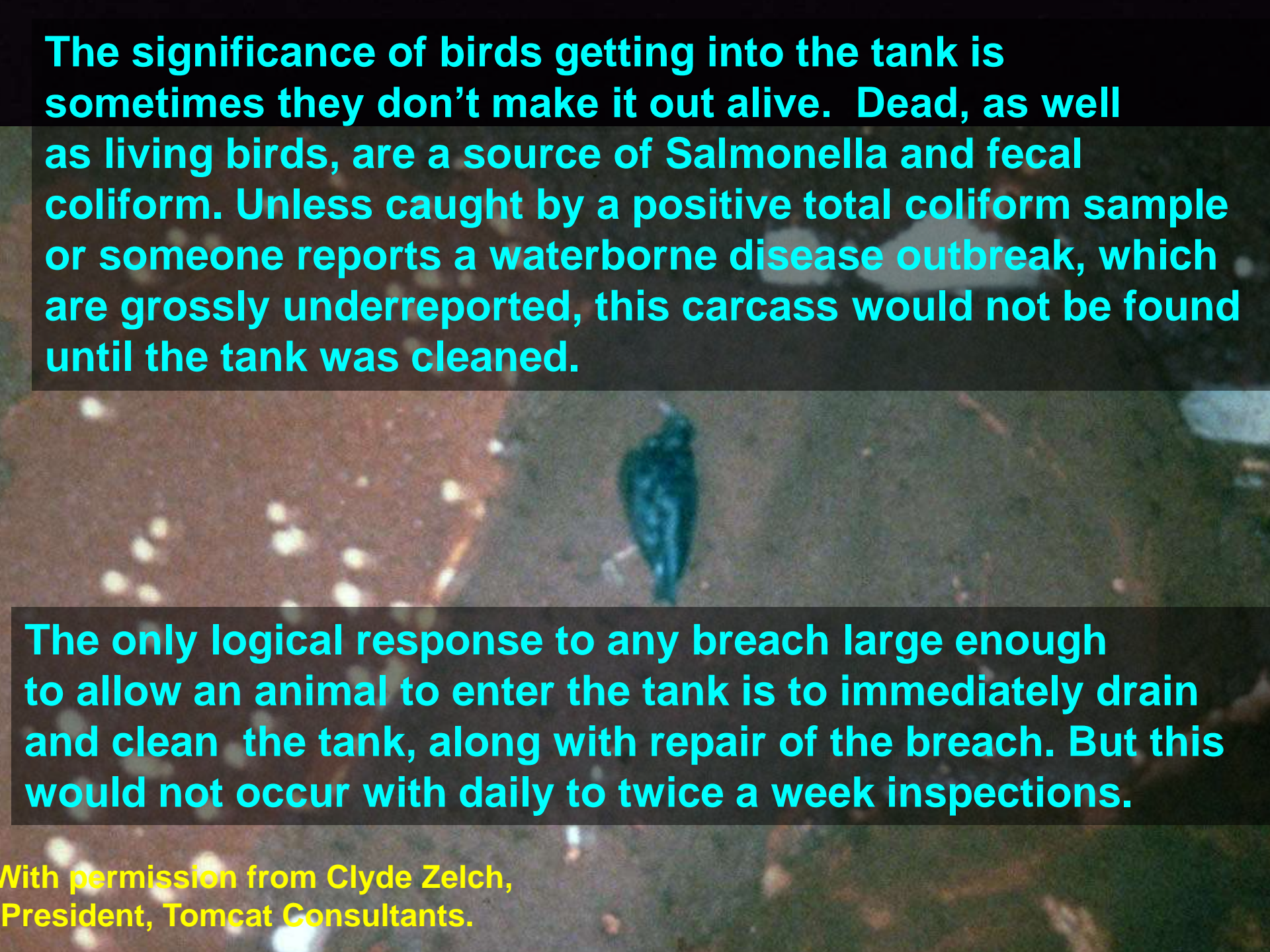
It was clogged with bloated mice.



A photograph showing a close-up of a metal overflow pipe on an elevated tank. The pipe is unshielded and has a date stamp '91 8 12' in the bottom right corner. The metal surface shows signs of rust and wear.

The significance of no screen at all on an overflow of an elevated tank is that it will allow birds to enter the tank.

**With permission from Clyde Zelch,
President, Tomcat Consultants.**

A dark, grainy photograph showing a bird carcass in a tank. The bird is dark in color and is positioned in the center of the frame. The background is dark and indistinct, suggesting a confined space like a tank. The overall image quality is poor, with significant noise and low contrast.

The significance of birds getting into the tank is sometimes they don't make it out alive. Dead, as well as living birds, are a source of Salmonella and fecal coliform. Unless caught by a positive total coliform sample or someone reports a waterborne disease outbreak, which are grossly underreported, this carcass would not be found until the tank was cleaned.

The only logical response to any breach large enough to allow an animal to enter the tank is to immediately drain and clean the tank, along with repair of the breach. But this would not occur with daily to twice a week inspections.

**With permission from Clyde Zelch,
President, Tomcat Consultants.**

Here is an screen on an overflow
but is it a # 24 mesh screen?

A #24 mesh would have 24
opening per inch.

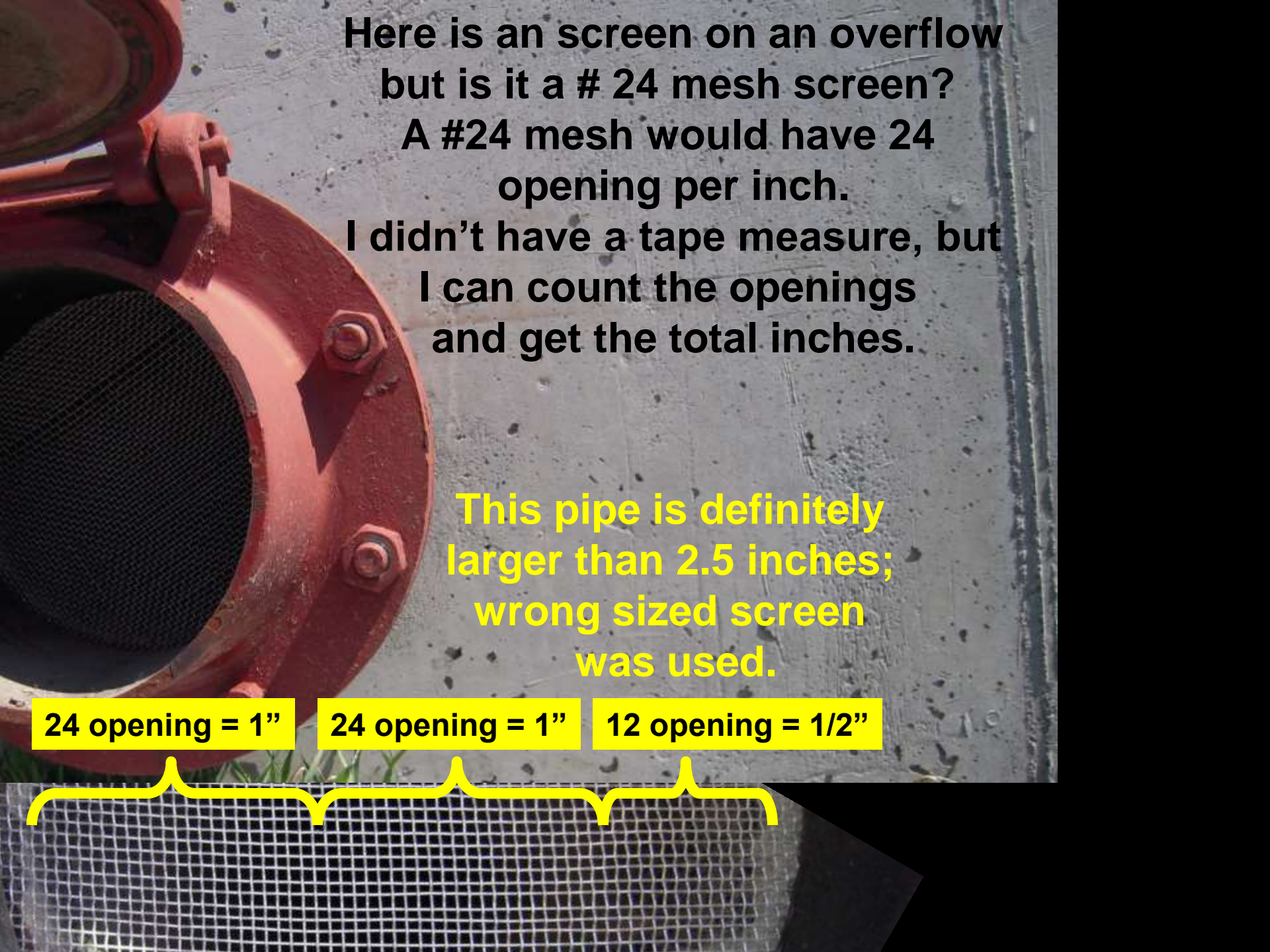
I didn't have a tape measure, but
I can count the openings
and get the total inches.

This pipe is definitely
larger than 2.5 inches;
wrong sized screen
was used.

24 opening = 1"

24 opening = 1"

12 opening = 1/2"



A #24 mesh screen on an overflow will keep living organisms down to the size of insects from entering and crawling or flying up the overflow pipe and into our finished water.





How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, a (2nd paragraph)}

Overflow events should be extremely rare events, but, when they do occur, operators must inspect the screen for any buildup from the inside and any damage.

Therefore, the screen must be removable. Placing the screen between two flanges provides the best seal but also allows operators to remove it for inspection. Flapper and duckbill valves can fail in the open position, so operators must install and maintain a #24 mesh screen prior to the flapper or duckbill valves.

Also see, Section 10.4.8 Components

Telemetry

inside of a tank turns the pumps off when the high level is reached and alarms absolutely need to be going off if the overflow level is reached.

Even though a high level indicator may be a simple float, it is subject to failure and can lead to an overflow event.

Water exiting the overflow is a top priority emergency and should be an extremely rare event.

It is not possible to inspect the overflow screen when it is way up here.



When the #24 mesh screen is wrapped around the overflow it is very likely the overflow event will push the screen off the pipe. If it is not inspected immediately and replaced rodents could enter.

07/22/2009





That is why the overflow screen needs to be between two flanges. Water flowing through this screen bowed the screen out but, it is still in place because it was between two flanges.

The bolts need to be removed and a new #24 mesh screen installed.



Here is a flange that simply needs the other half and six bolts to create a secure overflow screen but instead the screen is wrapped around the overflow. Daily to twice a week inspections would have caught the hole in the overflow screen that could allow mice to enter.



How to Conduct a Sanitary Survey of Drinking Water Systems

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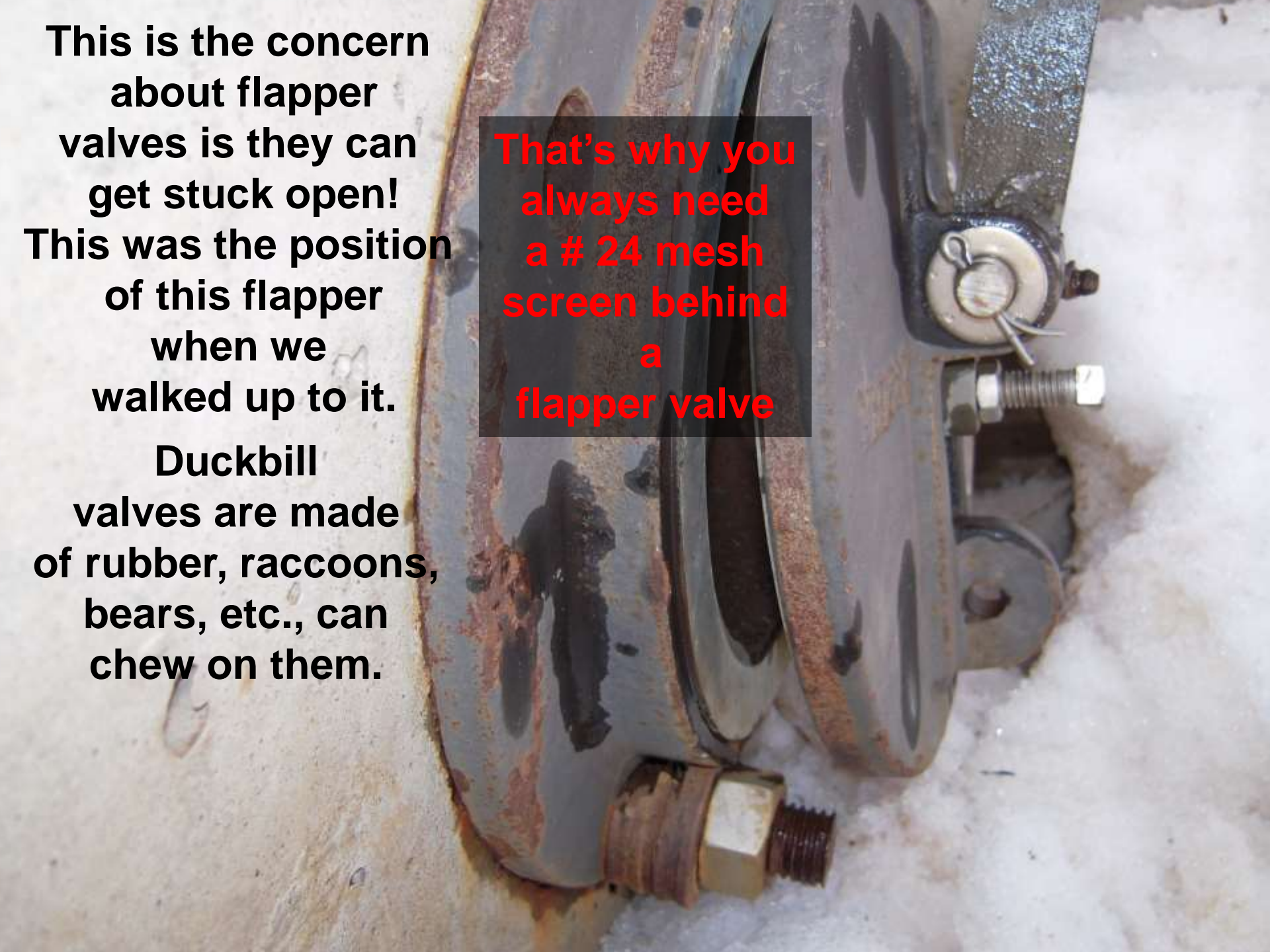
Also see, Section 10.4.8 Components



**The significance of a hinged door on a overflow,
without a # 24 screen
is that,
if it gets stuck open like this one, it
can directly allow birds, rodents,
and all insects in.**

This is the concern about flapper valves is they can get stuck open! This was the position of this flapper when we walked up to it.

Duckbill valves are made of rubber, raccoons, bears, etc., can chew on them.



That's why you always need a # 24 mesh screen behind a flapper valve



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, b (1st paragraph)}

Overflows, like vents, breathe air in and out of the tank and can inhale contaminants (leaves, soil, dried feces, feathers, etc.) into the finished water. Therefore, the screen must be at least 24 inches (but not less than 12 inches) above the splash plate. The overflow must be visible in case the telemetry fails such that operators or anyone nearby may observe and report the overflow. Water systems must not connect the overflow to a sanitary sewer, storm drain or tank drain.

Also see, Section 10.4.8 Components

This flapper valve is hiding a very damaged # 24 screen. This would be caught if daily to twice a week inspections were performed.

The significance of an overflow not being 24 inches above the ground is that animals like raccoons have the ground to push against and pry open the flapper and with the damaged screen they can climb up into the overflow, fall in and drown in the water.

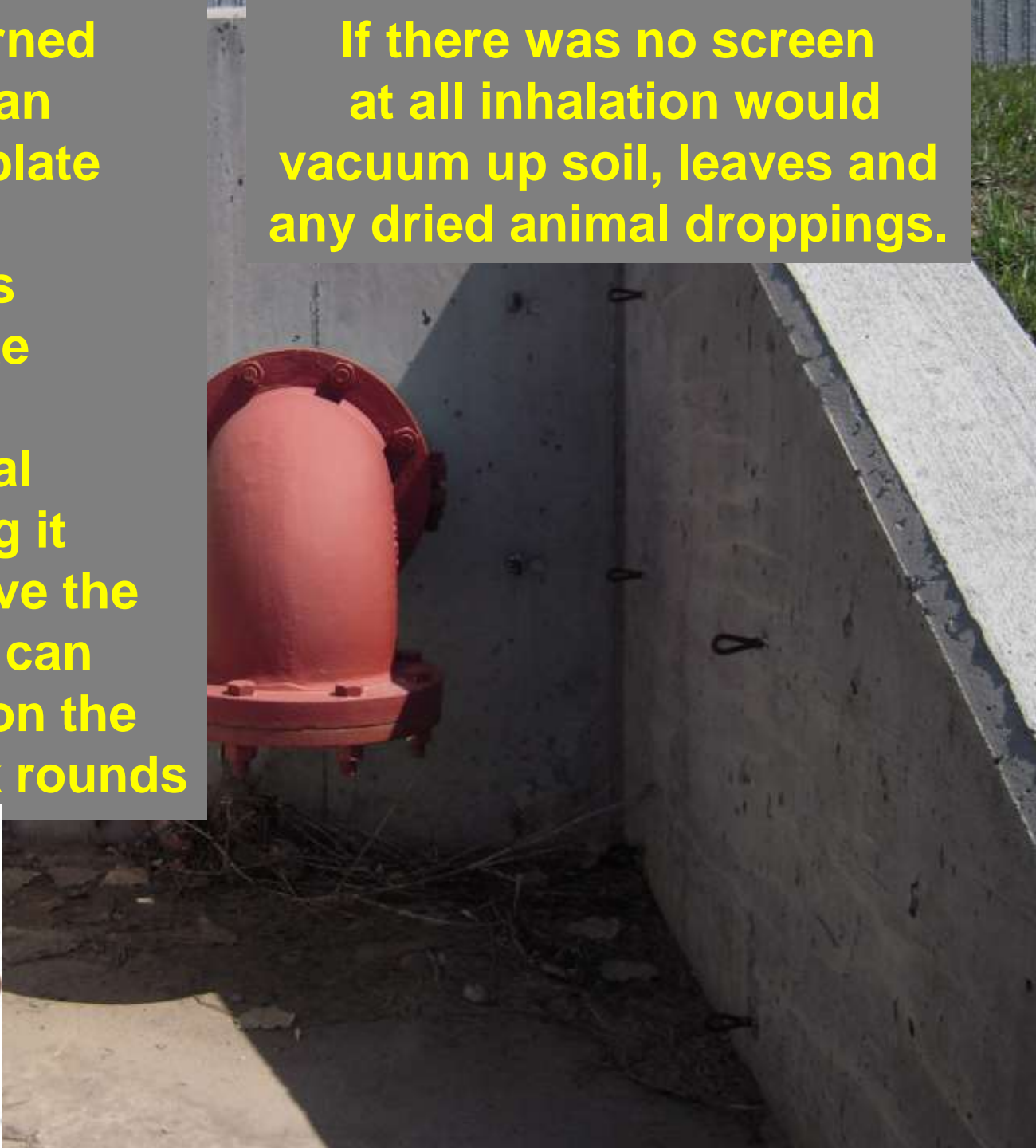


A mouse can fit into the opening of a plastic soda bottle ~ 1/2 inch.

Here is a downturned overflow above an excellent splash plate but it's only about 7 inches above the plate

Another practical reason for having it 12 to 24 inches above the ground is so you can inspect the screen on the daily to twice a week rounds

If there was no screen at all inhalation would vacuum up soil, leaves and any dried animal droppings.

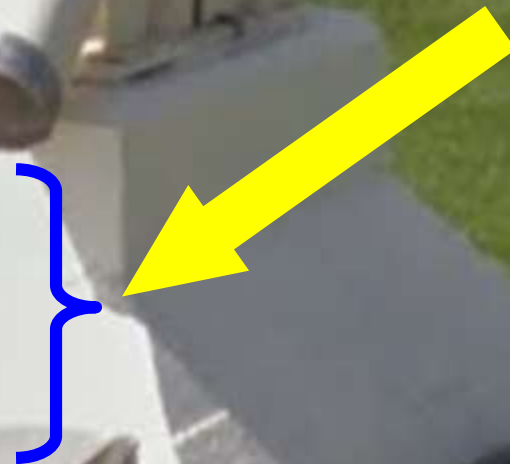


ska



May 2012

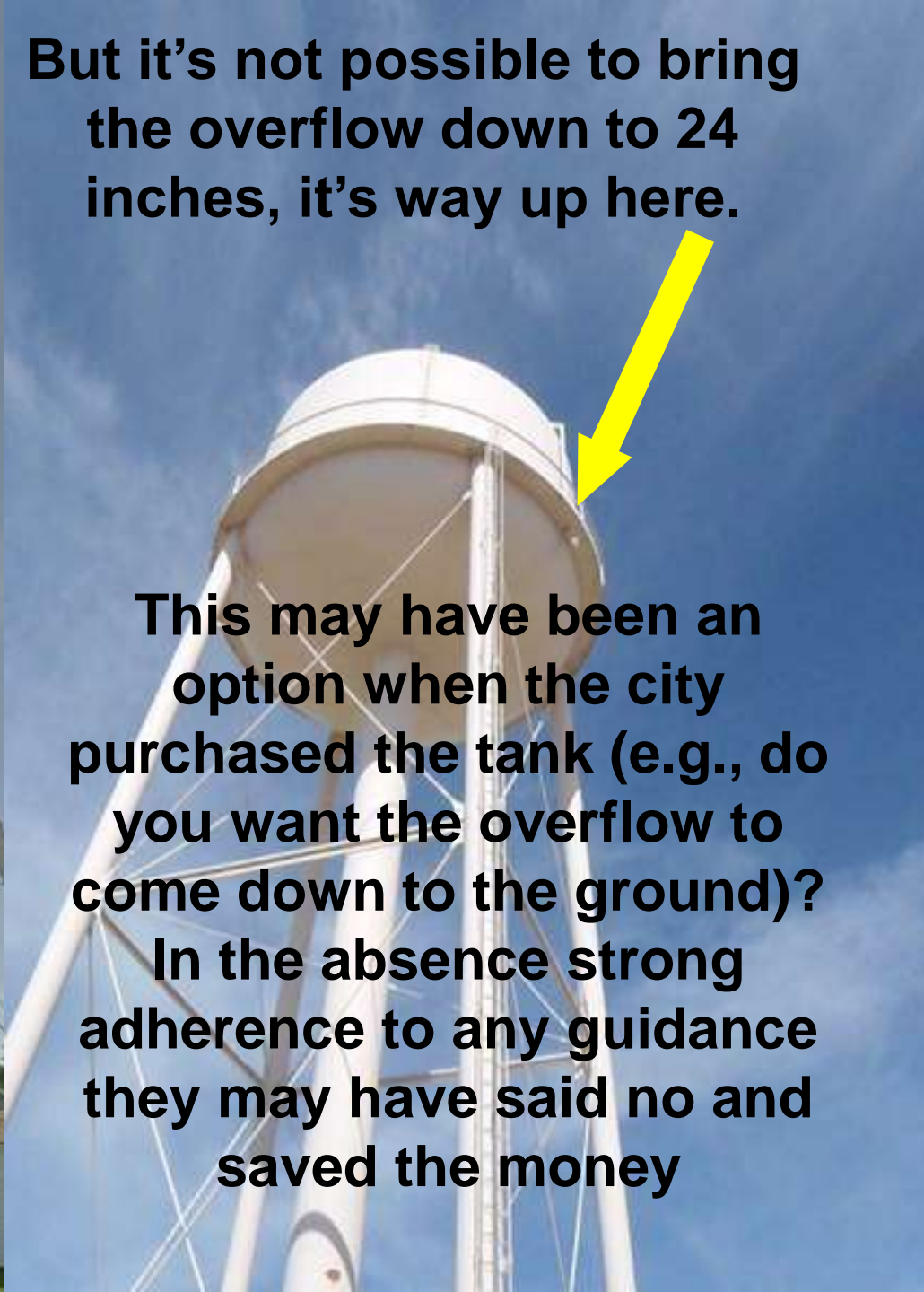
Here is a excellent example of an overflow being 24 inches above a splash plate.



But it absolutely is possible to bring the overflow down to 24 inches.



But it's not possible to bring the overflow down to 24 inches, it's way up here.



This may have been an option when the city purchased the tank (e.g., do you want the overflow to come down to the ground)? In the absence strong adherence to any guidance they may have said no and saved the money



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, b (1st paragraph)} Overflows, like vents, breathe air in and out of the tank and can inhale contaminants (leaves, soil, dried feces, feathers, etc.) into the finished water. Therefore, the screen must be at least 24 inches (but not less than 12 inches) above the splash plate. The overflow must be visible in case the telemetry fails such that operators or anyone nearby may observe and report the overflow. Water systems must not connect the overflow to a sanitary sewer, storm drain or tank drain.

Also see, Section 10.4.8 Components

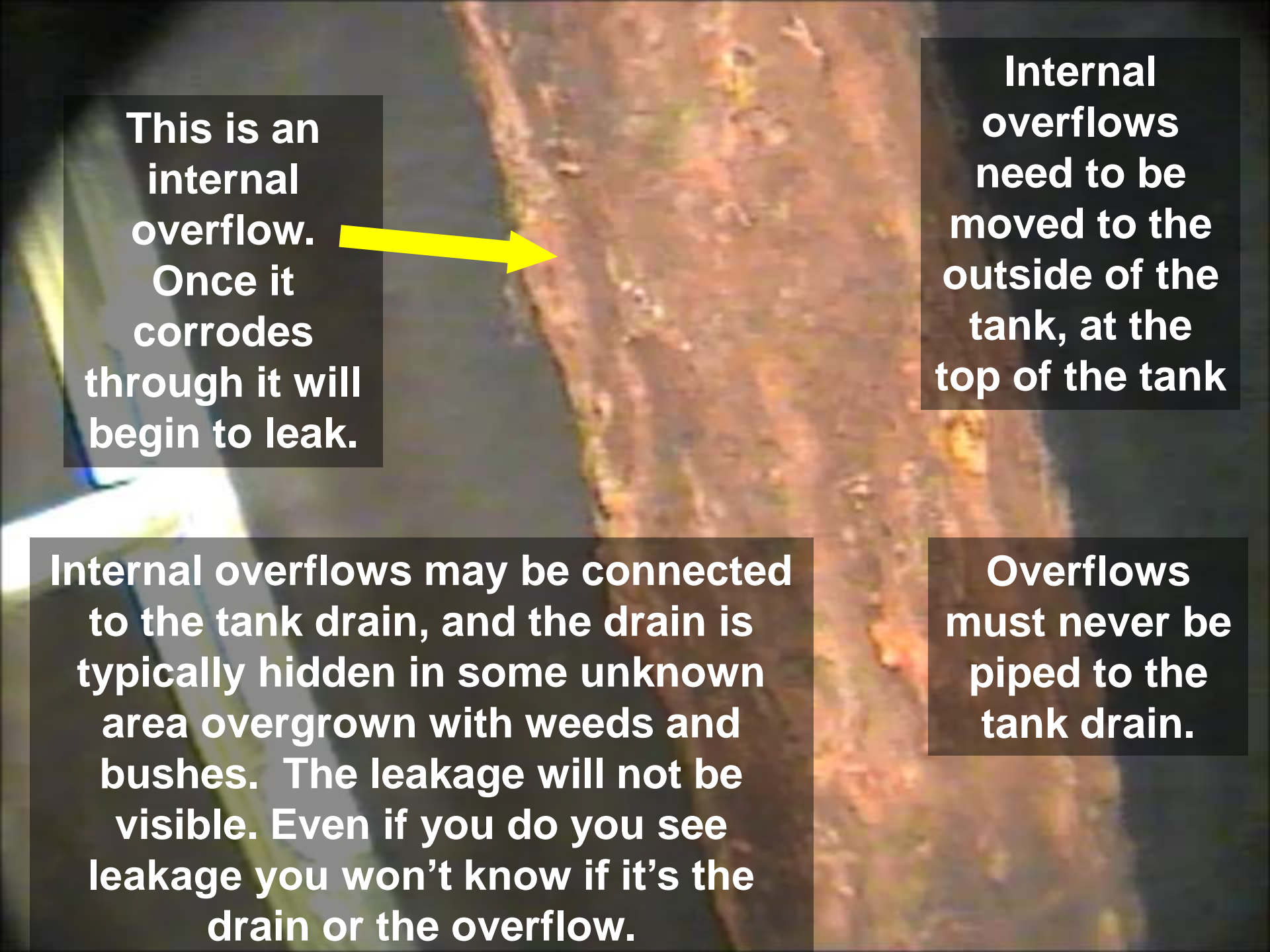
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2015 Draft Edition as of September 2015



This overflow is visible to everyone driving on this road. If it starts overflowing there will be a tremendous number of people to report it.



This is an internal overflow. Once it corrodes through it will begin to leak.

Internal overflows need to be moved to the outside of the tank, at the top of the tank

Internal overflows may be connected to the tank drain, and the drain is typically hidden in some unknown area overgrown with weeds and bushes. The leakage will not be visible. Even if you do you see leakage you won't know if it's the drain or the overflow.

Overflows must never be piped to the tank drain.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, b (1st paragraph)}

Overflows, like vents, breathe air in and out of the tank and can inhale contaminants (leaves, soil, dried feces, feathers, etc.) into the finished water. Therefore, the screen must be at least 24 inches (but not less than 12 inches) above the splash plate. The overflow must be visible in case telemetry fails such that operators or anyone nearby may observe and report the overflow.

Water systems must not connect the overflow to a sanitary sewer, storm drain or tank drain.

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This overflow is directly connected to the drain from the tank and those pipes directly connect to the storm sewer which is also connected to the drain of the business behind the tank. Not only is the overflow not visible (never know if it's overflowing), the overflow is breathing air directly from the storm sewer and what ever pollutants are coming from that business.

03.04.2010



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, b (2nd paragraph)} If the overflow discharges above a storm sewer, operators need to displace the outlet horizontally by at least 3 feet or have a duckbill valve to avoid breathing air from the storm sewer. The overflow must discharge over a splash plate or engineered outlet (concrete or riprap) that will not submerge the overflow when spilling. Also see, Section 10.4.8 Components



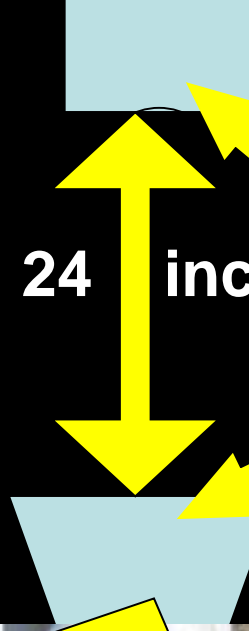
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A 26 inch section of the overflow can be cut out



24 inches



A 2 inch flange with the #24 mesh screen is placed on this end

and a funnel opening can be installed here with a #4 mesh screen



This achieves a three foot horizontal displacement from the storm sewer

The 3 foot horizontal displacement between the overflow and the storm sewer only seems ridiculous in poor designs.

The typical design has a much larger distance between the overflow and storm sewer.

Here is the overflow.



Here is the storm sewer.





How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #15 Overflows, b (2nd paragraph)} If the overflow discharges above a storm sewer, operators need to displace the outlet horizontally by at least 3 feet or have a duckbill valve to avoid breathing air from the storm sewer. The overflow must discharge over a splash plate or engineered outlet (concrete or riprap) that will not submerge the overflow when spilling. Also see, Section 10.4.8 Components



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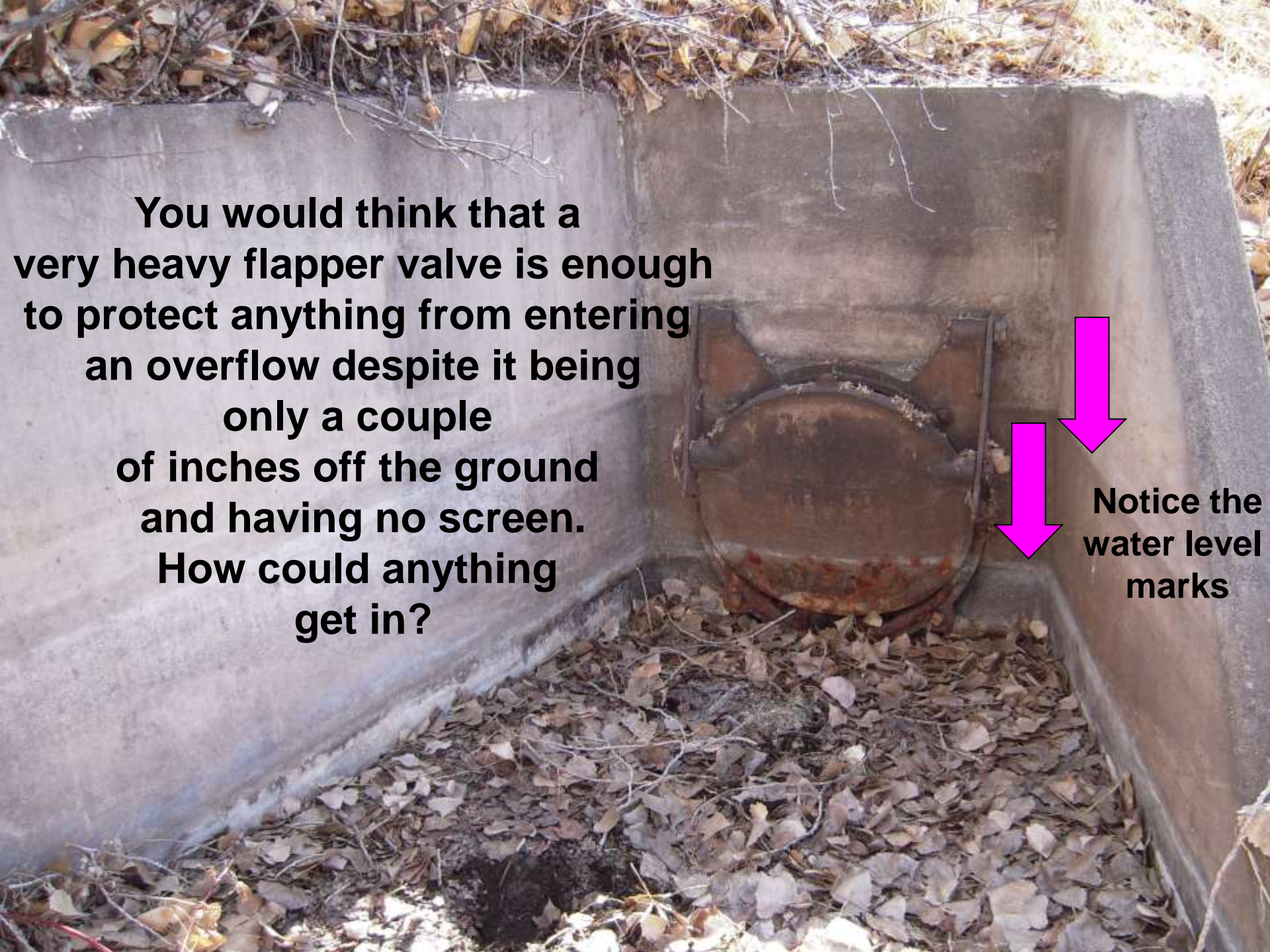
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**Here is a downturned
overflow above an
excellent splash plate
but it's only
about 7 inches
above the plate**



You would think that a very heavy flapper valve is enough to protect anything from entering an overflow despite it being only a couple of inches off the ground and having no screen. How could anything get in?

Notice the water level marks





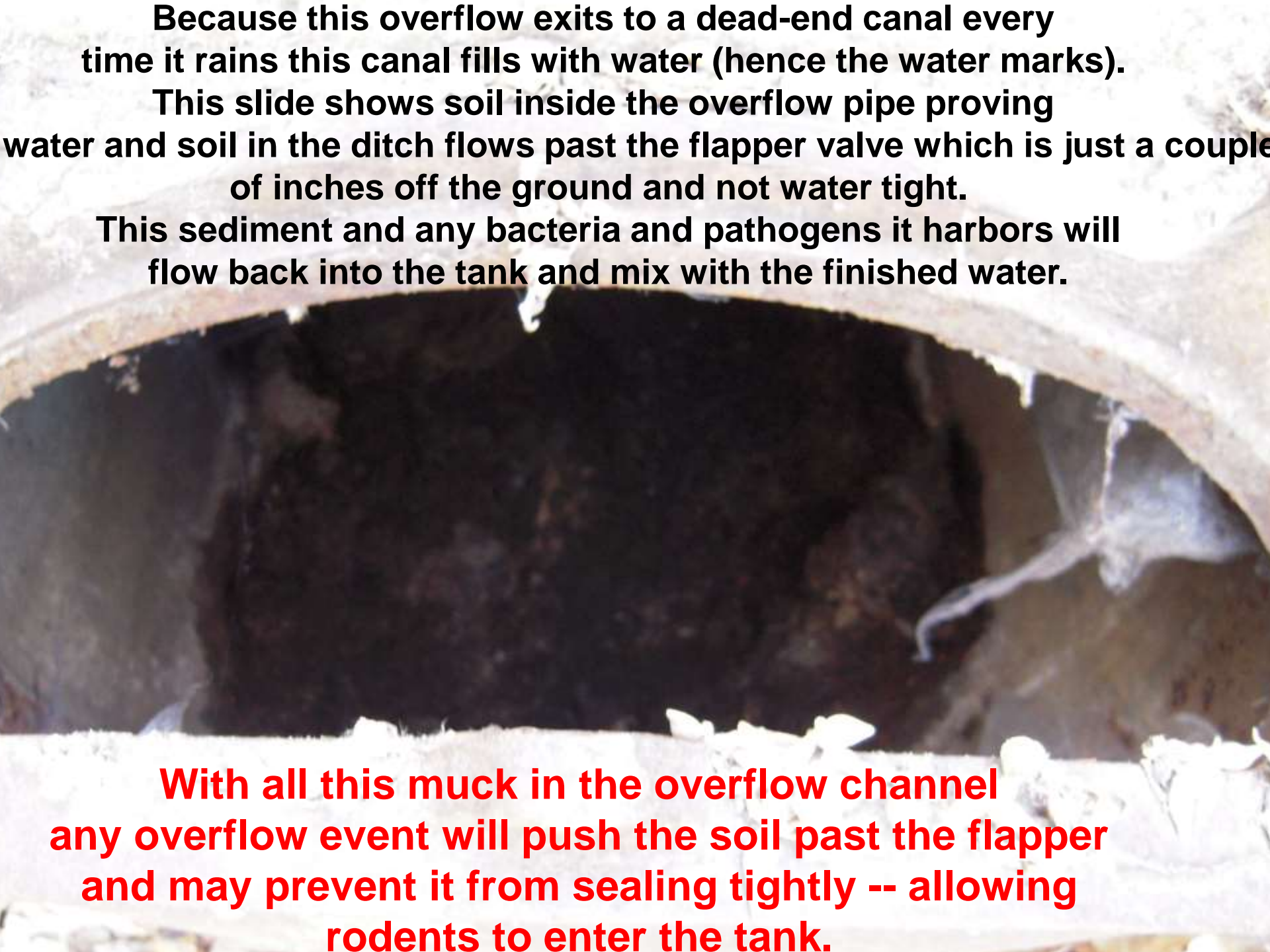
**Dead end
Overflow ditch**

The overflow goes into an overflow ditch that dead ends. Because there were multi-million dollar homes surrounding their storage tanks, the City never laid a pipe through their property to connect to the storm sewer.


Because this overflow exits to a dead-end canal every time it rains this canal fills with water (hence the water marks).

This slide shows soil inside the overflow pipe proving water and soil in the ditch flows past the flapper valve which is just a couple of inches off the ground and not water tight.

This sediment and any bacteria and pathogens it harbors will flow back into the tank and mix with the finished water.



With all this muck in the overflow channel any overflow event will push the soil past the flapper and may prevent it from sealing tightly -- allowing rodents to enter the tank.



Overflows provide direct access to the finished water just like a vent but can be a much larger opening into the tank.

A flapper valve with a # 24 screen not only protects against insects but also acts as a deterrent to entry by humans.

A submerged overflow should never occur. The flapper valve weighs less in water and can be moved by animals accustomed to living in the water, they could enter, crawl up the pipe and drown in the tank. Also, overflows breathe, and in this case, it will breathe in water vapor from stagnant water. Stagnant water is host to a broad array of organisms, few of which you would ever want in your finished water. In a word, this situation is “unsanitary” and should never be allowed and fixed immediately.





Overflow

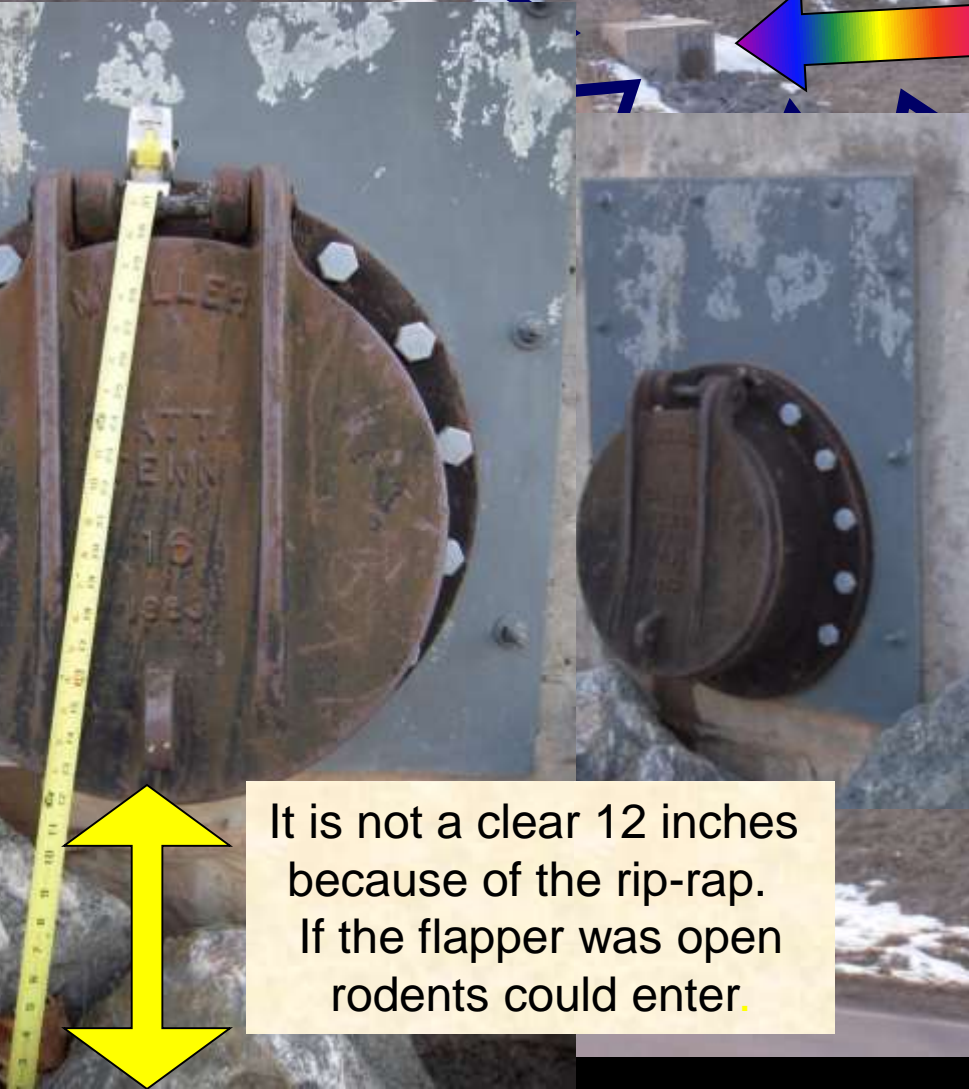
How does the overflow in our example stack up to these best practices in the Learners Guide?



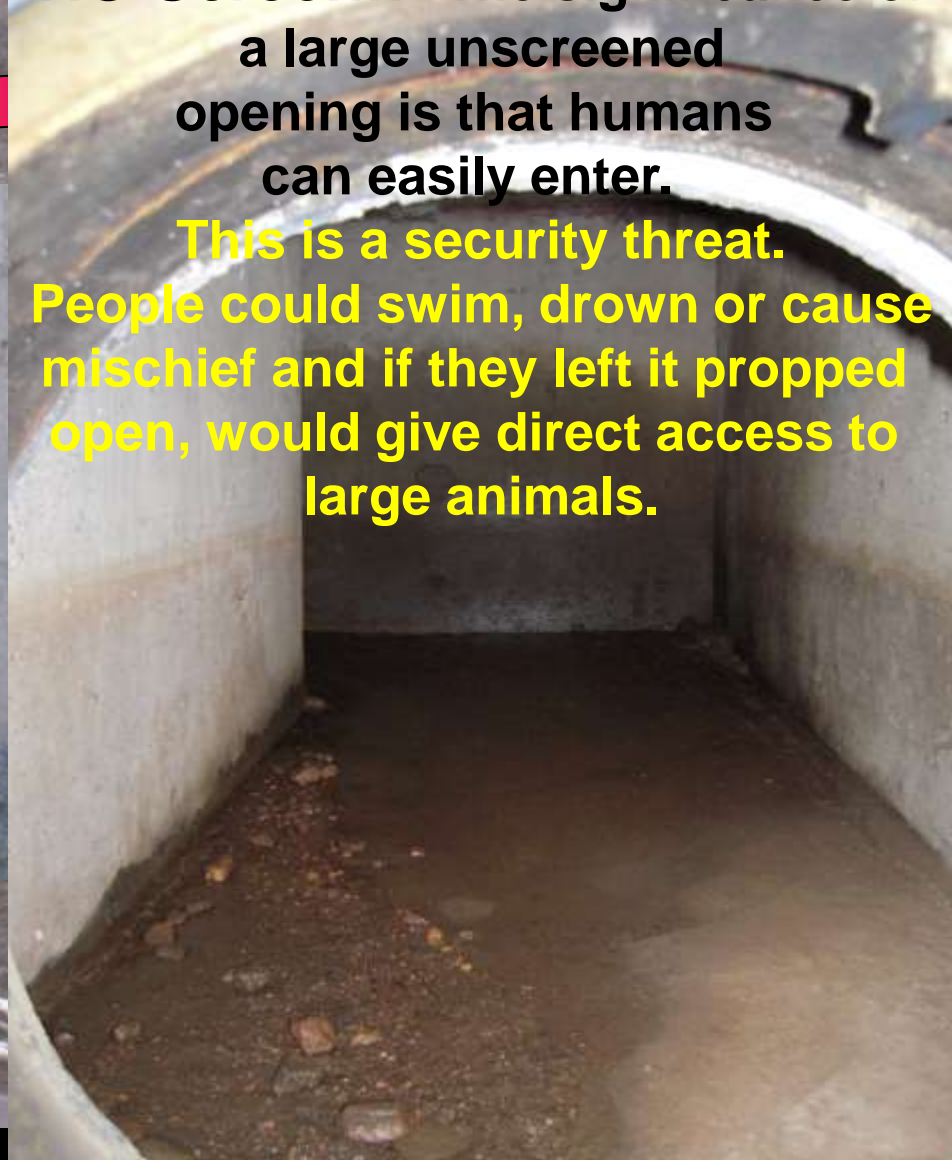
Overflow

NO Screen!! The significance of a large unscreened opening is that humans can easily enter.

This is a security threat. People could swim, drown or cause mischief and if they left it propped open, would give direct access to large animals.



It is not a clear 12 inches because of the rip-rap. If the flapper was open rodents could enter.



Overflows



Failed!



Hatch

Let's look at the best practices in the Learners Guide for hatches and see how our storage tank stacks up.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #16 Hatches (1st paragraph)} For ground level tanks (buried and partially buried), is the hatch at least 24 inches above the ground?
Also see, Section 10.4.8 Components



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Here is a hatch on a ground level tank and it is at least 24 inches high. This height allows it to be found in an emergency even when there is deep snow. The height also acts a barrier that prevents large animals and humans from accidentally falling into the tank if the lid was removed by vandals or was blown off by the wind. It also prevents tools, dirt, etc., from entering during maintenance.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #16 Hatches (2nd paragraph)} ...Is the lid solid and water tight, as well as hinged at one side.
Is the lid a shoebox design that overlaps the rim by one or two inches? Does the lid fit over the hatch like the top of a shoebox, with no more than a ¼ to ½ of an inch space between the hatch edging and all sides of the lid?
Also see, Section 10.4.8 Components



A Learner's Guide

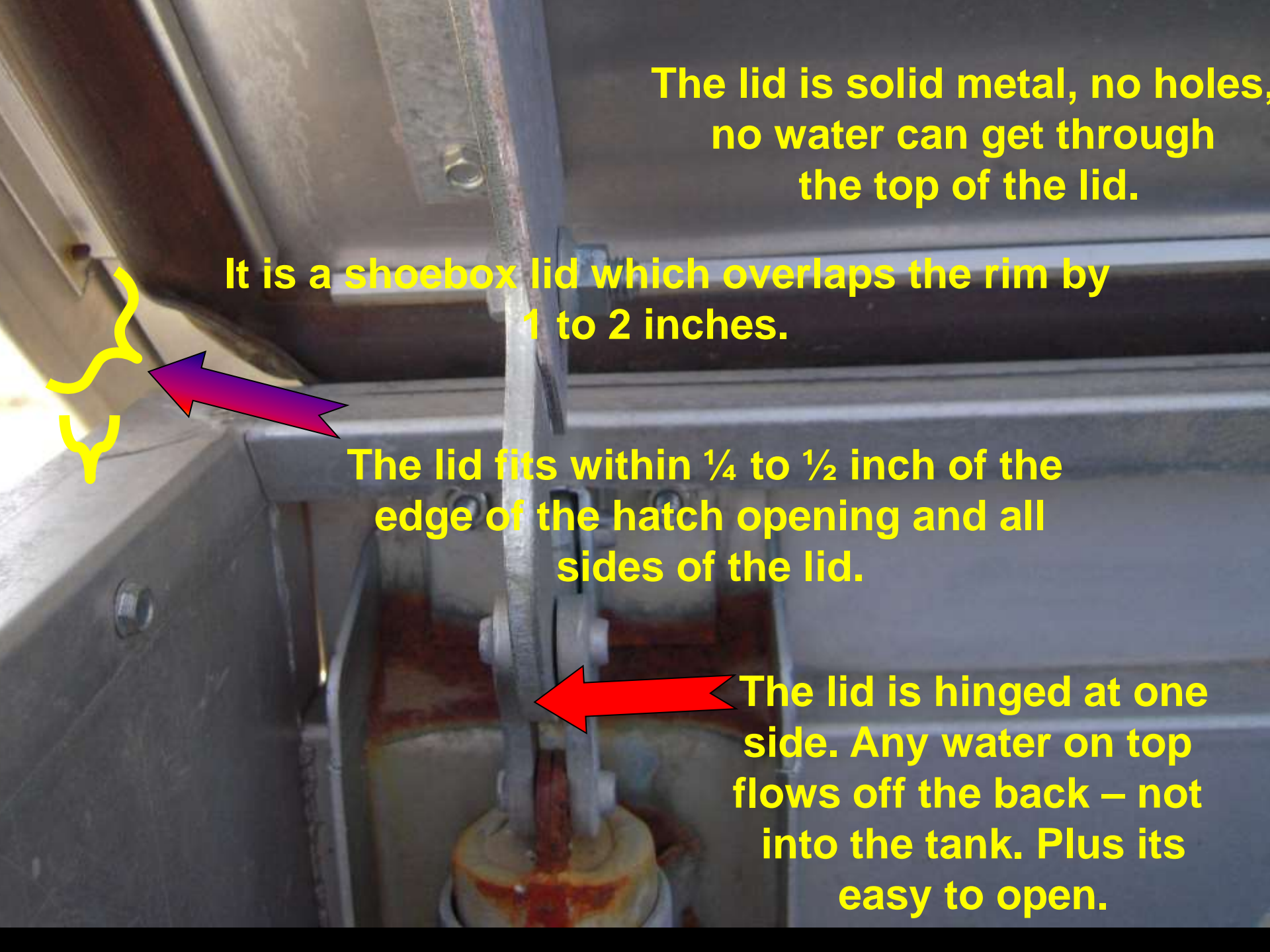
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The lid is solid metal, no holes, no water can get through the top of the lid.

It is a shoebox lid which overlaps the rim by 1 to 2 inches.

The lid fits within $\frac{1}{4}$ to $\frac{1}{2}$ inch of the edge of the hatch opening and all sides of the lid.

The lid is hinged at one side. Any water on top flows off the back – not into the tank. Plus its easy to open.



You can use this type of hatch for a transmission line from a spring box to the storage tank because it is not under pressure. But what is the significance of using a non-shoebox lid.

That tiny hole in a manhole cover allowed snakes into the storage tank!

03.02.201

03.02.201



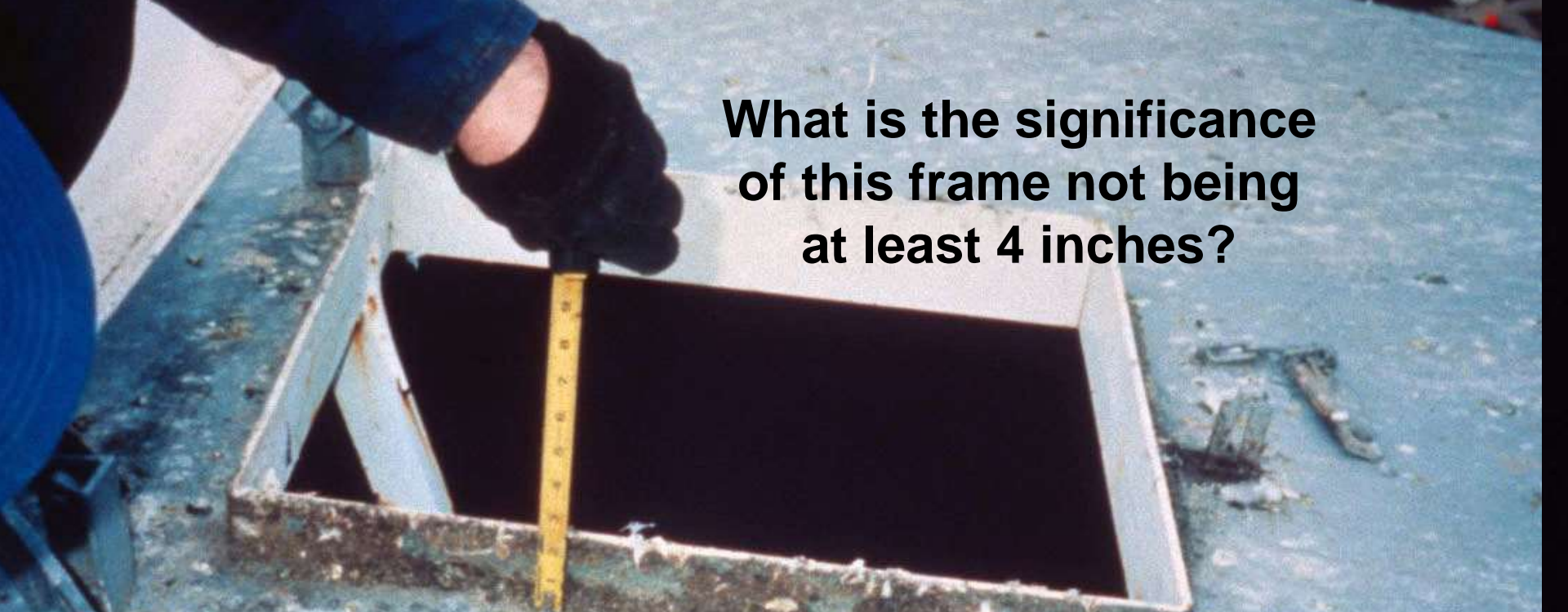
How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #16 Hatches (2nd paragraph)} For elevated tanks, is the hatch at least four inches above the roof...


{Section 10.4.10, #16 Hatches (3rd paragraph)} The lid must seal tight to prevent the inhalation or blowing of dust, dried bird droppings, and feathers into the hatch opening. Improperly fitted hatch covers are a common problem, but an operator may only need to make minor modifications to make many of them acceptable.

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**What is the significance
of this frame not being
at least 4 inches?**



**The hinges were designed
to fit a 4-inch frame.
This small design oversight
held the lid above the
lip of the frame on one side**

**With permission from Clyde Zelch,
President, Tomcat Consultants.**

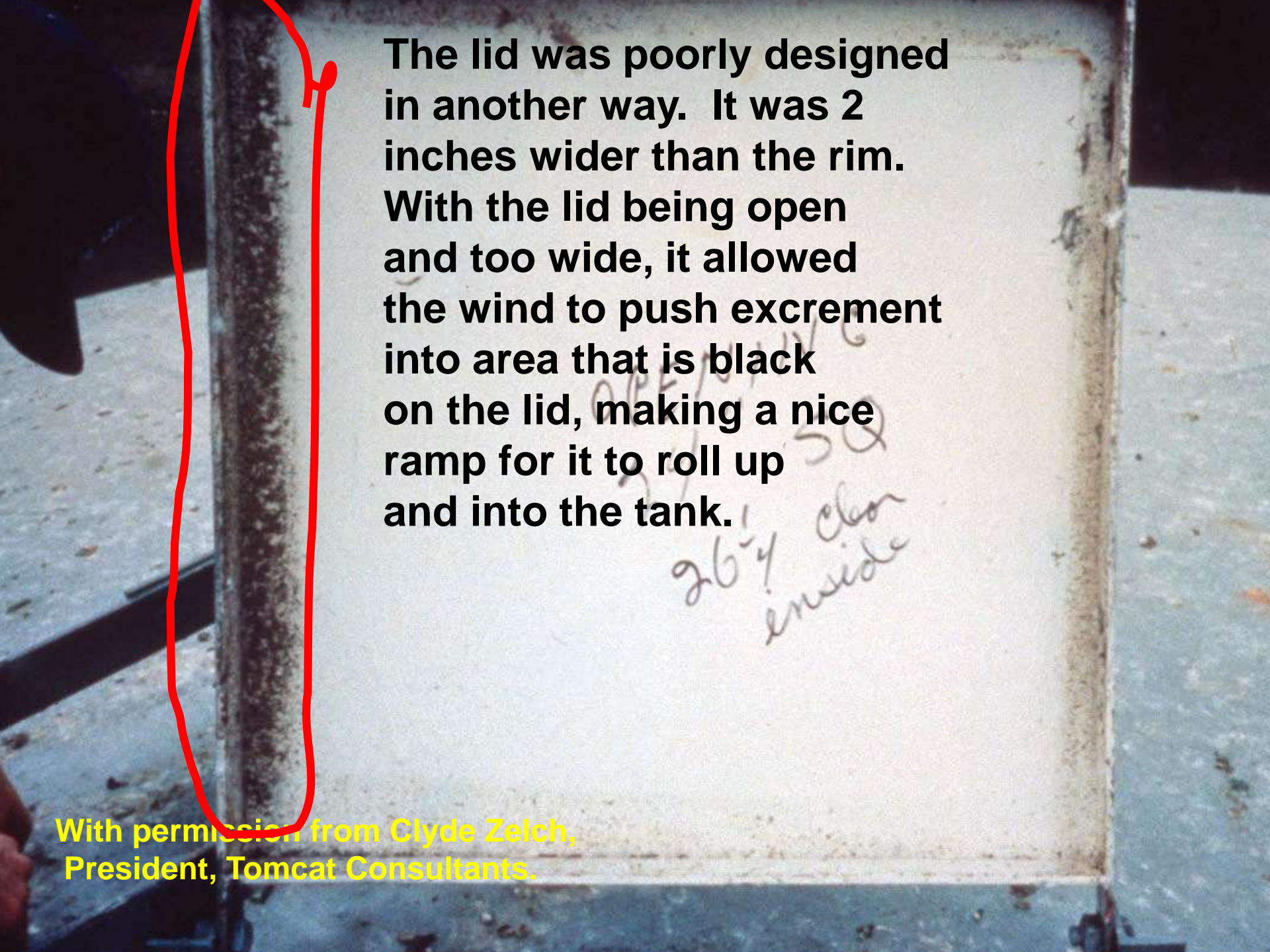
113'94

26-4
Clear
inside

The lid sat ~ 1.5 inches above the rim on one side. This allowed bird feces and feathers to be blown in the tank




**With permission from Clyde Zelch,
President, Tomcat Consultants.**



The lid was poorly designed in another way. It was 2 inches wider than the rim. With the lid being open and too wide, it allowed the wind to push excrement into area that is black on the lid, making a nice ramp for it to roll up and into the tank.

26 1/4 clear inside

With permission from Clyde Zelch,
President, Tomcat Consultants.



The significance of bird feces and feathers being blown into the tank is that the pathogens can now be washed off of the feathers and as the feces dissolves enter the water column.

**With permission from Clyde Zelch,
President, Tomcat Consultants.**



These pathogens in the water column can also become lodged in the sediment at the bottom of the tank. The significance of this pathogen laden sediment being suddenly washed into the distribution system led to a Salmonella outbreak in Gideon, Missouri, that made hundreds ill and led to 7 deaths.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #16 Hatches (4th paragraph)} Is there a gasket between the rim and the lid and does the latch pull the lid tight against the gasket? When shut, push down on the lid to see if it moves. Movement indicates it is not tight against the gasket creating a pathway for insects, bird droppings, dust, feathers and mice. Also see, Section 10.4.8 Components

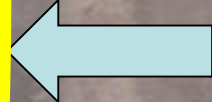


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The significance of no gasket between the lid and the lip of the lid is that insects, spiders, etc., can enter, and rain water can carry sediments and any pathogens they may be harboring over rim and into the finished water.

No gasket



This channel relies on a very small drain not getting plugged; otherwise it overflows

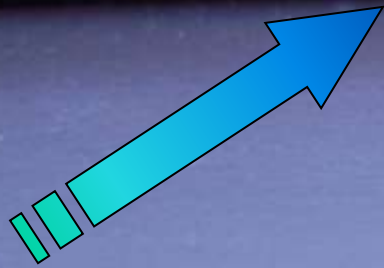


How do those spiders get in?
Easy when there is a sanitary breach





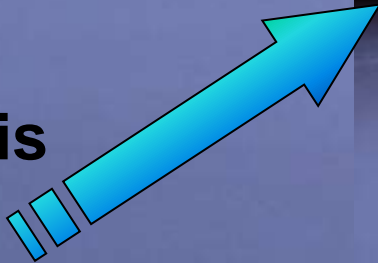
Here is that same hatch with no gasket in the closed position. The light indicates at least a 1/2-inch gap between the lid and the lip of the lid. The significance of this breach to the hatch is that it will allow all types of insects and possibly small rodents into the finished water.



A lid with a properly seated gasket should look like this



Not like this



**With a hatch that is tight against
the gasket and an inverted
U for the vents, the inside of your
tank should look like this. No light at all.**

**No light is very important it shows there are no holes and
it eliminates the possibility of algae growth.**

**There is one difficulty with
shoebox lids.
You can't look under
them to ensure
they're tight against the lip.**



**But there is an easy test you can do
to ensure the lid is tight against
the rim of the lid.**

**Shut the lid and secure it, then
push down on the lid – if it doesn't move.
Then it is tight and you have
a proper seal for a hatch**



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #16 Hatches (5th paragraph)} Hatches flush with the roof need to be raised to the minimum heights discussed above to protect against rain and snow washing sediment, bird droppings, mouse pellets (a single mouse pellet can have thousands of Salmonella in it), etc., into the tank.

Also see, Section 10.4.8 Components



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This hatch is not a shoe box lid and is only 3 ½ inches above the roof. It needs to be raised to at least 24 inches.

No Matter What Your Application...

Job-Built
Wood Curbs

Job-Built
Concrete Curbs

Existing Irregularly
Sized Curbs

Job-Built/
Prefab Metal Curbs

Over Existing
Scuttle Curbs



**The VersaMount™
Has You Covered**

Some companies have pre-made hatches and extensions that can be bolted to the concrete frame to raise a hatch.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #16 Hatches (6th paragraph)}

Constructed tanks may have large double doors that meet in the middle, for removing construction materials, that do not create a watertight and insect proof seal.

These types of hatches need to be replaced with a solid cover, with a typical manway that has a shoebox lid.

Also see, Section 10.4.8 Components



A Learner's Guide


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Some hatches may seem impossible to raise to at least 24 inches— but let's see how one system raised their hatch.

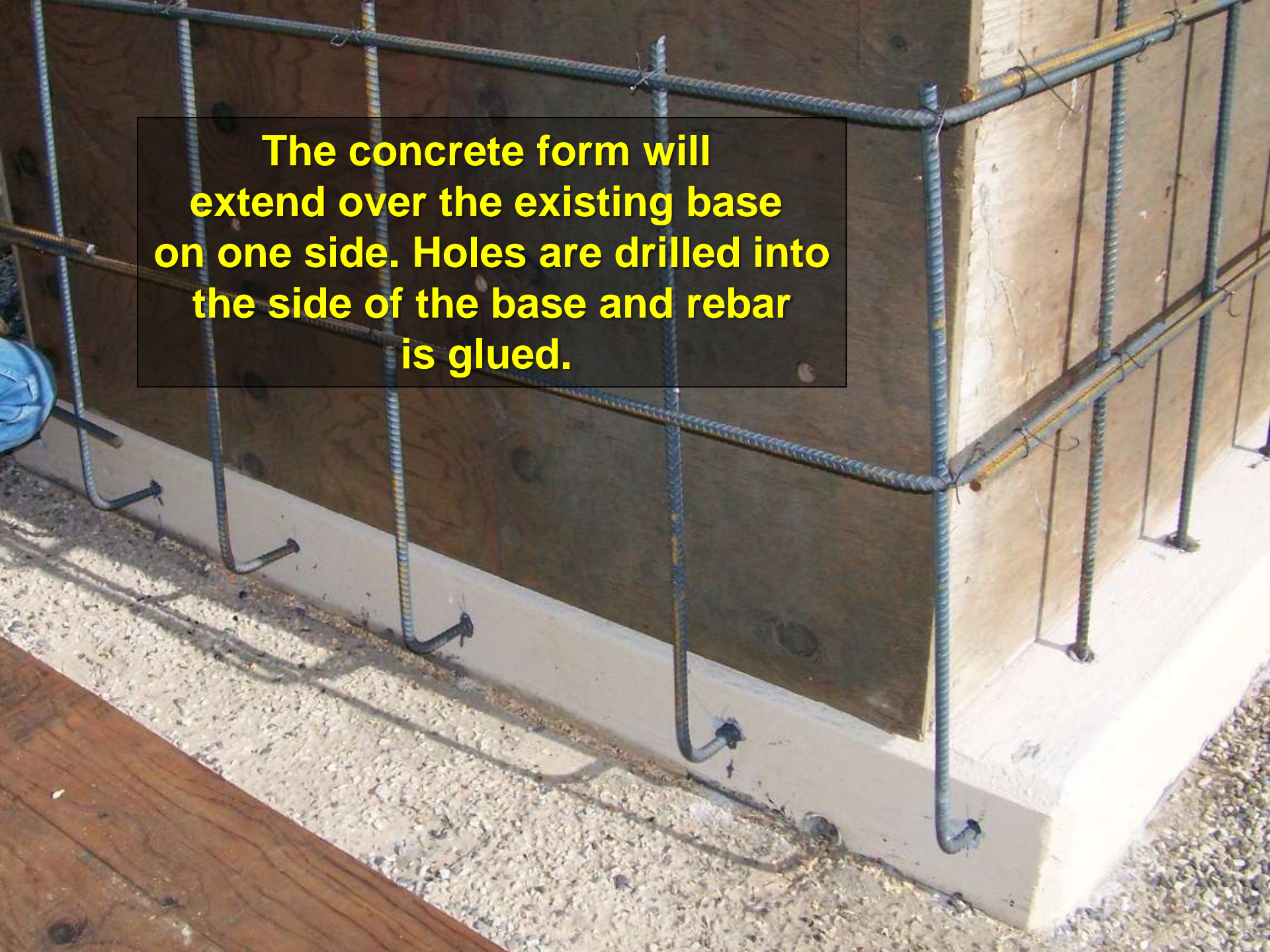


This system wanted to maintain the double doors.





A form was made from plywood and holes were drilled for the rebar and glued. The existing concrete pad for the double doors is used to build the walls.



The concrete form will extend over the existing base on one side. Holes are drilled into the side of the base and rebar is glued.

Bolts are added to hold the hatch to the concrete walls.






Concrete walls have been poured.

A stainless steel hatch is mounted on the bed of a truck. The hatch is rectangular with a silver, reflective finish and a handle on top. It is secured to the wooden truck bed with metal brackets. In the background, there is a workshop setting with various tools and equipment. A black truck is partially visible in the upper right corner.

The stainless steel hatch fabricated by a local company.

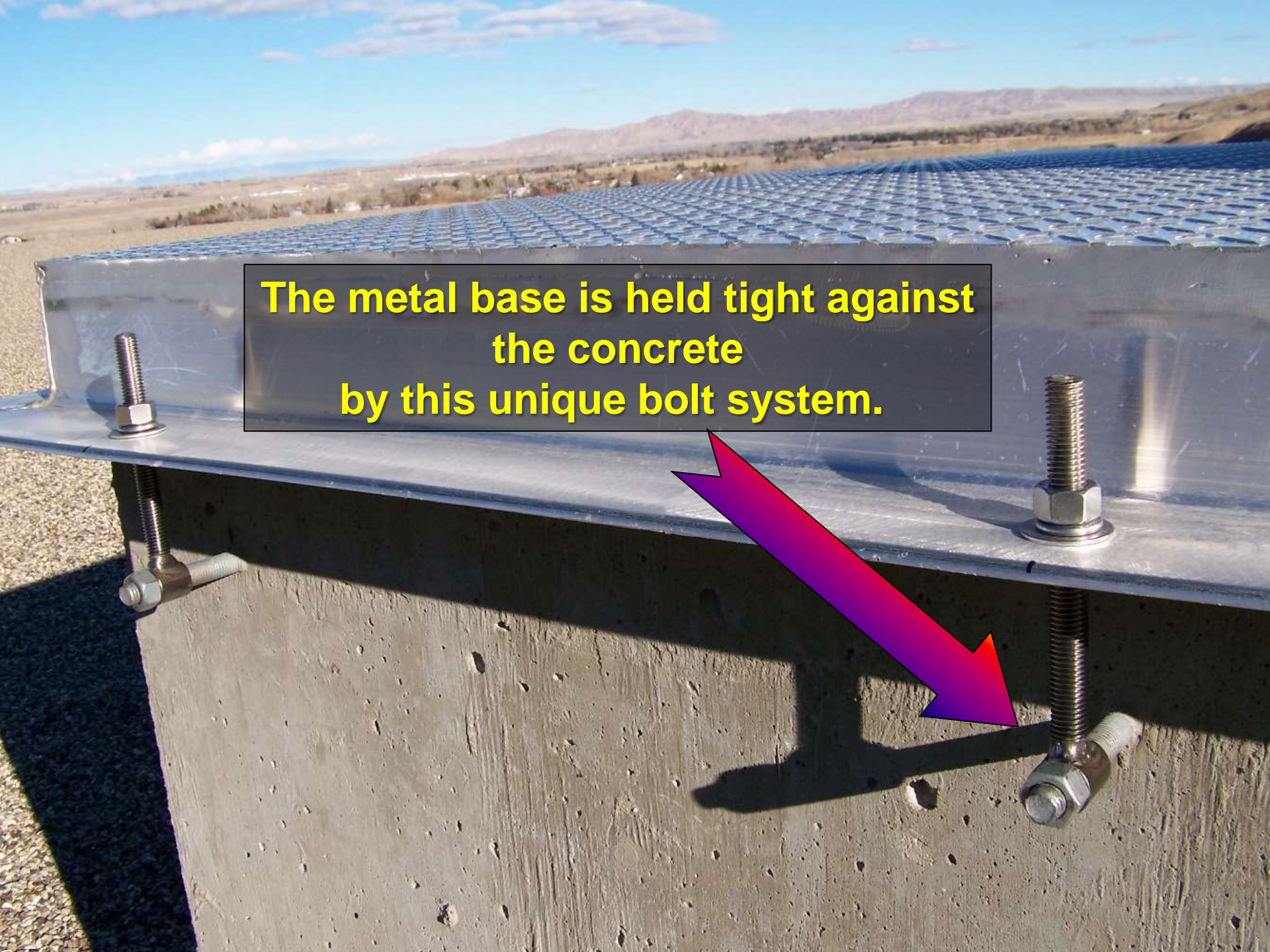
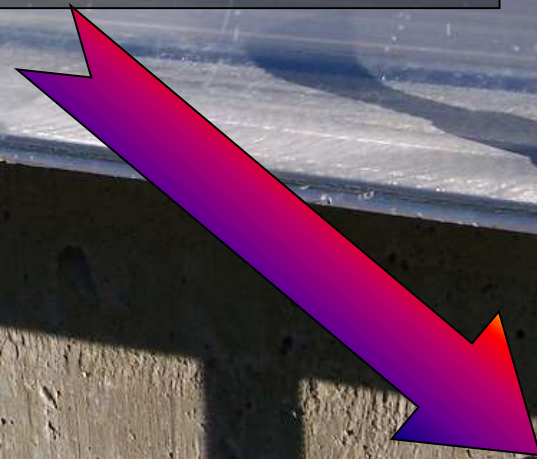


Rubber gaskets are added to ensure the concrete to metal and metal to metal connections are tight and secure.

A photograph of a rectangular wooden box with a metal mesh lid. The box is constructed from light-colored wood panels and is mounted on a concrete base. The lid is made of a silver metal mesh and is hinged to the top of the box. The box is situated on a gravel surface. In the background, there is a concrete curb and some sparse vegetation.

The fabricated base is set on the concrete form. A shoebox lid has been created for the entire double door area with a normal hatch placed on top.

The metal base is held tight against the concrete by this unique bolt system.

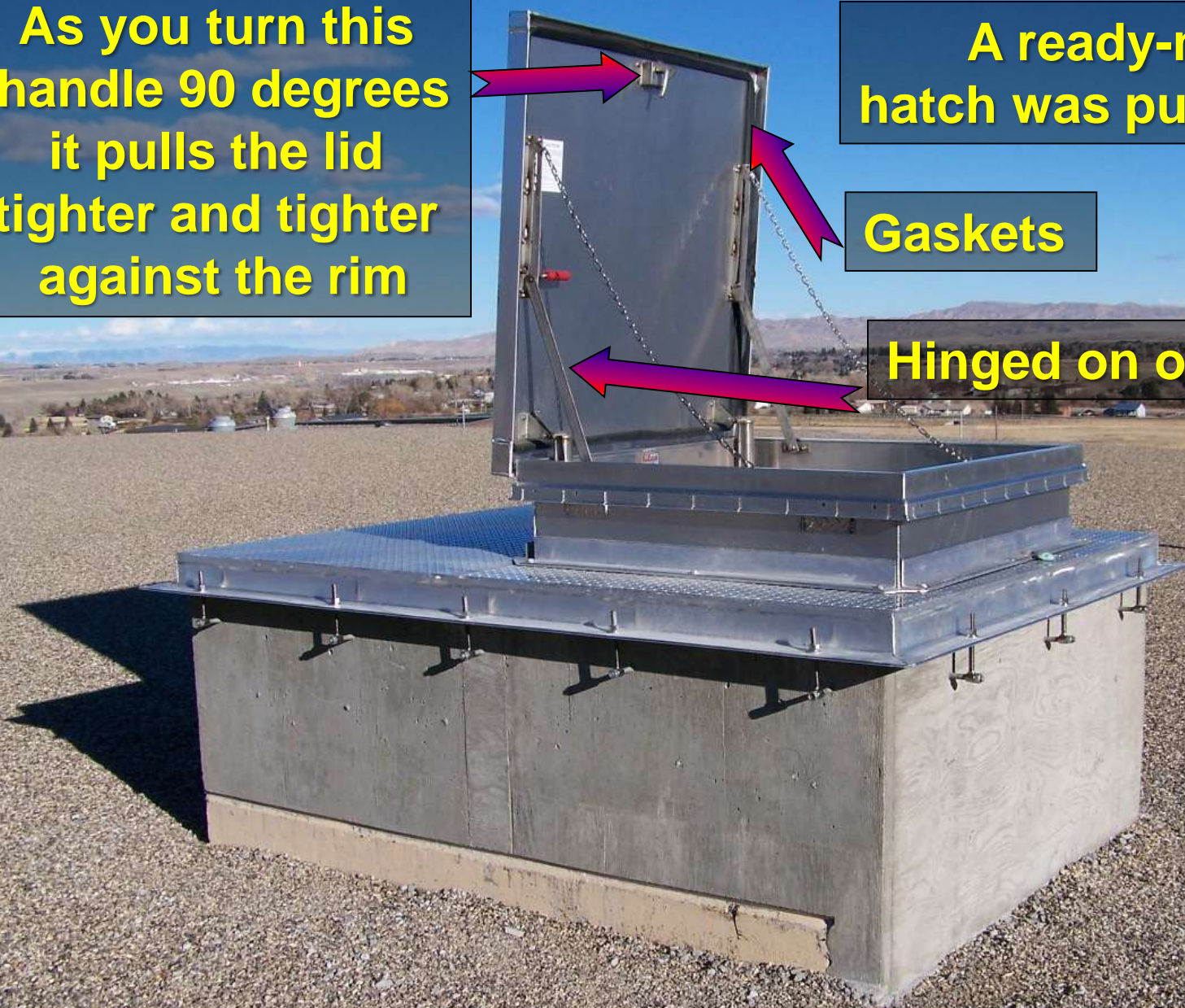


As you turn this handle 90 degrees it pulls the lid tighter and tighter against the rim

A ready-made hatch was purchased.

Gaskets

Hinged on one side.



Two hatches were raised.



It is indeed possible to raise a hatch, and even to raise a existing double door hatch.



Hatch

How does the hatch in our example stack up to these best practices in the Learners Guide?




Perfect! The electric lines for telemetry are sealed beautifully!

Perfect! It's 36 inches to the bottom of the shoebox lid





**Perfect! A latch that
pulls the lid tighter and tighter
as it is turned and locked.**

A close-up photograph of a metal structure, likely a shoebox lid, showing a corner where two panels meet. The corner is reinforced with a vertical weld bead. The metal surface is smooth and reflective. Several bolts are visible along the bottom edge of the structure. The background is slightly blurred, showing some greenery and a bright sky.

**Finally, a picture
perfect example!
No openings,
sealed to the concrete,
welded corners,
shoebox lid**

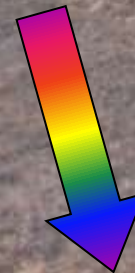
Hatch



A+!

Let's look at the best practices in the Learners Guide for drains and see how our storage tank stacks up.

Drains





How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #18 Drains (1st paragraph)} Does the drain have a removable #24 mesh, non-corrodible, screen? Water will only be exiting a drain pipe when an operator opens the gate valve for some planned event like tank cleaning. Therefore, one of the steps in this planned process is removing the screen from the drain pipe, prior to flushing to prevent damage, then immediately replace it after cleaning. Putting the screen between two flanges makes it easily removable and prevents rodents, snakes and insects and any diseases they may harbor, from nesting in the drain pipe.

Also see, Section 10.4.8 Components

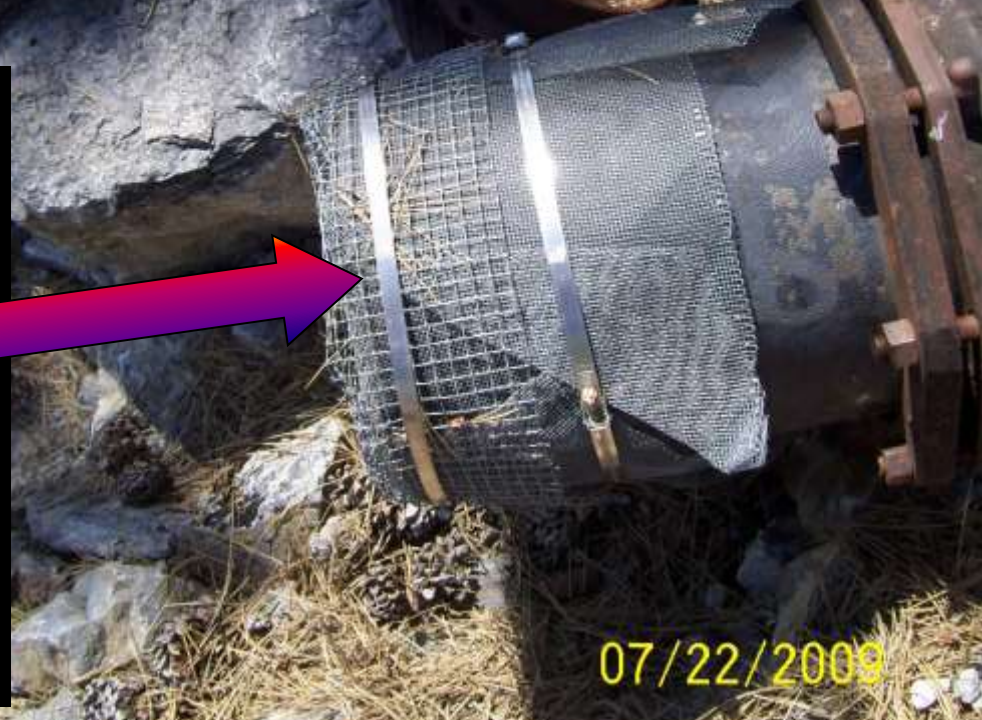
Typically, the concern about the proper sanitary conditions for drains is low due to the fact that there is a gate valve between the outfall and the water in the tank.



Insects, rodents, animals can't get through a gate valve. So, what's the concern?

Drains

Many say, I would never use a #24 mesh screen it would just be blown off. A screen wrapped around a drain would most definitely be blown off when you open the valve to drain your tank.



But if the #24 mesh screen on your drain is between two flanges it will bow out but will stay put. This #24 mesh had several million gallons pushed out through it





Still many say I can't use a #24 mesh screen on a drain because it will be either be blown off or damaged. The rust and the sediment will clog a #24 mesh screen.

But the best practices say the #24 mesh screen on a drain needs to be removable.

Water is never going to come out of your drain unless someone opens the valve during a planned cleaning event.

During a planned cleaning event, simply undo the bolts, remove the #24 mesh screen and when you're done replace the screen immediately.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #18 Drains (2nd paragraph)} Drains typically leak, creating a wet environment that attracts life of all sorts. It is simply good sanitary practice to not allow any rodents, snakes, or insects to live in any part of the drinking water infrastructure. The wet environment from a drain pipe creates an environment that will support a significant bacteriological community, which is why water systems must never connect an overflow pipe to the tanks' drain pipe.

Also see, Section 10.4.8 Components

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Because there is a valve upstream and pressure behind the valve, drains will eventually leak. This moisture rich environment will support a diverse microbiological community and that is why you never want an overflow to be directly connected to a tank drain. You don't want an overflow breathing from this wet environment.



How to Conduct a Sanitary Survey of Drinking Water Systems

{Section 10.4.10, #18 Drains (3rd paragraph)} The screened outlet must be at least 24 inches (but not less than 12 inches) above the splash plate. The drain must discharge over a splash plate or an engineered outlet (concrete or riprap) that will not submerge the drain when it is flowing. Operators must not directly connect the drain to a sanitary sewer, storm drain or be under water. The drain can indirectly discharge to a sanitary sewer or storm drain, but only if there is at least a 3 pipe-diameter air gap.

Also see, Section 10.4.8 Components



Animals have sharp claws and teeth. Having the screen so close to the ground gives the rodents leverage to really work at tearing the screen apart. Water attracts life, wildlife will work hard to get to it. Only stainless steel # 24 mesh, not fabric screens should be used.

That's at most 2 inches from the ground to the pipe. No splash plate, any tank cleaning event will cause severe erosion.

07/22/2009

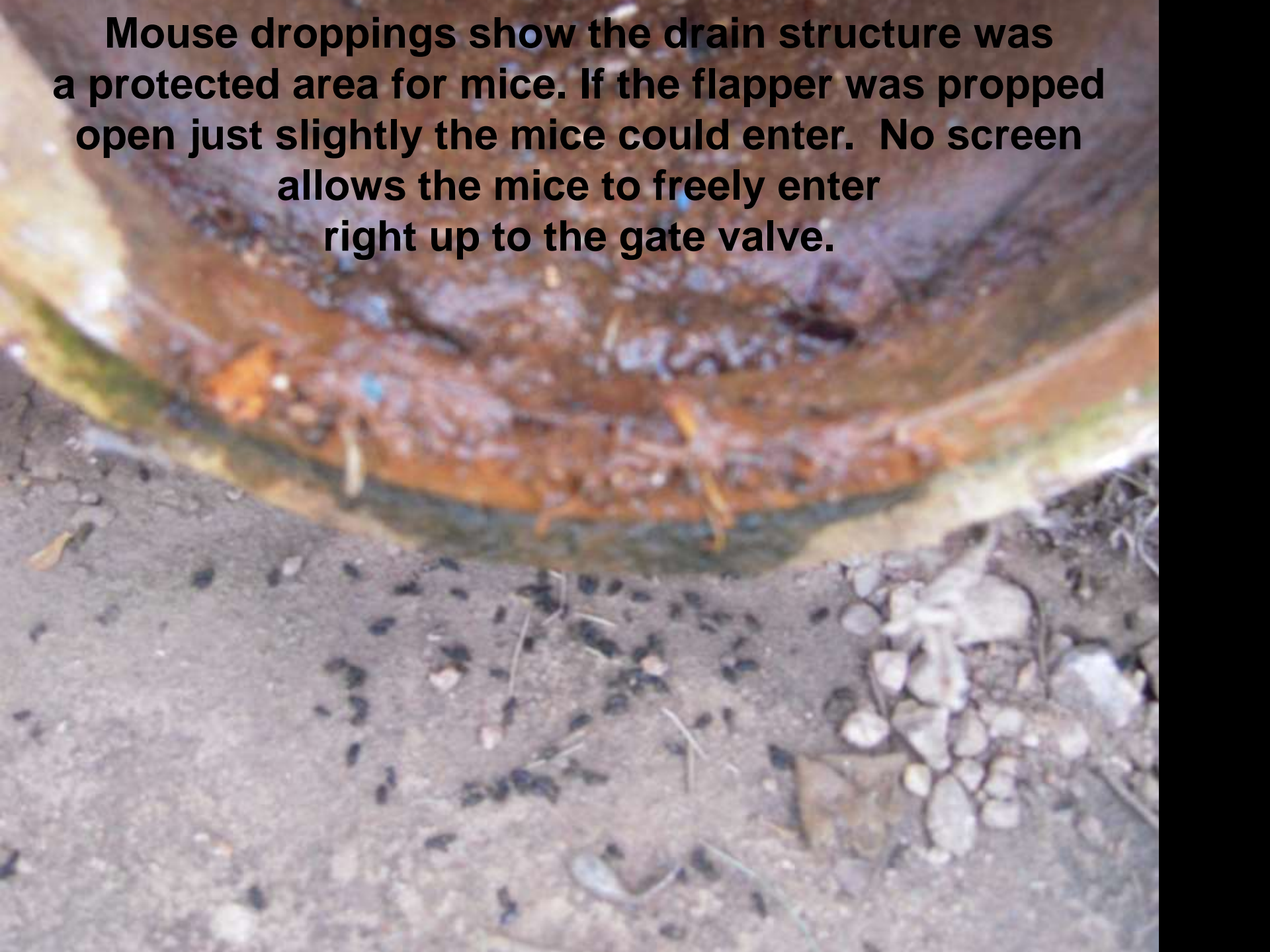
It does not meet the minimum of 12 inches above the splash plate. It's short by 8 inches! There's no screen at all and the drain gets submerged during rain storms!



Submerged drains should be regraded such that they are not submerged during a typical rain event and that water does not pool at the drain. Stagnant water is host to a broad array of microorganisms and is unsanitary. Any unsanitary condition at any tank component needs to be eliminated to reduce the risk of disease transmission.



Mouse droppings show the drain structure was a protected area for mice. If the flapper was propped open just slightly the mice could enter. No screen allows the mice to freely enter right up to the gate valve.





Raccoons!

A black and white microscopic image showing a raccoon's head and body. The raccoon is facing forward, and its ears are visible. The image is somewhat blurry and has a grainy texture. In the bottom left corner, the number '34' is visible.



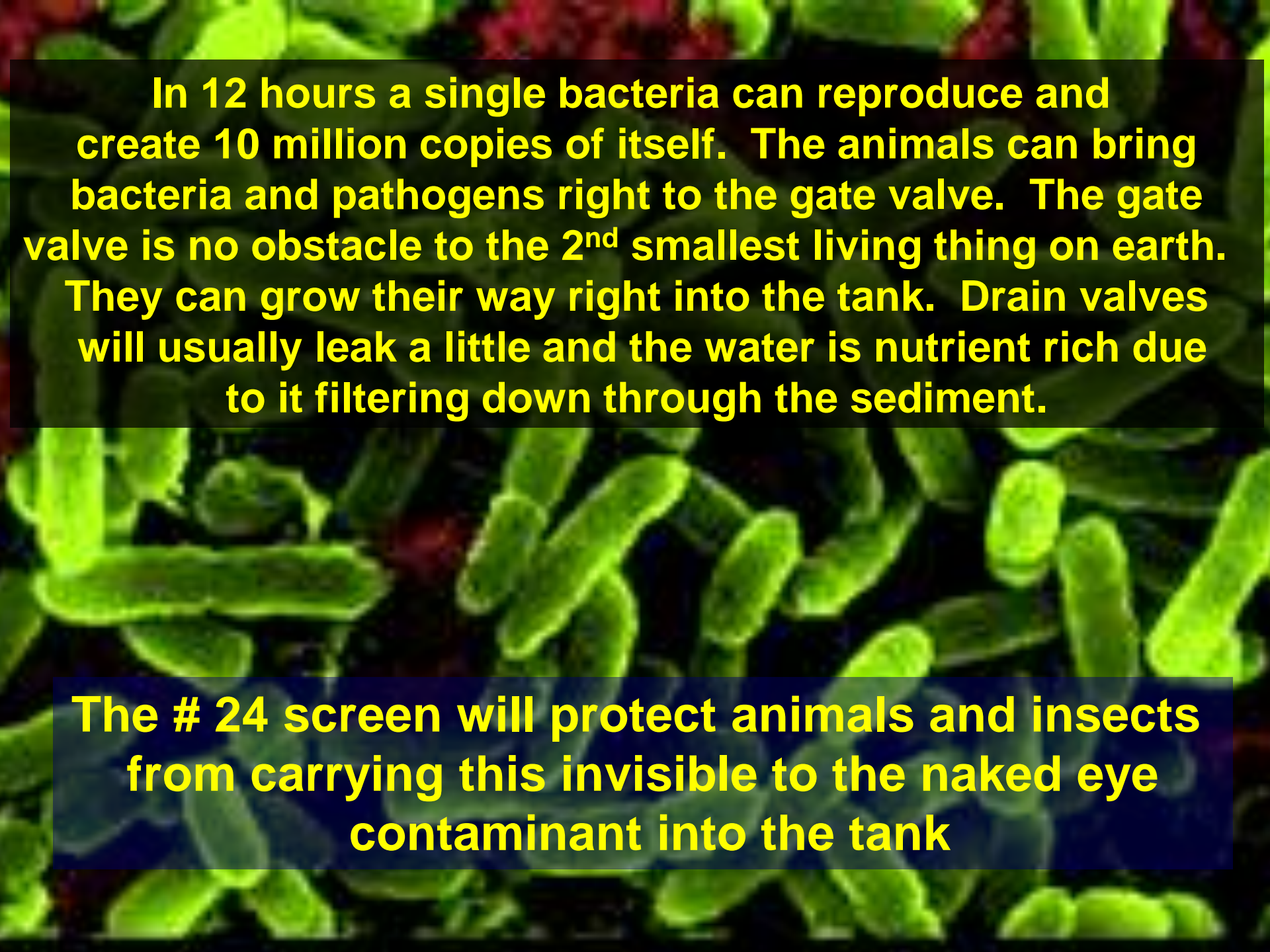
Snakes!

A black and white microscopic image showing a snake's head and body. The snake is facing forward, and its mouth is open, showing its tongue. The image is somewhat blurry and has a grainy texture.

The wet and enclosed environment will attract rodents, snakes etc. and they can travel to the a gate valve and nest.

Animals are a vector for disease and will bring bacteria, viruses, and protozoa right to the gate valve.



A microscopic view of numerous green, rod-shaped bacteria, likely E. coli, against a dark background. The bacteria are scattered throughout the frame, with some appearing in small clusters and others as individual cells. The lighting highlights their cylindrical shape and some internal structure.

In 12 hours a single bacteria can reproduce and create 10 million copies of itself. The animals can bring bacteria and pathogens right to the gate valve. The gate valve is no obstacle to the 2nd smallest living thing on earth. They can grow their way right into the tank. Drain valves will usually leak a little and the water is nutrient rich due to it filtering down through the sediment.

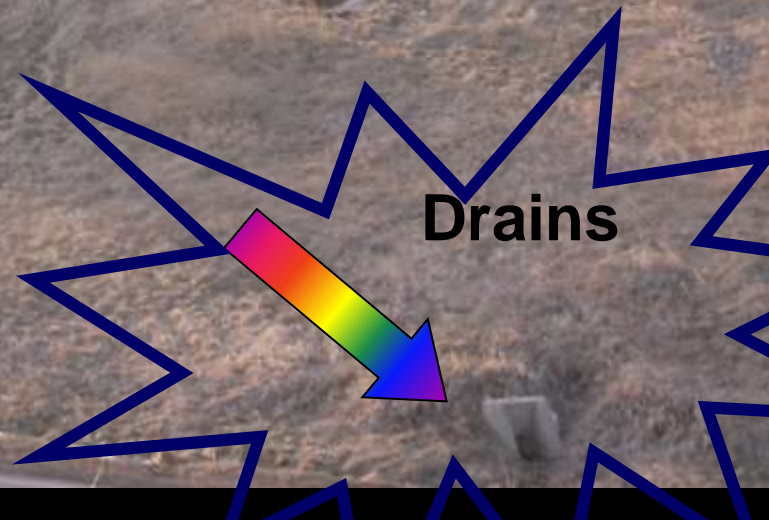
The # 24 screen will protect animals and insects from carrying this invisible to the naked eye contaminant into the tank

This drain is a direct connection to a storm sewer. The pipe would need to be cut off at least 3 pipe diameters above this grate. We are not worried about vapors from the storm sewer getting into the tank via the drain because it has a valve on it.

It is impossible to check for a screen on this drain in its current configuration.

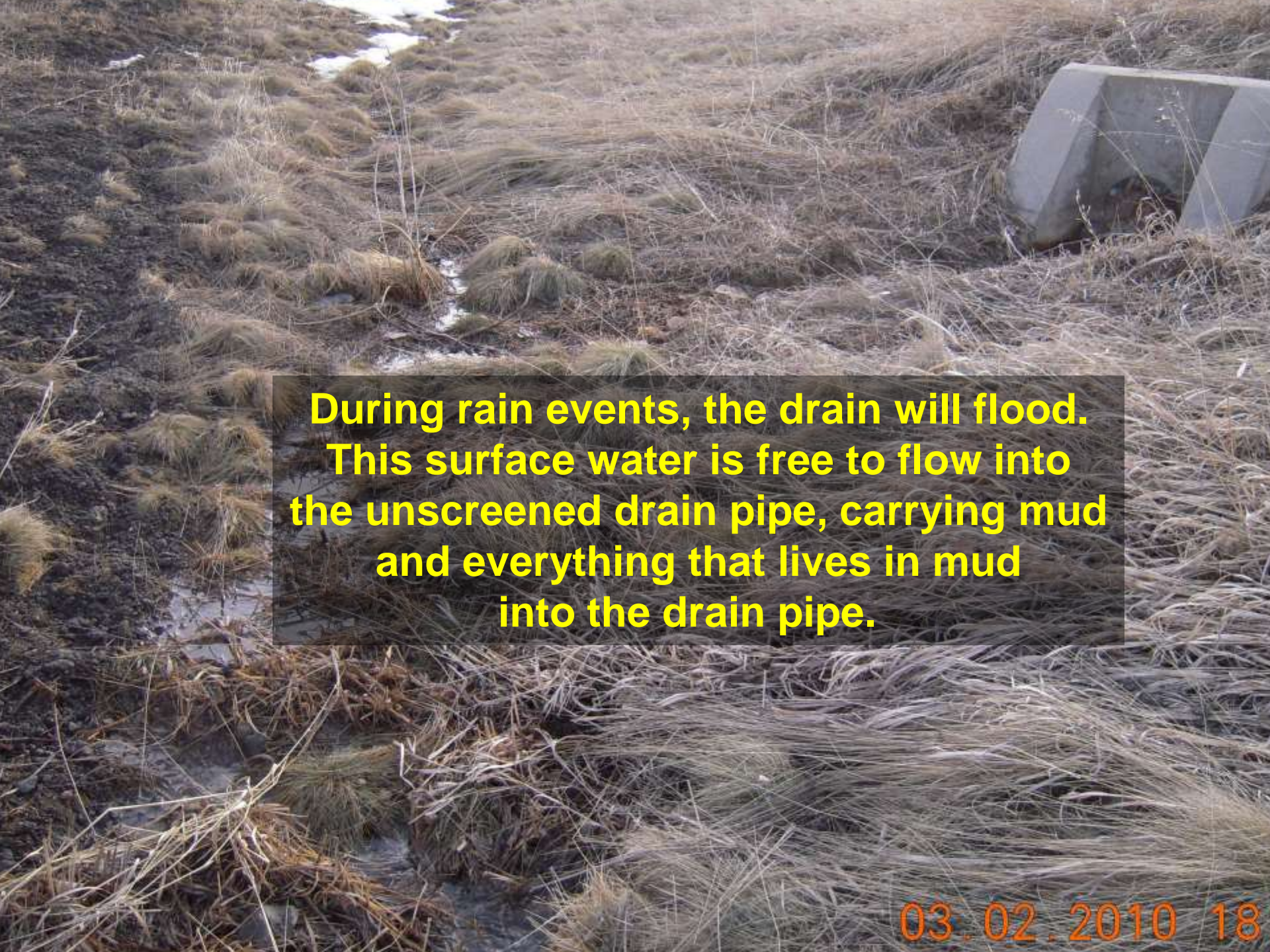


How does the drain in our example stack up to these best practices in the Learners Guide?



It has a nice engineered splash plate but the drain is 3 inches from the ground, 21 inches shy of 24 inches. It has no screen





**During rain events, the drain will flood.
This surface water is free to flow into
the unscreened drain pipe, carrying mud
and everything that lives in mud
into the drain pipe.**

03.02.2010 18



Failed!

Drains





Failed!

Hatches



A+!

Vents

Overflows



Failed!

So, what's the report card for vents, overflows drains and hatches in our example?



Failed!

Drains



How to Conduct a Sanitary Survey of Drinking Water Systems

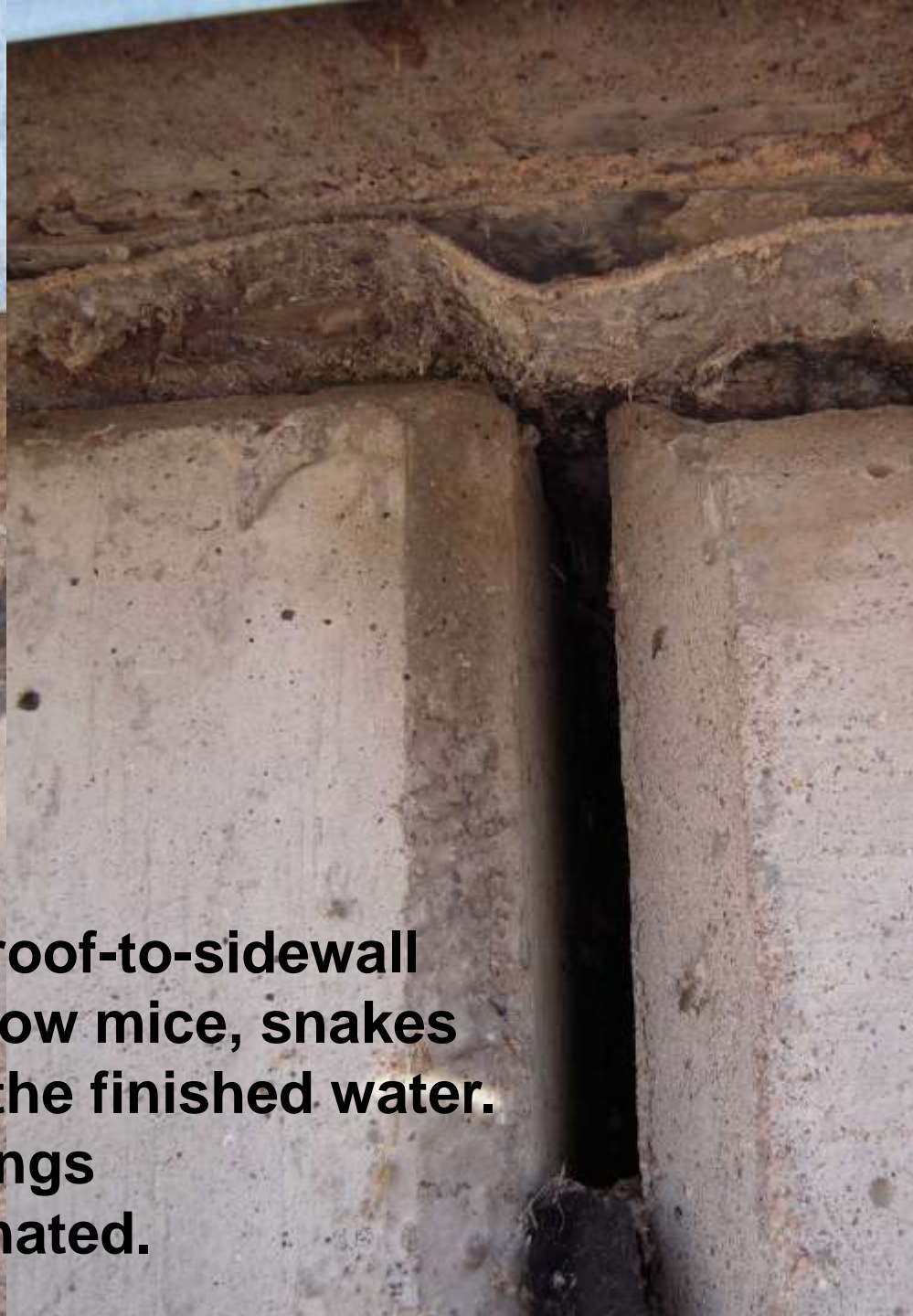


{Section 10.4.10, #19 openings (walls, wall-to-roof or roof)} There must be no other hole larger than that afforded by a #24 mesh screen. Record any openings in the roof, walls or wall-to-roof connection that operators need to seal or need more significant repair.



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The significance of these roof-to-sidewall openings is that it would allow mice, snakes and insects to directly enter the finished water. All such openings need to be eliminated.




With permission from Clyde Zelch,
President, Tomcat Consultants.

**These tanks are notorious
for roof-to-sidewall openings;
they freely allow insects and the
host of diseases they carry
directly into the tank.
All such openings
need to be eliminated.**

**Why must tanks be designed to exclude insects?
Where do flies dine? Calves excrete billions of Crypto and Giardia. The Crypto are small enough to be ingested and excreted and stick to the legs and body of a fly and be transported to the finished water.**



**With permission from Clyde Zelch,
President, Tomcat Consultants.**

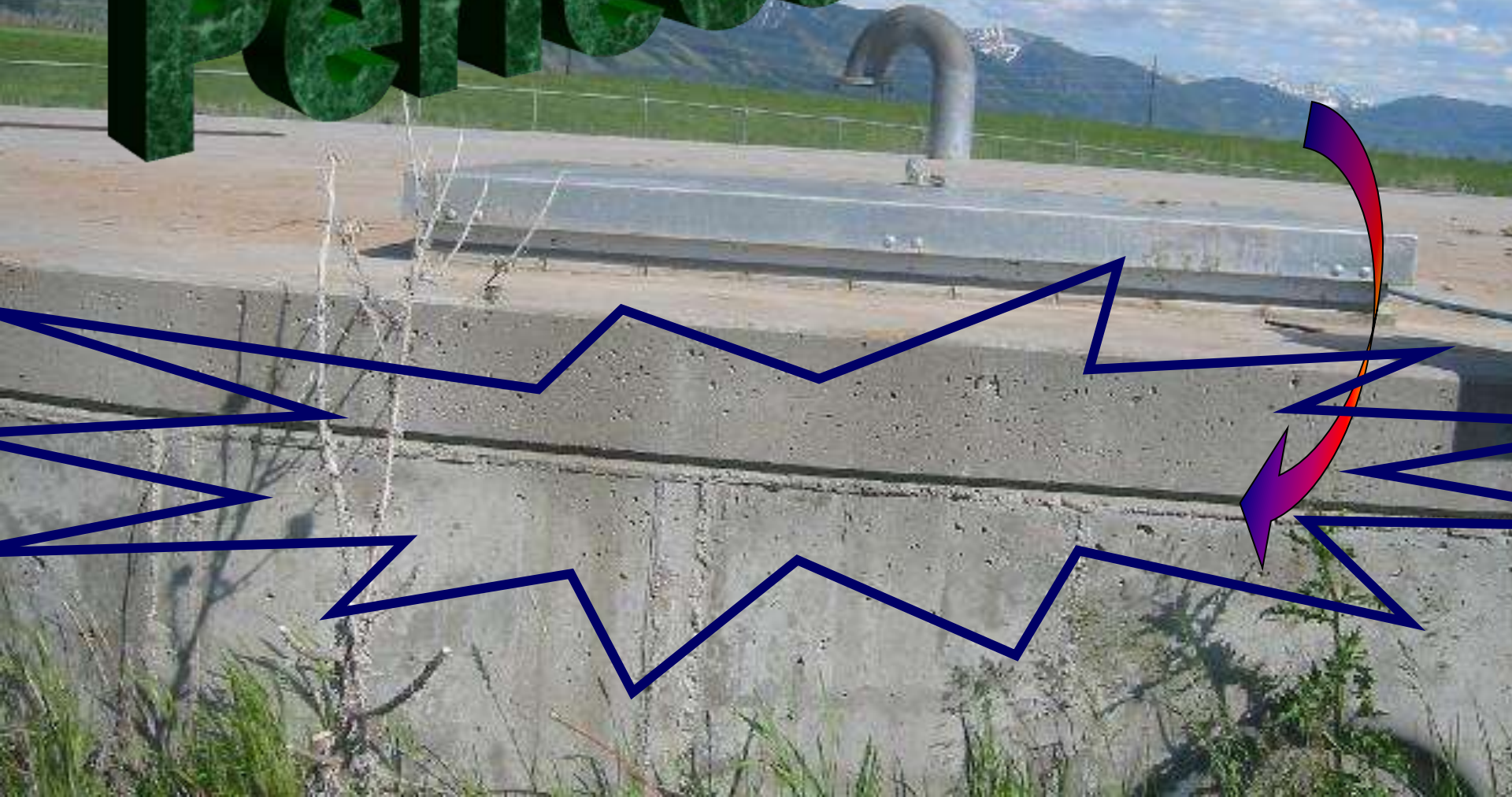


This is a wonderful picture of a reflection. But we don't want to see this on the top of a storage tank.

The roof of a tank needs to have a slope so water runs off

03.04.2010 18:42

Perfect seal!





Whoa!!

Ooh la
la!!

That's the
size of
Lincoln's
eyeball on a
penny!

The Learner's Guide stated NO openings greater than what is afforded by a # 24 mesh non-corrodible screen.

The size of the openings for a # 24 screen is 0.0277 inches. Therefore, you should have no openings in and around your storage tank greater than 0.0277 inches



Why do we use a # 24 screen?

**Because the opening, 0.0277 inches,
will exclude all mosquitoes and
almost all insects.**



INCHES

$\frac{1}{8}$ $\frac{1}{4}$ $\frac{3}{8}$ $\frac{1}{2}$ $\frac{5}{8}$ $\frac{3}{4}$ $\frac{7}{8}$

**There are 24 openings in one inch for a # 24 screen.
19 openings to the diameter of a penny (in case you don't
have a tape measure with you).**

Will a #24 mesh screen keep these insects out?



24 screen opening 0.0277 inches

YES



Black widow spider: 0.5518 inch

YES



House fly: 0.315 inch

YES



Deer ticks: 0.166 inch

YES



Asian Tiger Mosquito: 0.078 inch

YES



Noseeums, biting midges: 0.059 inch
(smallest blood-sucking insects)

No



Fairy fly: (smallest) 0.00826 inch
Very little is known about this species.



Asian Tiger mosquitoes, like other insects, are highly migratory. Since the invasive species arrived in December of 2007, they have spread to the green areas in the U.S. They are very difficult to control due to their remarkable ability to adapt to various environments, including cold, and their reproductive biology.

A #24 mesh screen will not allow the water in your tank to become a breeding ground for mosquitos.



A mosquito boat contains 300-400 new mosquitoes.

Mosquitoes are the world's most dangerous insect. They cause more human suffering than any other organism on the planet— over one million people die from mosquito-borne diseases every year.

Diseases from mosquitoes: malaria, yellow fever, dengue, filariasis and encephalitis West Nile virus (WNV), Zika virus.

Even a common housefly is a vector for disease through

mechanical transmission of pathogens on its hairs, mouthparts, vomitus, and feces:

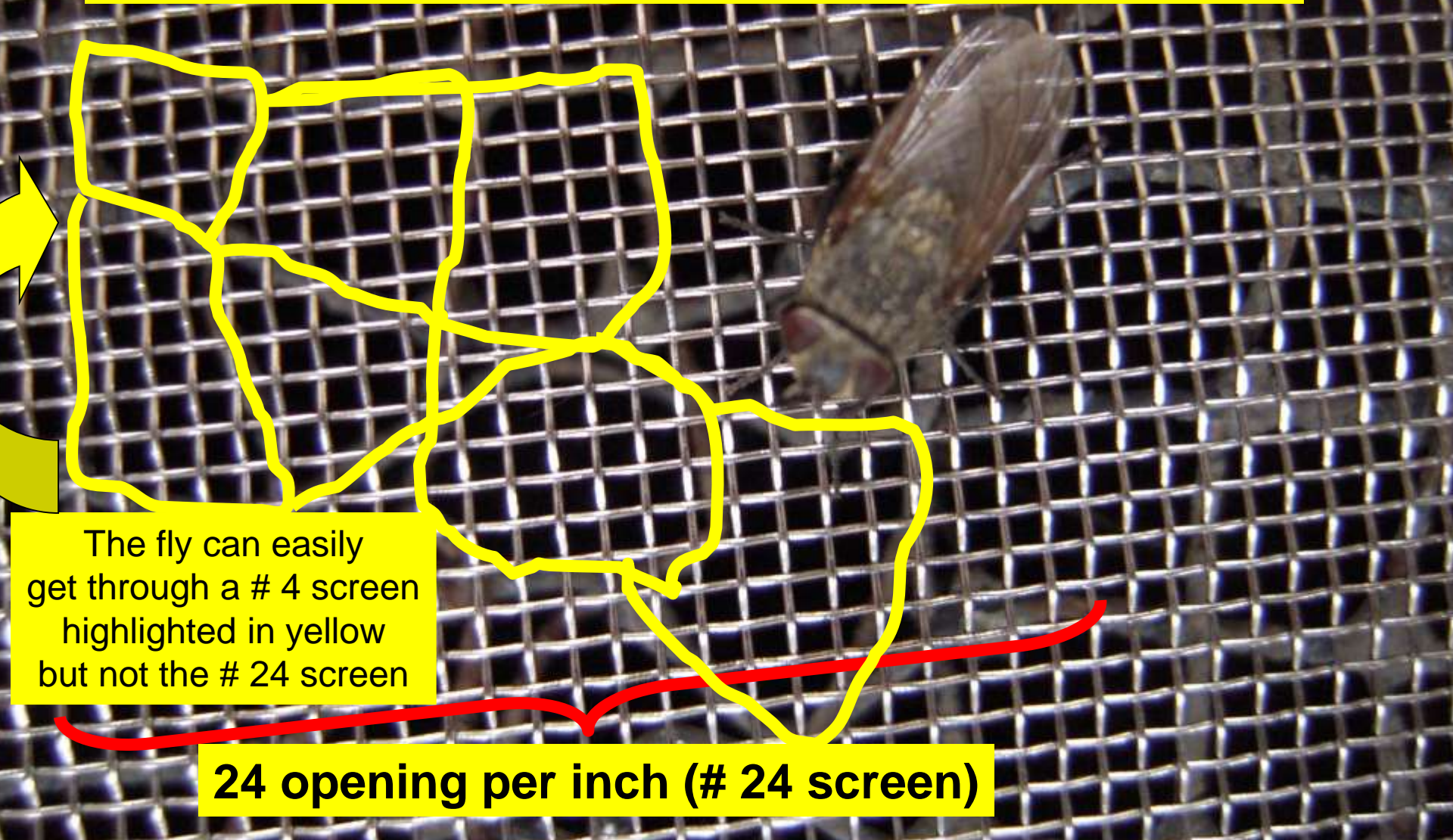
It carries parasitic diseases: cysts of protozoa e.g. Entamoeba histolytica, Giardia lamblia,

bacterial diseases: typhoid, cholera, dysentery, pyogenic cocci, Campylobacter,

E. coli O157:H7

viruses: enteroviruses: poliomyelitis, (A & E), etc.

Here is a picture comparing a # 24 screen with the # 4 screen below it with a house fly.




The fly can easily get through a # 4 screen highlighted in yellow but not the # 24 screen

24 opening per inch (# 24 screen)




**So, we should be checking for and fill
any opening greater than a # 24 screen!
Sound ridiculous?**

**Not when you compare it to what
size opening the water has already come through
in a well-operated filter or aquifer**

A microscopic view of several sand grains. The central grain is a light blue, circular, concentric shell. To its left is a yellowish, porous, and irregularly shaped grain. To its right is a white, elongated, and irregularly shaped grain with yellowish spots. Below the central grain is a smaller, yellowish, rounded grain. At the bottom left is a dark, irregularly shaped grain with some internal structure. The background is black.

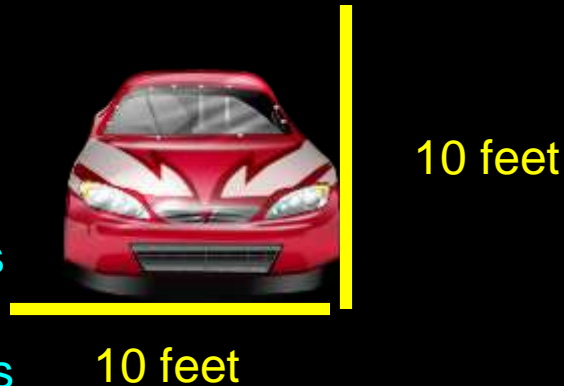
**These are the light
brown grains
of sand you
would find on any
beach but, as seen
at the
microscopic
level**

In a well operated filter plant or aquifer the water is passing through openings of ~ 0.0000275 inch. That's ~ 1000 -fold smaller than the opening of a # 24 screen 0.0277 inch.

A yellow arrow with a black outline, pointing from the text box towards the right side of the image.

Let's see what a 1000-fold increase looks like.
If we have a car going through a 10 foot by 10 foot opening,
what would a 1000-fold increase look like?

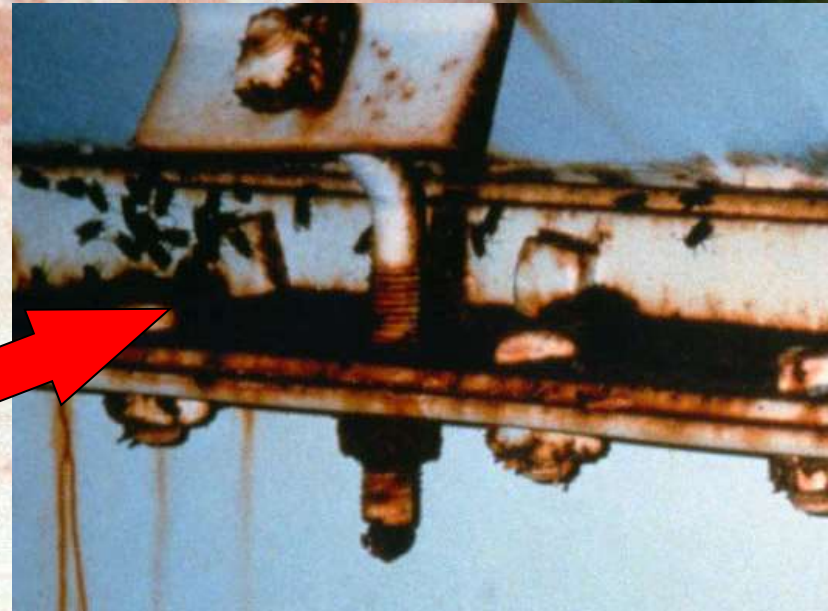
So, in comparison to filtration, the opening of a # 24 screen is quite a compromise to the sanitary integrity of the finished water. We should try our best to find and eliminate any openings larger than afforded by a # 24 screen. Caulking works well to fill small holes.



**A 1000-fold increase
would equate to stacking
8 Empire State Buildings end-on-end!**



**Even though a # 24 screen
has an opening 1000 times
larger than our best
sand media filters, it will keep out
animals, birds
and insects
and the
infinitesimally smaller
bacteria and viruses they harbor**



**With permission from Clyde Zelch,
President Tomcat Consultants.**

There is a more subtle way that a waterborne disease outbreak can be caused by a storage tank. It takes a perfect storm of three things; sediment buildup, breaches and a rare and unpredictable washout event. Two major waterborne disease outbreaks from tanks have occurred as a result of this perfect storm of events.





**What about the sediment in our tanks?
Isn't it just sand?**

**Unfortunately, no, due to bacteria. Bacteria can change
this nice clear sand from this...**

...to this. You can see the sand turning into muck from bacteria.



10/13/2009

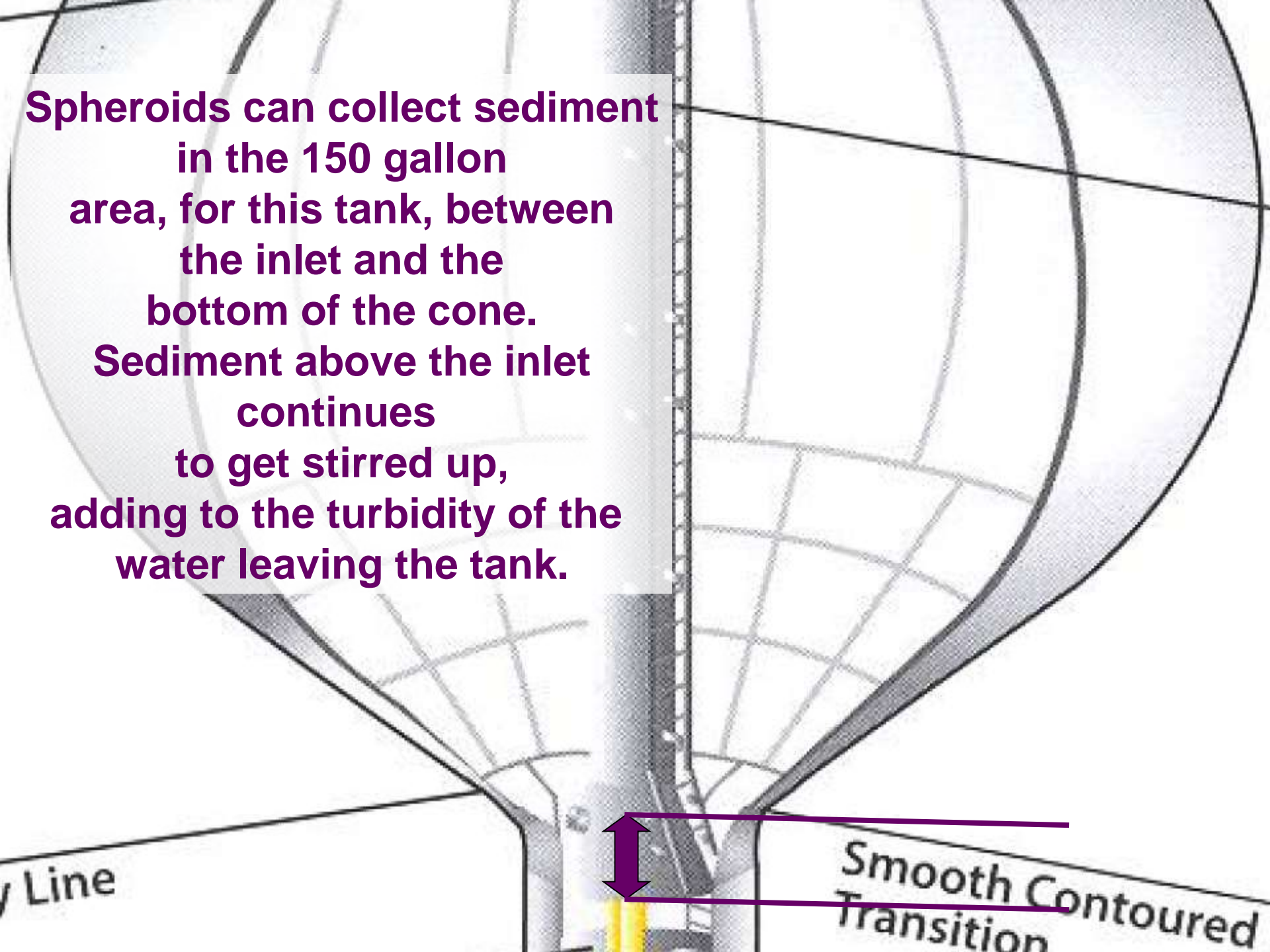
**...and then finally to this -
a slimy, sticky, muck.**


**Bacteria can produce
10 million copies of itself
in 12 hours and can turn
ordinary sand into this!
The sediment becomes a
nutrient-rich media able to
support billions upon
billions of bacteria.**

**A shovel
standing
on its own
in the
muck**

With permission from Clyde Zelch, President Tomcat Consultants.

Spheroids can collect sediment in the 150 gallon area, for this tank, between the inlet and the bottom of the cone. Sediment above the inlet continues to get stirred up, adding to the turbidity of the water leaving the tank.



A large, circular, spheroid tank is shown from an overhead perspective, filled with a thick layer of sediment. The sediment is a dark, textured material that covers the entire floor of the tank. The tank's structure is visible as a series of concentric rings and a central support structure. The lighting is dim, highlighting the texture of the sediment and the metallic surfaces of the tank.

**This is what a spheroid tank looks like
when that concentric area is full of sediment.
All tanks need to be
comprehensively cleaned. Only when they
are cleaned can they be inspected. This needs to be done
at least every 3 to 5 years**

**With permission from Clyde Zelch,
President Tomcat Consultants.**

**Time between cleanings
increases the depth
of the sediment**

**Two tanks were last cleaned
7 years ago. The result:
4 to 12 inches of sediment**



**Brookfield, Wisconsin, had
3 spheroids.**

**One tank was cleaned
15 years ago. The result:
28 inches of sediment**

**Wisconsin had
recommendations for
inspections every 5 years**



For a normal healthy biofilm on a pipe wall a 3/8-by 3/8-inch area will be home to millions of bacteria, but it is only ~1/64

of an inch thick. Amazingly, these bacterial populations exist in the presence of chlorine residuals.

Microbial Biofilms:

Sticking Together for Success

Single-celled microbes readily form communities in resilient structures that provide advantages of multicellular organization.

Waiting to grow

Bacteria can shrink to a spore-like state to wait in water, soil—even rock or tissue—until conditions are right for active growth.

Changing their spots

Active bacteria will attach to virtually any surface. Within minutes, changes in gene expression transform "swimmers" to "stickers."

Building houses of slime

Attached bacteria multiply and encase their colonies with a slimy matrix.

Meeting the challenge

While antimicrobials damage outer cell layers, the biofilm community can survive.

Finding a niche

Chemical gradients create micro-environments for different microbial species or levels of activity.

Getting breakfast in bed

Nutrients diffuse into the matrix as they flow by.

Going with the flow

Propelled by shear forces, aggregated cells can break loose, roll, or ripple along a surface in sheets and remain in their protected biofilm state.

Sending the right signals

Close proximity of cells facilitates the exchange of molecular signals that regulate behavior.

"Persisters"

"Dispersers"

"Wall formers"

Dividing the labor?

Genetic regulation may allow a degree of differentiation among cells of a single species to serve the community as a whole.

How can bacteria survive in disinfected water?

Bacteria easily survive in disinfected water with this set of complex microbiological mechanisms to aid them.

- 1) Attachment: Bacteria are more than 600 X more resistant when attached to particles.
- 2) Encapsulation: Bacteria in low nutrient environments create an extracellular polysaccharide capsule which increases resistance 3 X.
- 3) Aggregation: When bacteria are in clumps, their resistance to free chlorine increases 100 X.
- 4) Low nutrients/low temperatures: Bacteria grown in these conditions are up to 9 X more resistant than agar-grown.
- 5) Strain variation: Disinfection selects for bacteria with resistance mechanisms.
- 6) Resistance mechanisms are multiplicative: For example, attached to glass (150 X) & encapsulated (3 X) resultant resistance 450 X.

Fungi (yeasts & molds) are even more resistant to disinfection



than bacteria (densities up to 10⁴)



Amoebae



Nematodes



Amphipods



Copepods



Fly larvae

What other things live in the sediment

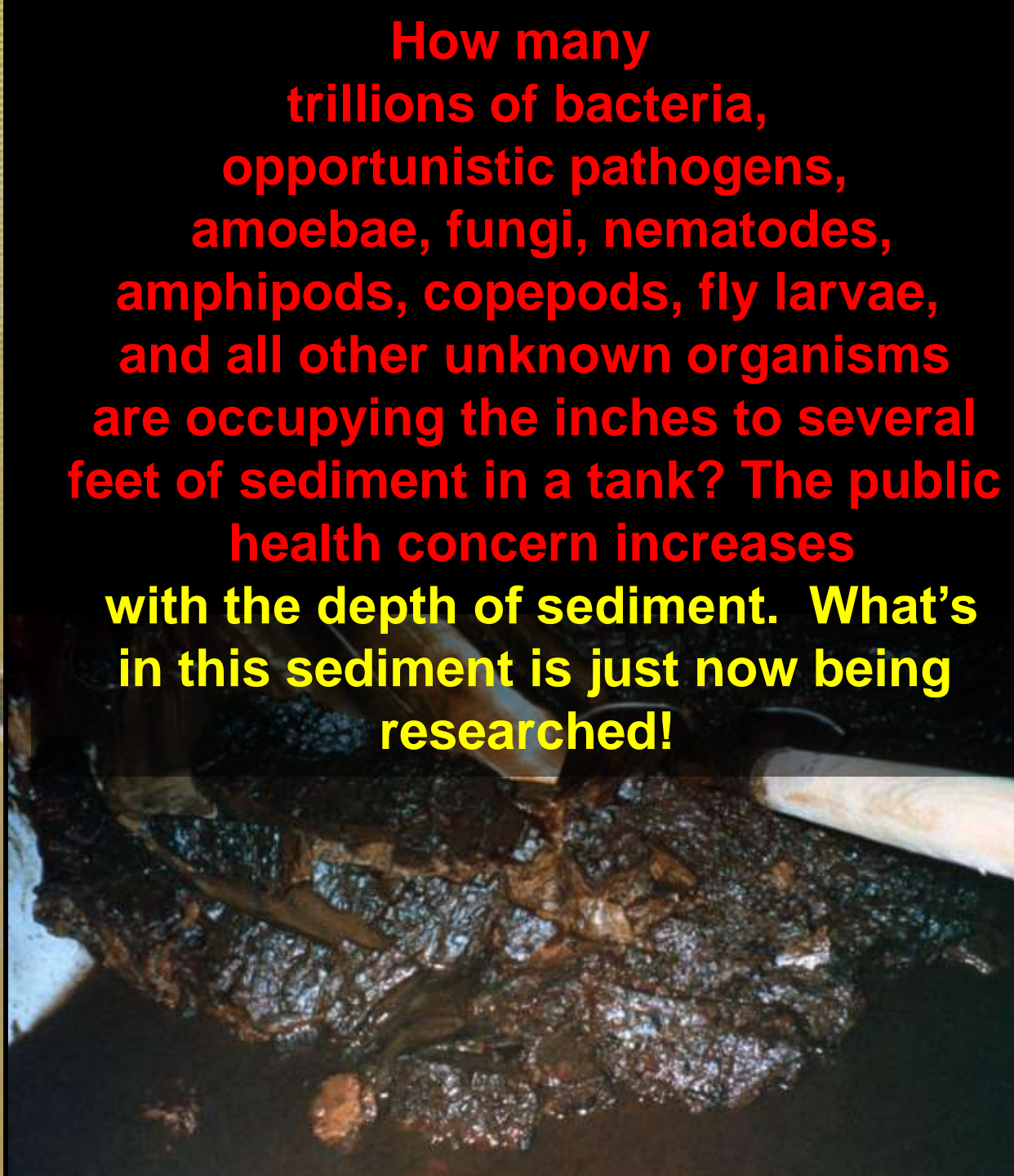
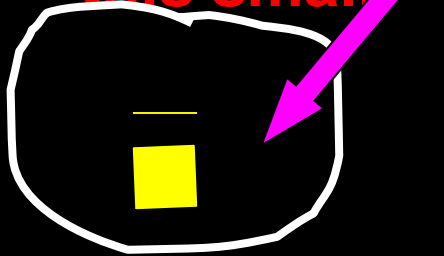
Amphipods

This is E. coli. It's continued presence indicates a fresh source of contamination.



Most pathogens do not live long outside of the intestinal tract. However, in a microbial and nutrient-rich environment, like the sediment in tanks, they can survive for a greater length of time.

Millions of bacteria can live in an area this thin and in an area this small



How many trillions of bacteria, opportunistic pathogens, amoebae, fungi, nematodes, amphipods, copepods, fly larvae, and all other unknown organisms are occupying the inches to several feet of sediment in a tank? The public health concern increases with the depth of sediment. What's in this sediment is just now being researched!



As long as the sediment remains undisturbed, the water out of your tanks will look like this



Unfortunately, the situations that may disturb this sleeping public health concern are uncontrolled (fire flows) and unpredictable (telemetry problems). The best way to mitigate this public health concern is to clean the tank every 3 to 5 years.



But where we have both breaches to allow diseases from insects, rodents, birds and animals to enter and inches to feet of sediment we have a truly dangerous public health potential.

Now, if that uncontrolled and unpredictable washout event occurs the public health concern is elevated up to the potential of a waterborne disease outbreak.

This is the Salmonella contaminated sediment from Gideon's storage tank. The draining of the tank pulled this sediment from the walls and into the distribution system.



Alamosa faces water lawsuit

29 families blame city for salmonella that sickened, killed residents

On March 2, 2010, 2 years after the outbreak a class action lawsuit is initiated. The estimated cost to the PWS and residents was 2.6 million dollars. The upper estimate is 7.8 million dollars. Milwaukee spent millions dollars simply defending itself. The law firm that brought suit against Milwaukee had developed one of the most extensive libraries in the country.

Immunocompromised individual was due to cancer. These are your most vulnerable customers.

That dangerous combination of breaches and sediment buildup to 18 inches (since 1984) is cited in the lawsuit. Those 18 inches of sediment resulted from wells a 1,000 feet deep.

took him to a hospital in Pueblo, which found the salmonella infection.

By then, "it was already septic — there was nothing they could do," she said. "He passed away at the hospital."

_____ had colon cancer and a weakened immune system when his body was invaded by bacteria in the city water supply. But "I

That caused the worst waterborne-disease outbreak in the U.S. since 2004. In Alamosa, a city of 8,900, an estimated 1,300 people might have been ill, including 40 percent of its infants. State officials identified 442 cases of "probable salmonella infections" and pointed to a cracked water reservoir as a likely point of origin.

The lawsuit claims that the reservoir, Alamosa's primary water well, had cracks and noticeable holes, 12 to 18 inches of sediment at the bottom, and had not been drained and cleaned since 1984.

It also had not been professionally inspected since 1997, and the structural deficiencies noted in that inspection "remained uncorrected through the time of the 2008 Alamosa water outbreak," the lawsuit claims.

A scanning electron micrograph (SEM) showing several Salmonella bacteria. The bacteria are rod-shaped and have a textured, slightly irregular surface. They are surrounded by a complex network of fine, fibrous structures, likely representing the extracellular matrix or flagella. The background is a dark, mottled greenish-brown color.

Remember Salmonella is not just a disease of birds, all vertebrates and insects can carry it.

A single mouse fecal pellet contains 10^5 Salmonella.

Salmonella can survive for weeks in a dry environment and months in a water environment.

Salmonella is just one of many types of diseases we are trying keep out of our water by excluding living things down to the size of insects. It is indeed folly to underestimate the tenaciousness of disease causing organisms.

With no regulations, choose to implement the very best practices in EPA Learners Guide that will eliminate insects and any associated diseases they carry from entering your storage tank. Eliminate the nutrient rich sediment that can harbor pathogens by comprehensively cleaning and inspecting your tank every 3 to 5 years. PWSs have the ultimate responsibility to provide for the safety of their water. At all costs avoid this...



**With permission from
Clyde Zelch,
President, Tomcat Consultants.**

The purity of water is indeed just a fleeting moment once it is drawn from an aquifer or treated.

In fact, even after it's purified, we don't want it residing in our distribution system for more than 2 or 3 days.

Choose to implement the very best protective measures as this pure water travels through the most vulnerable part of your distribution system – the storage tank.

Don't wait for your sanitary survey, implement these best practices now.