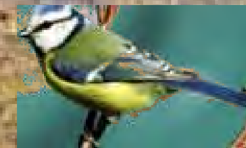
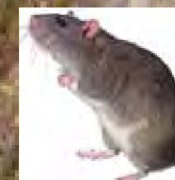




Understanding the Significance of Breaches to and Sediment Buildup in Finished Drinking Water Storage Tanks

Bob Clement, Environmental Engineer M.S., Microbiologist EPA Region 8, April, 2019

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:

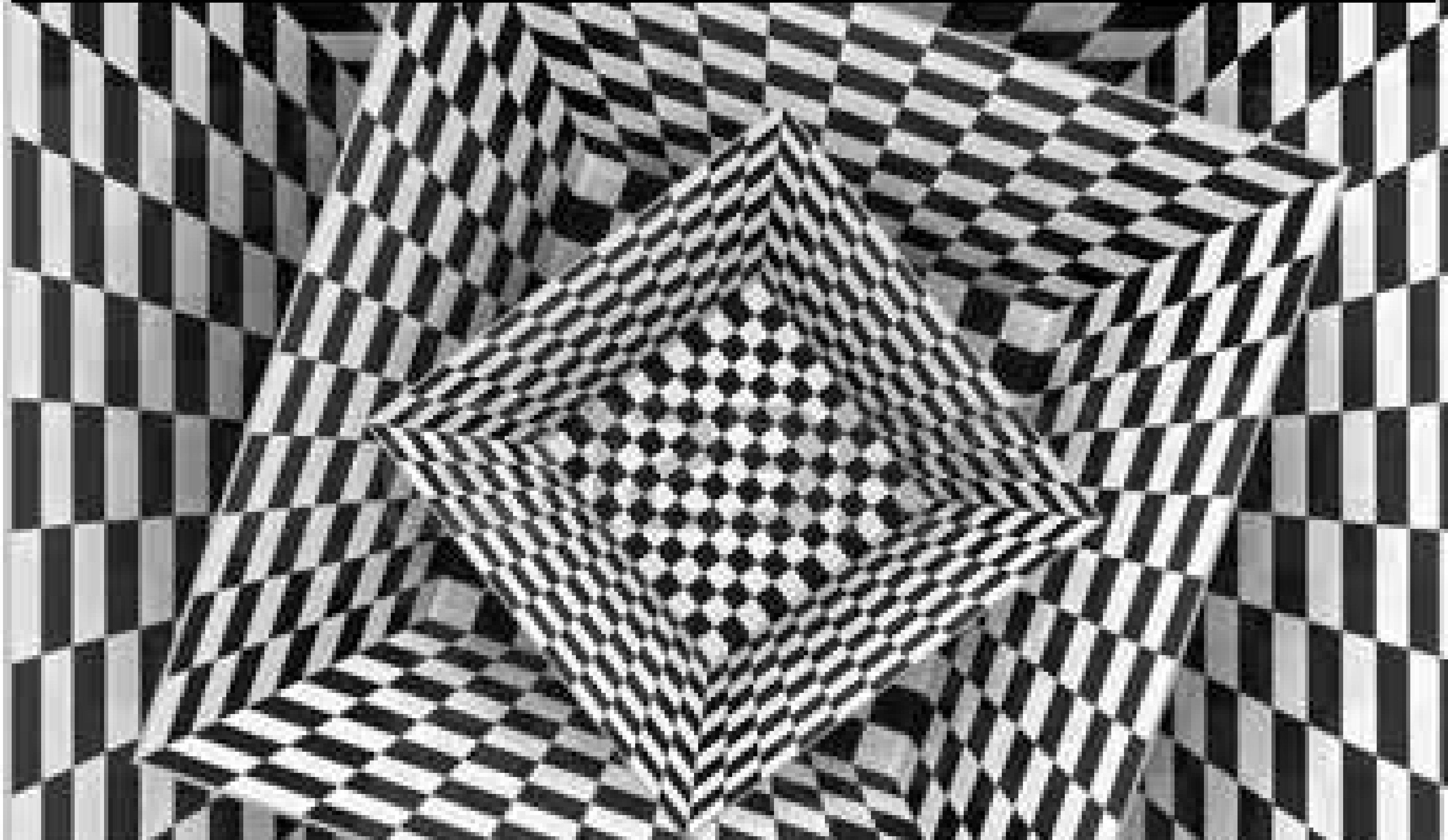
-How differences in perspective can effect one's ability to assess a waterborne disease outbreak.

- 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.

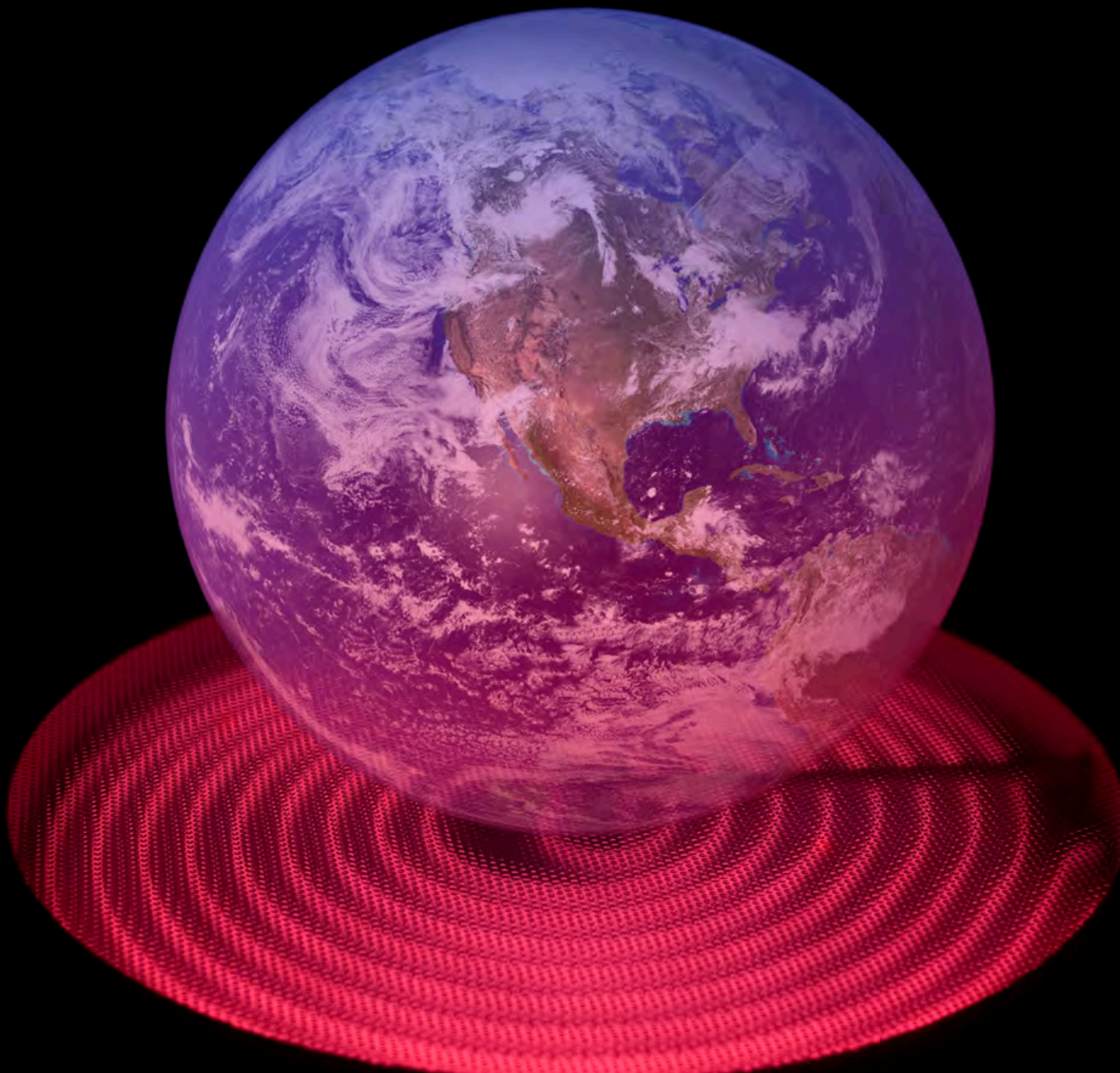
This statement epitomizes the lack of understanding of the significance that breaches can have in a storage tank.
A 3-inch hole has led to waterborne disease outbreaks that have sickened hundreds and has caused fatalities at some systems.

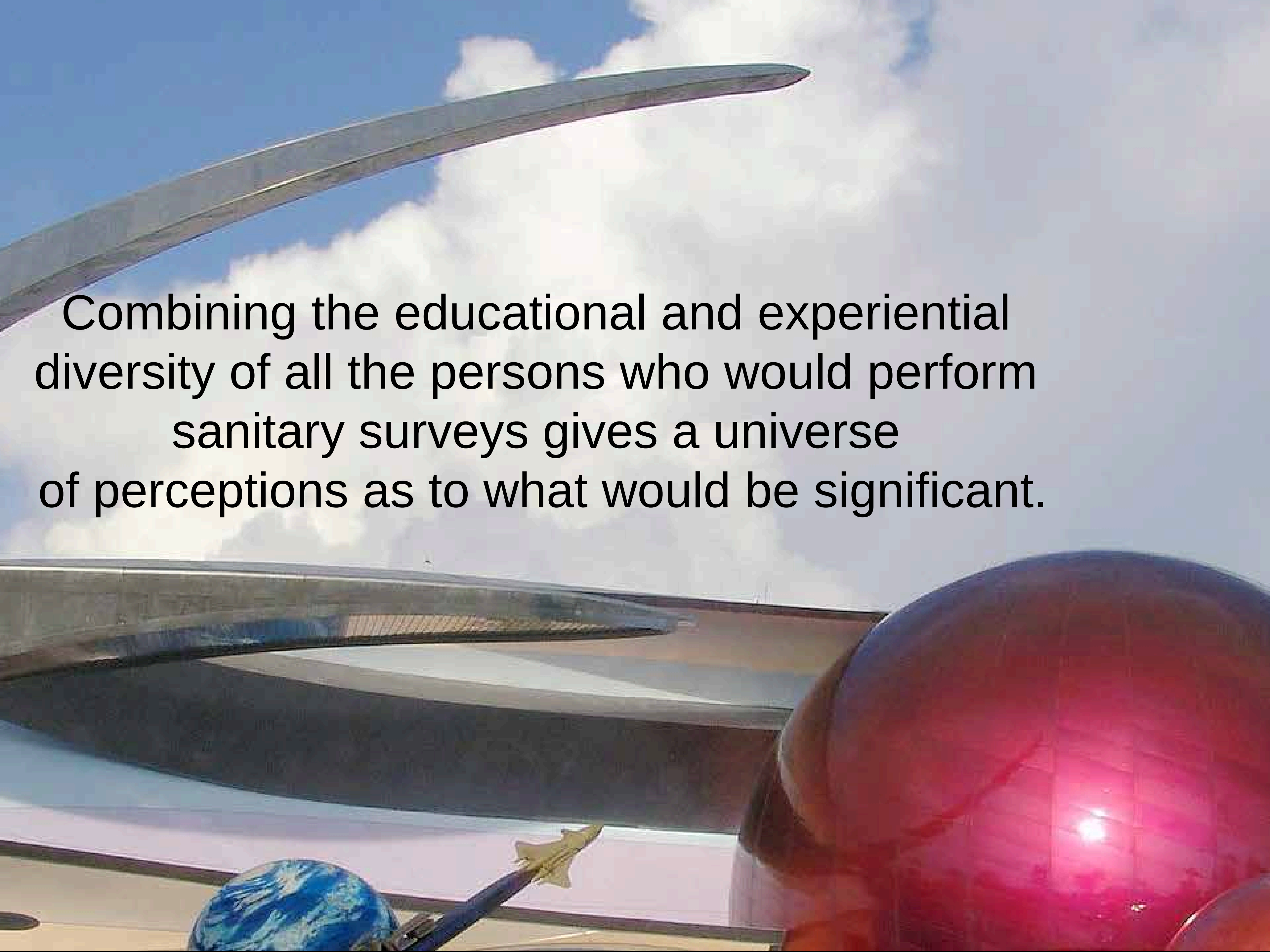
What causes differences in perception?

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

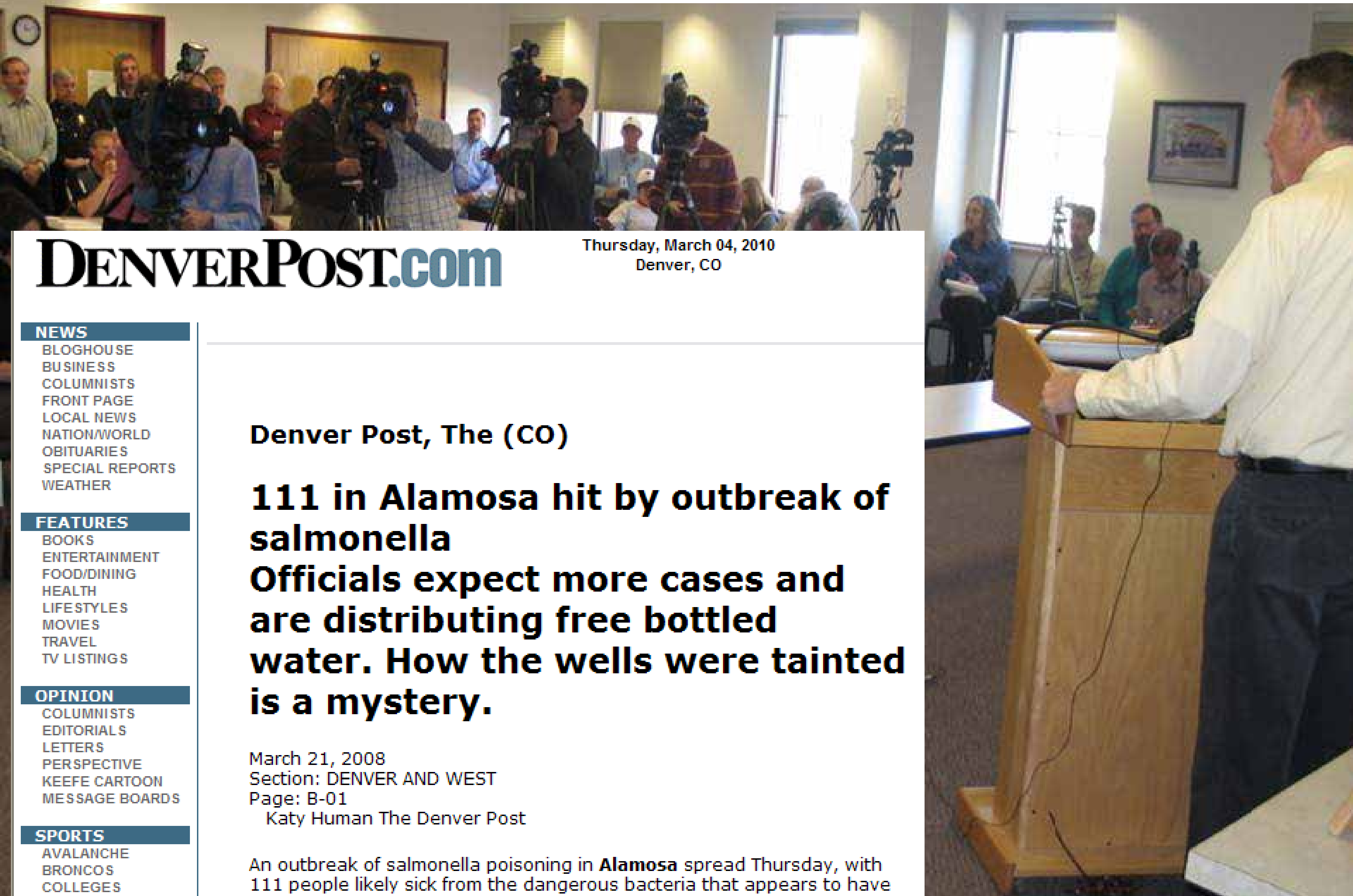
Degree: Microbiology, Biochemistry
Work: Federal employee (mostly desk work)
Visits a system
that has a knot hole missing
in a board covering a spring
collection box. Action:
requested that the boards be removed to
investigate further.

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
- BLOGHOUSE
- BUSINESS
- COLUMNISTS
- FRONT PAGE
- LOCAL NEWS
- NATION/WORLD
- OBITUARIES
- SPECIAL REPORTS
- WEATHER

FEATURES
- BOOKS
- ENTERTAINMENT
- FOOD/DINING
- HEALTH
- LIFESTYLES
- MOVIES
- TRAVEL
- TV LISTINGS

OPINION
- COLUMNISTS
- EDITORIALS
- LETTERS
- PERSPECTIVE
- KEEFE CARTOON
- MESSAGE BOARDS

SPORTS
- AVALANCHE
- BRONCOS
- COLLEGES

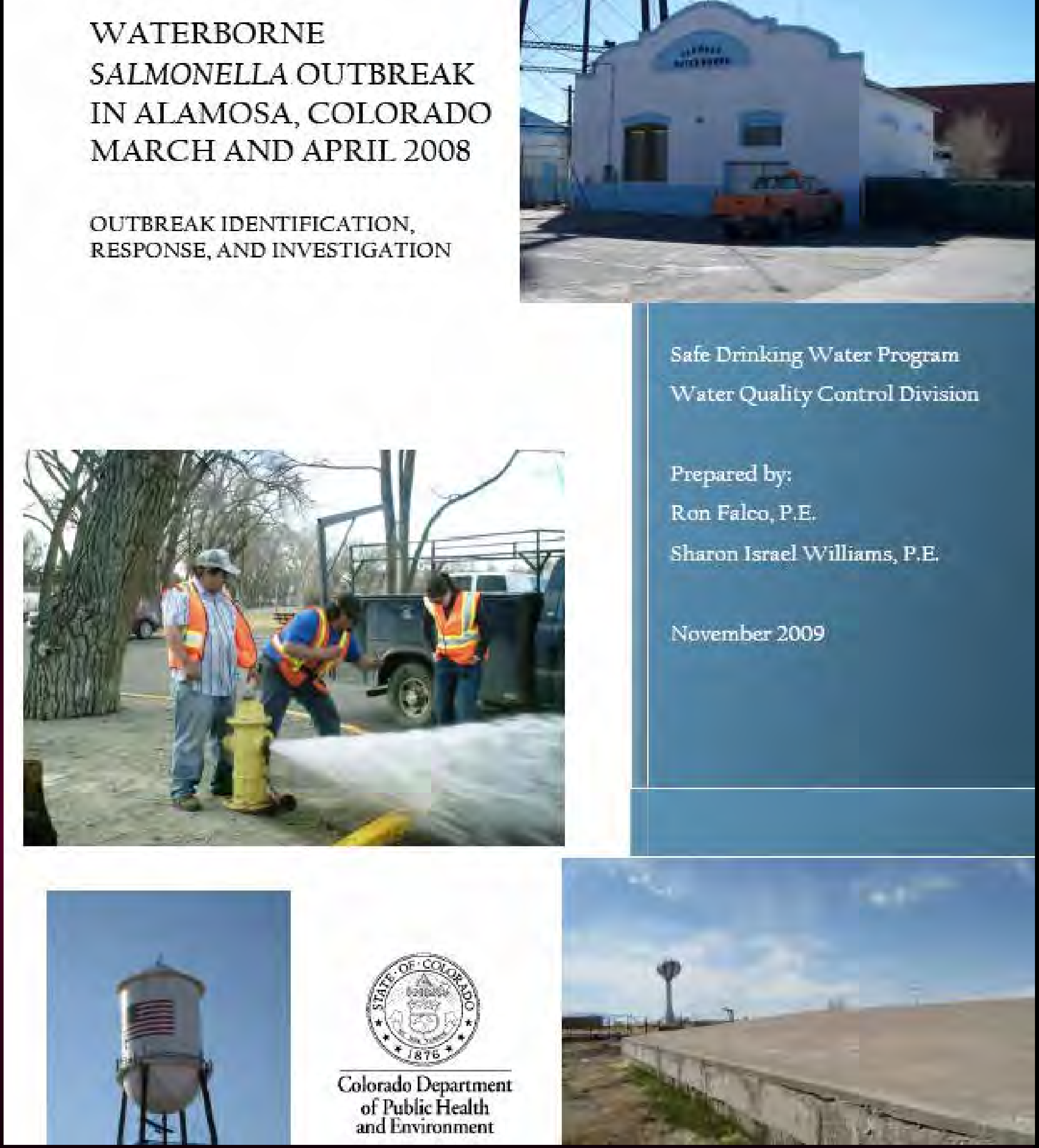
Denver Post, The (CO)

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

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:



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.

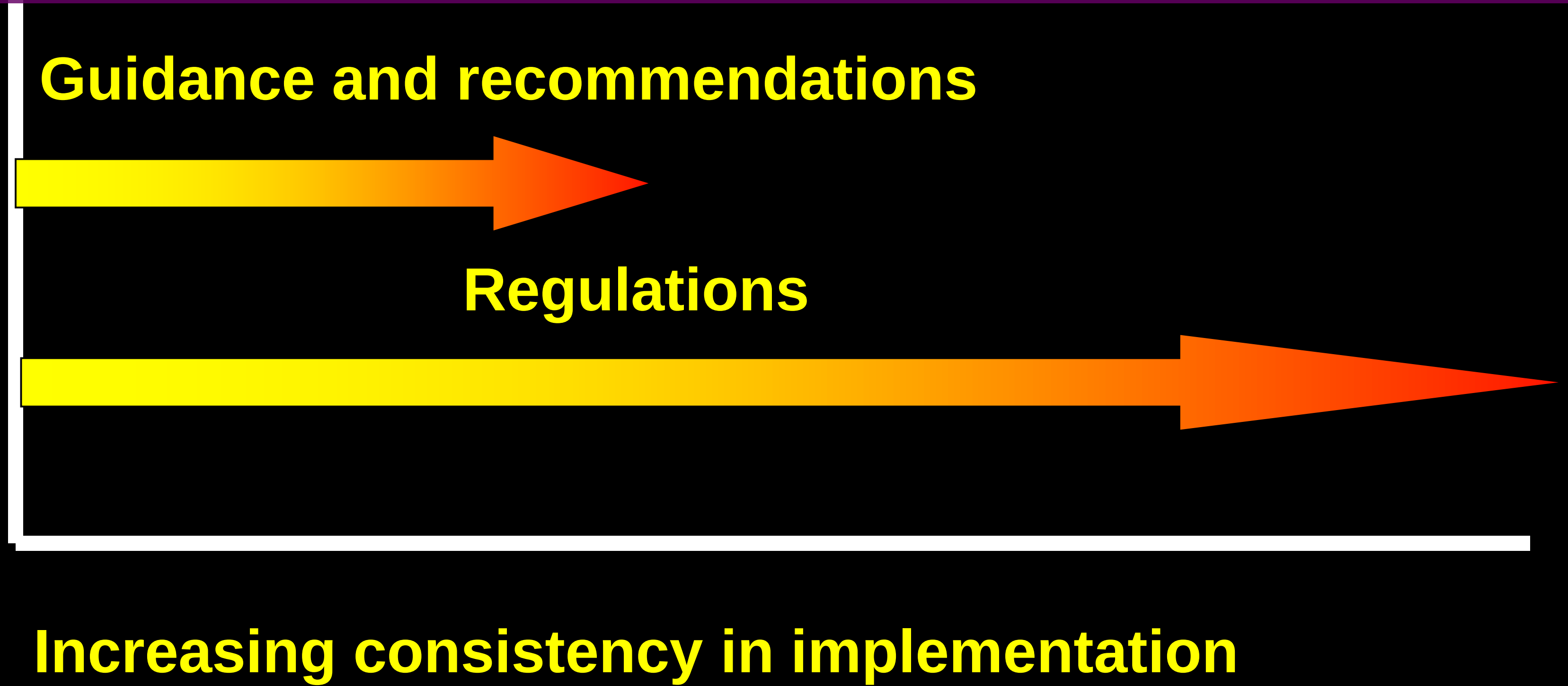
November 2009

Colorado Department of Public Health and Environment

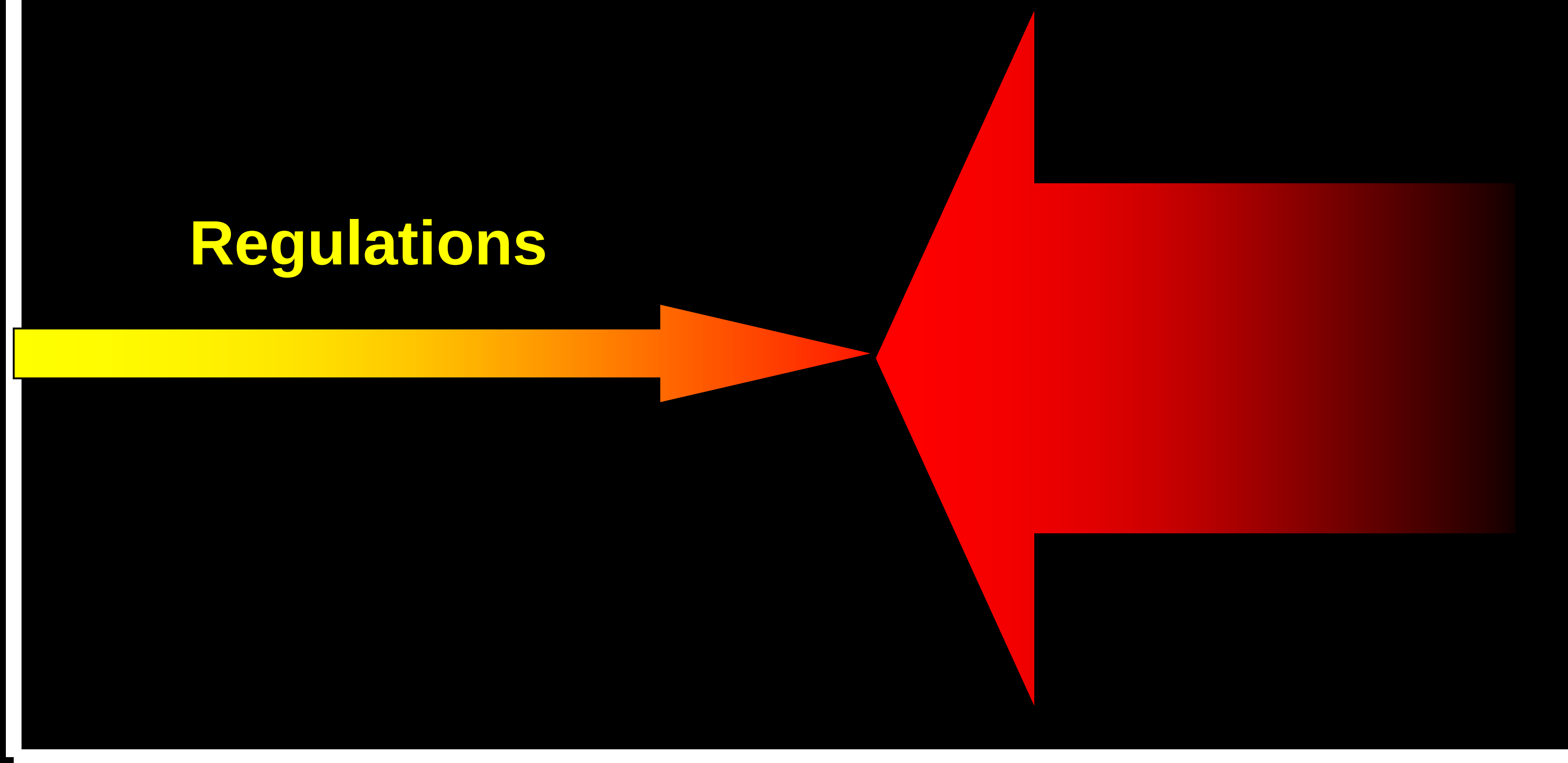
www.cdphe.state.us/wq/drinkingwater/AlamosaOutbreak

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.



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



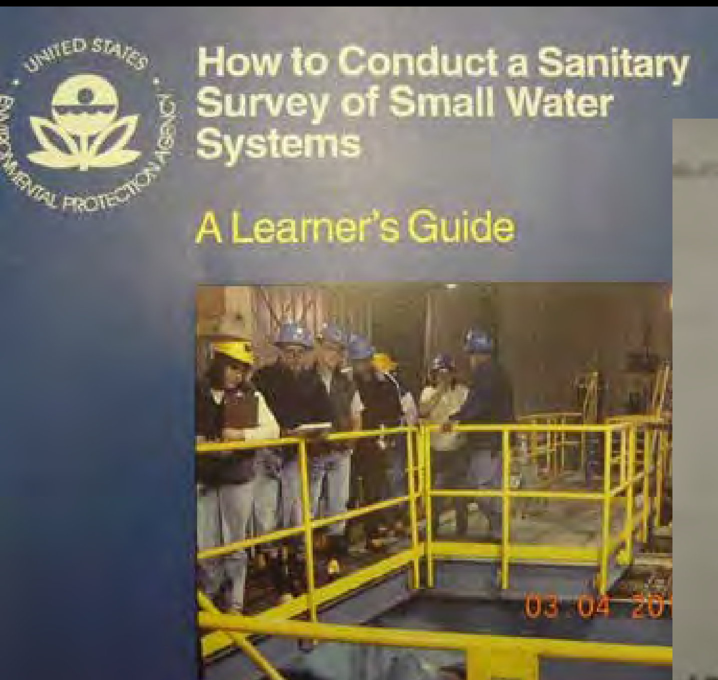
Increasing consistency in implementation

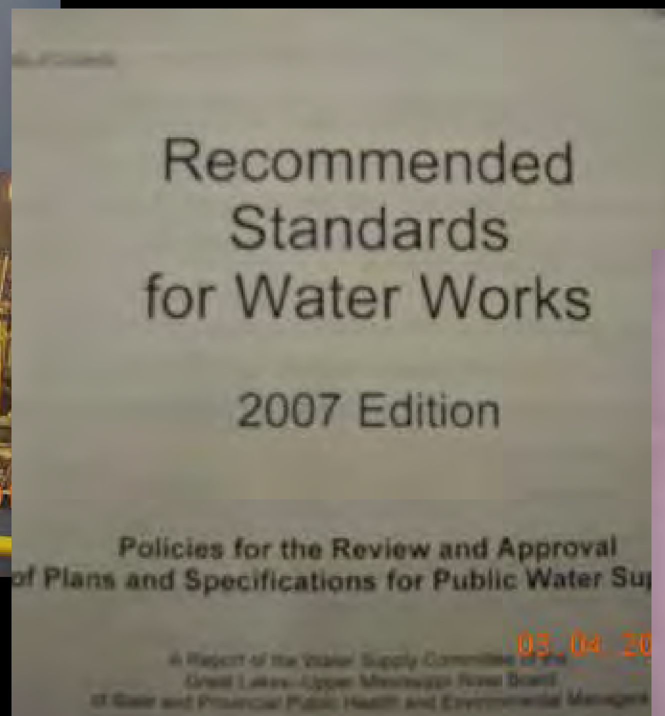
Can we rely on simple common sense?

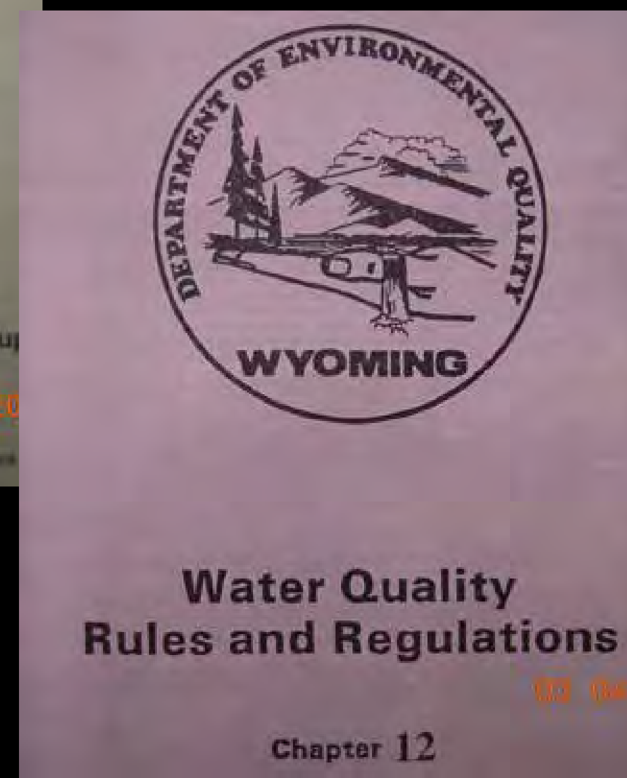
This is an open finished water reservoir in a major city. In the decades it has been in use, common sense never prevailed to cover this reservoir. In fact, it never prevailed at ~150 open reservoirs serving tens of millions in some of America's largest cities. EPA had to create regs to protect people 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.







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. According to a Committee Member for Ten State Standards the 2018 revision will require #24 mesh screen on both elevated and ground level tank vents and overflows.

Finally, as of November, 2016,
we have a guidance document that, for the first time ever in the history of storage tank guidances, describes <u>very best sanitary integrity practices</u> 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 NOVEMBER 2016 EDITION

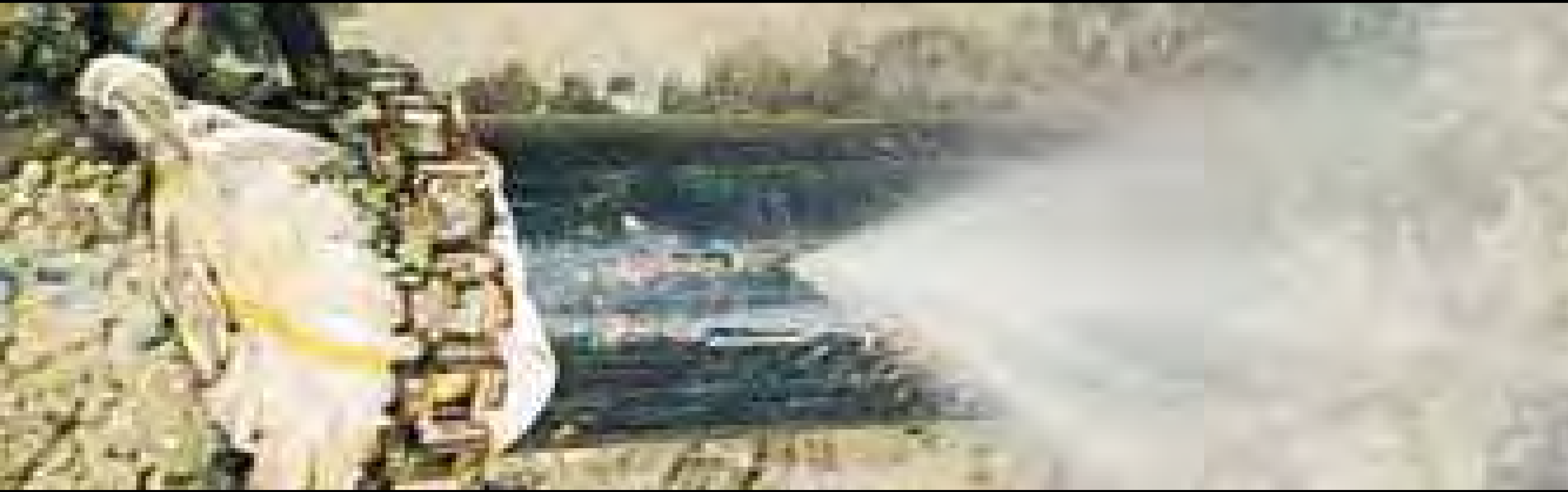
How to Conduct a Sanitary Survey of

{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.

A Learner's Guide

DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE NOVEMBER 2016 EDITION

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



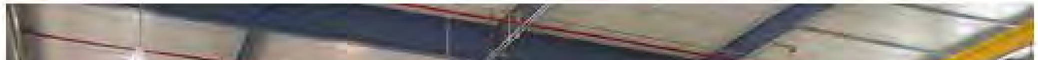
Drinking water pipes are placed in a hostile environment.
Sewage and storm pipes are always leaking.
Although sewage pipes are supposed to be laid below drinking water pipes, high water tables can bring this contaminated water in direct contact with drinking water pipe.
But, drinking water in a pipe 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.

A Learner's Guide

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

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.

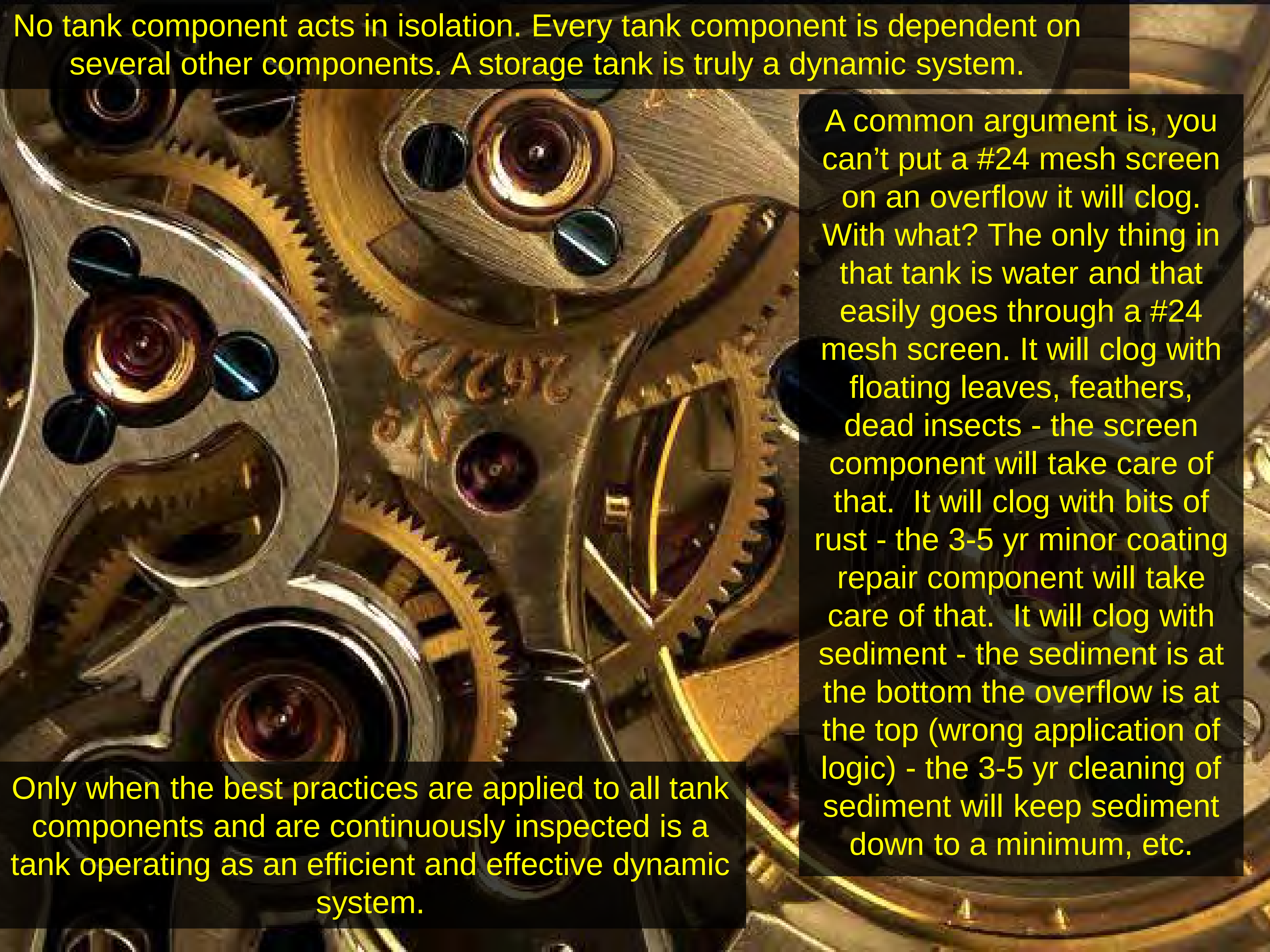
It doesn't matter where the research is done, 20 to 30 % of the microbes in dust are known pathogens to some animal on the planet

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.

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



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

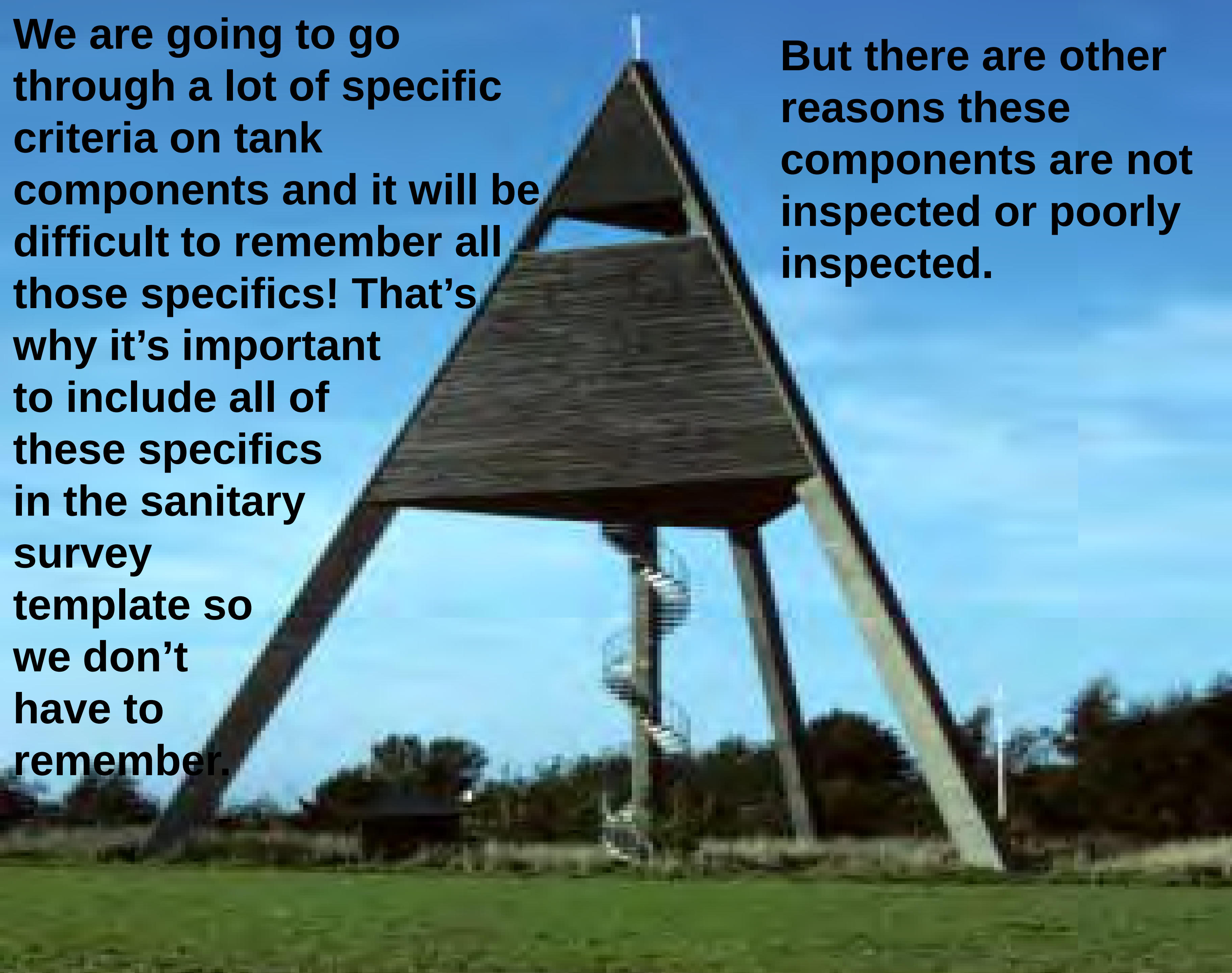
A common argument is, you can’t put a #24 mesh screen on an overflow it will clog. With what? The only thing in that tank is water and that easily goes through a #24 mesh screen. It will clog with floating leaves, feathers, dead insects - the screen component will take care of that. It will clog with 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.

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.

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!

Sanitary Survey **page 3**

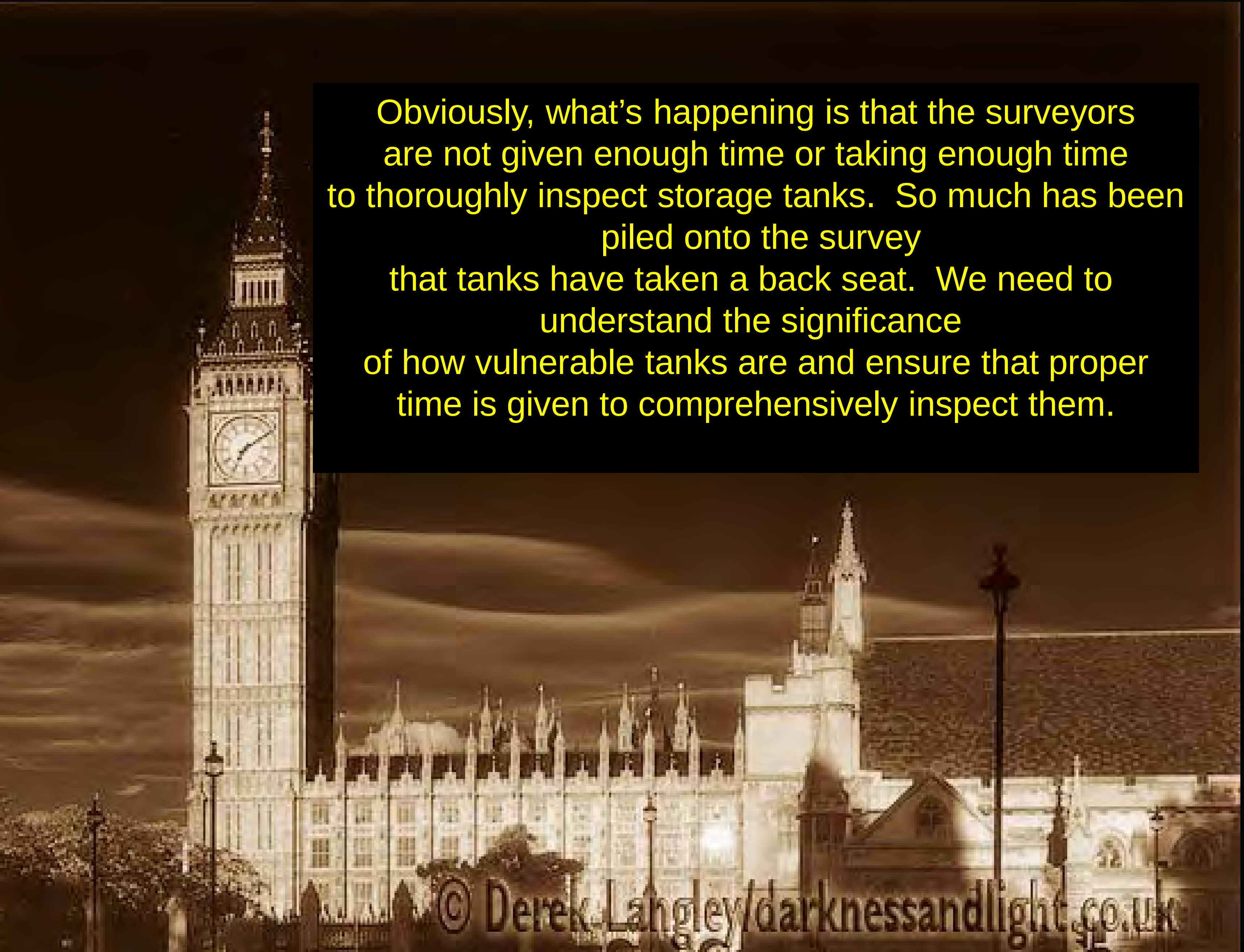
Baloney

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)} <u>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.</u>

A Learner's Guide

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

How to Conduct a Sanitary Survey of Drinking Water Systems

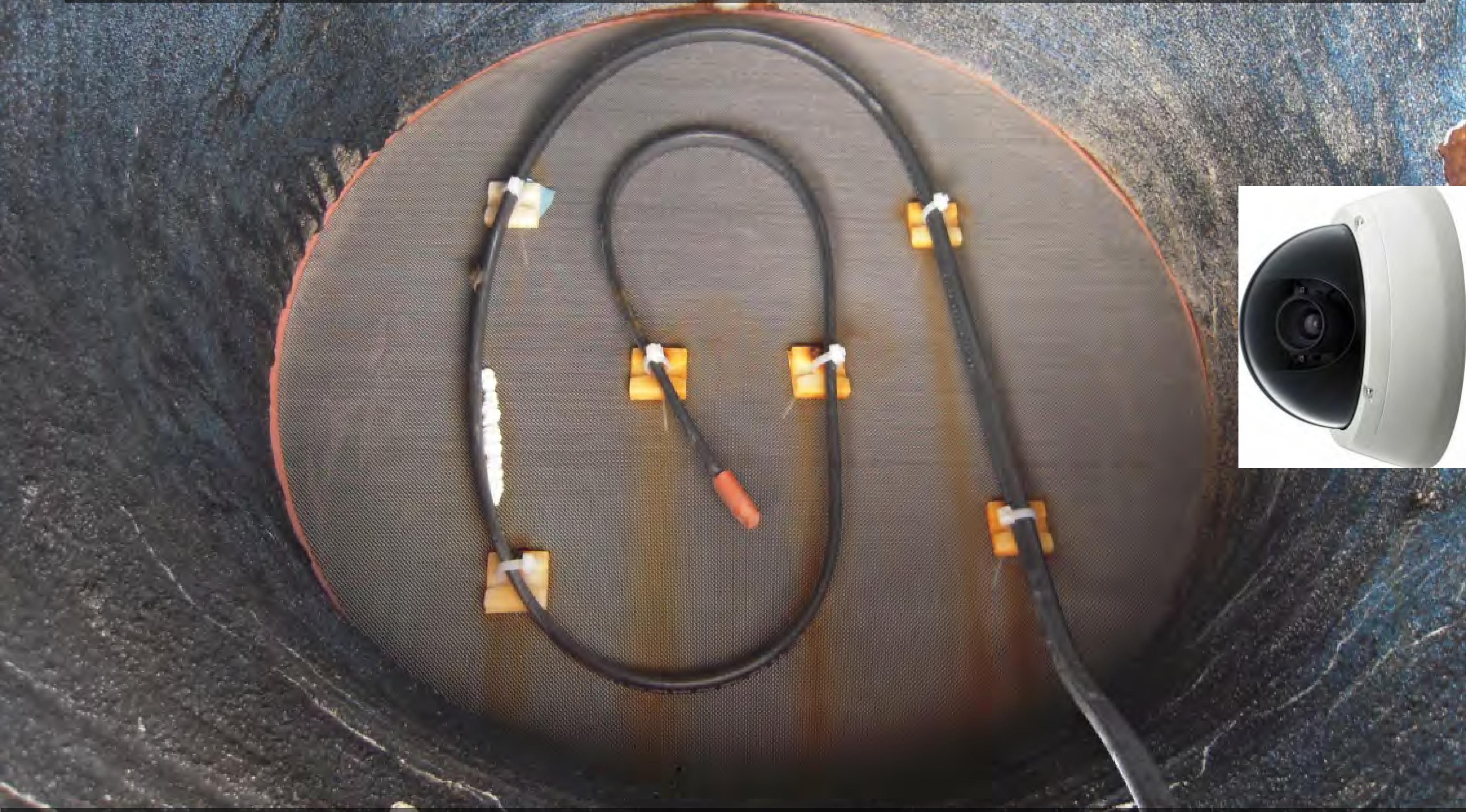
{Section 10.4.10 #12, Cleaning and inspection(2nd paragraph)} In between these comprehensive inspections, operators must also conduct daily to biweekly (twice a week) inspections to observe the key components of the tank, like the vent and overflow, and look for holes in the tank. Systems need to conduct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

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

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	BC
Saturday July 2, 2015	OK	OK	Leaking - check telemetry	OK	OK	OK	BC
Sunday July 3, 2015	Birds roosting- set bird spikes	OK	OK	OK	OK	Antenna connection - needs to be re-caulked	CB
Monday July 4, 2015	OK	Bolt cutter marks on lock - install video	OK	OK	OK	OK	BC
Tuesday July 5, 2015	OK	OK	OK	OK	Spalling concrete SE corner - concrete patch	OK	CB

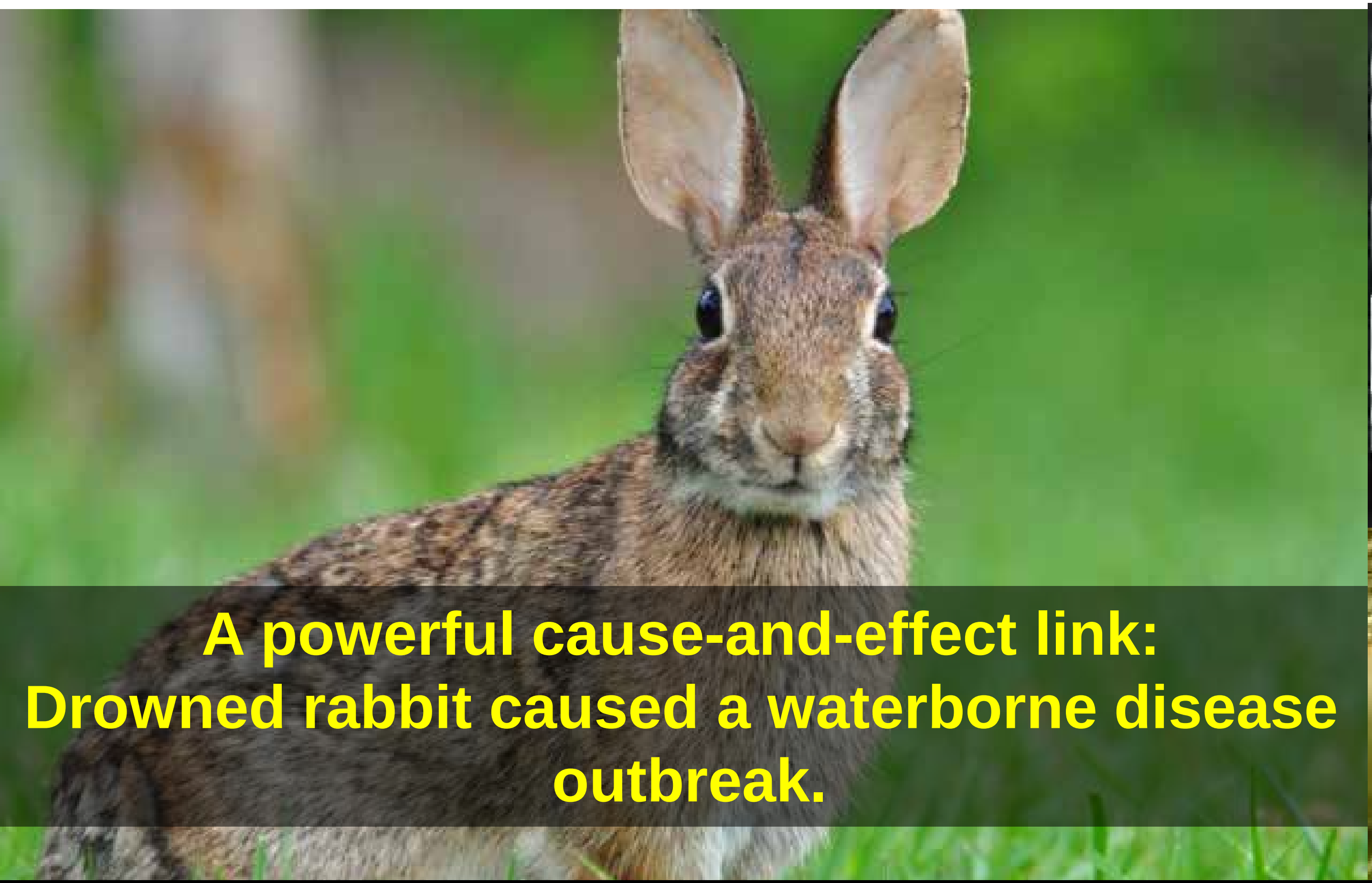
For continuous monitoring of tank components consider installing cameras to view the vent screens, hatches, overflows and entire tank area.



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.

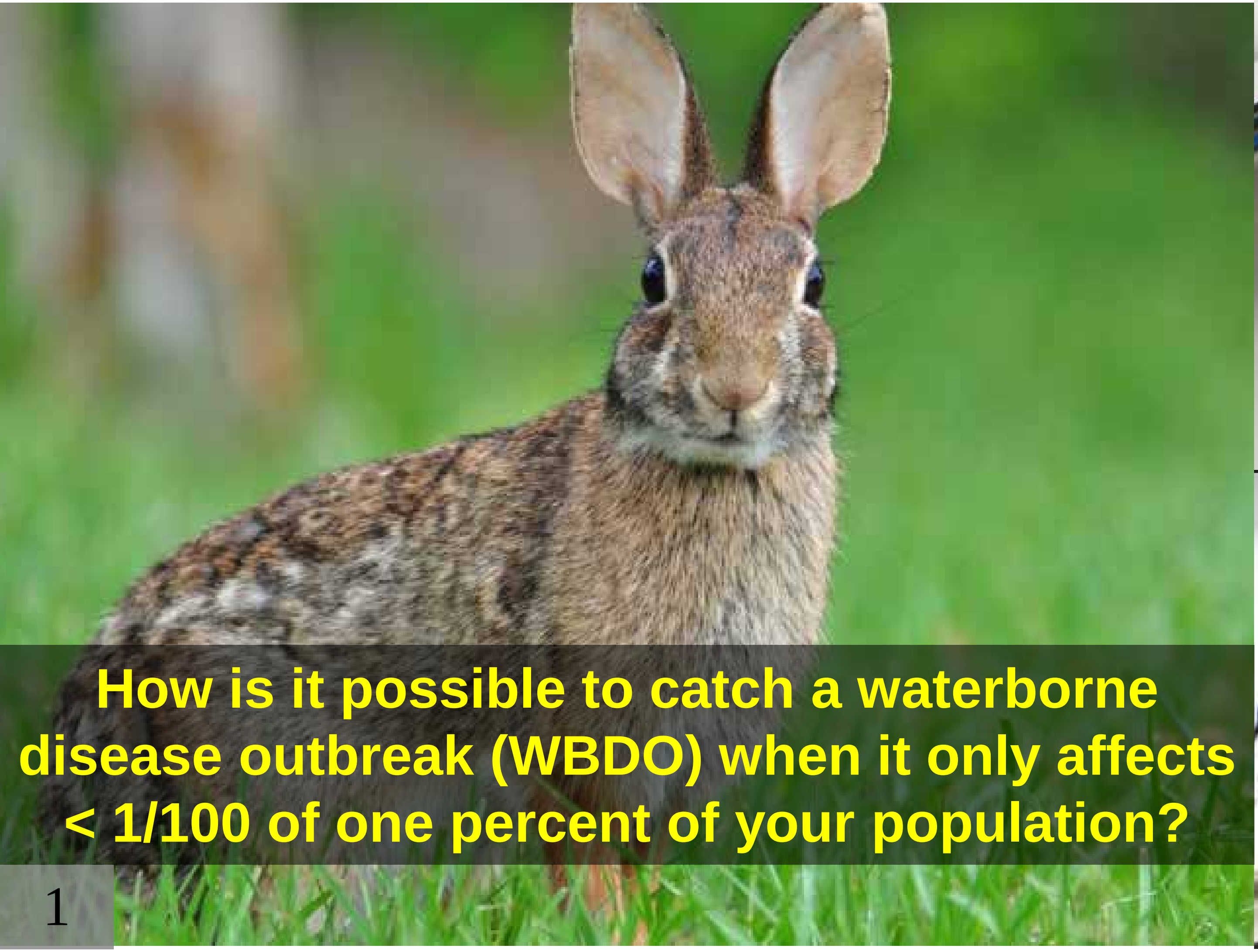
If daily/twice a week inspections are not performed on tanks you risk disaster-like an animal entering through that breach.



A powerful cause-and-effect link: Drowned rabbit caused a waterborne disease outbreak.

Bob Clement, Environmental Engineer M.S./Microbiologist, EPA Region 8, April 17, 2019

The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency

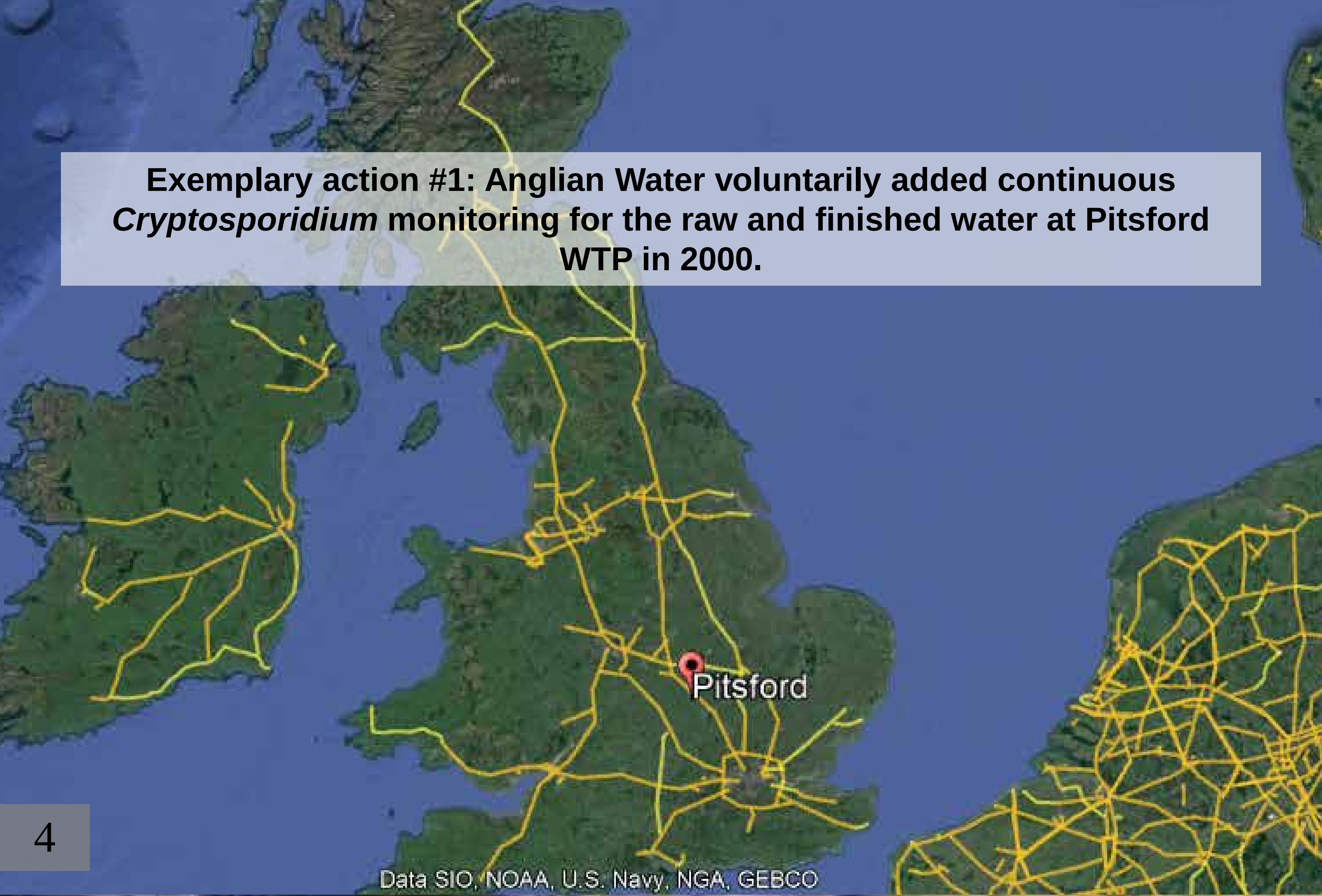

How is it possible to catch a waterborne disease outbreak (WBDO) when it only affects < 1/100 of one percent of your population?

To find this example you need to travel across the “pond”

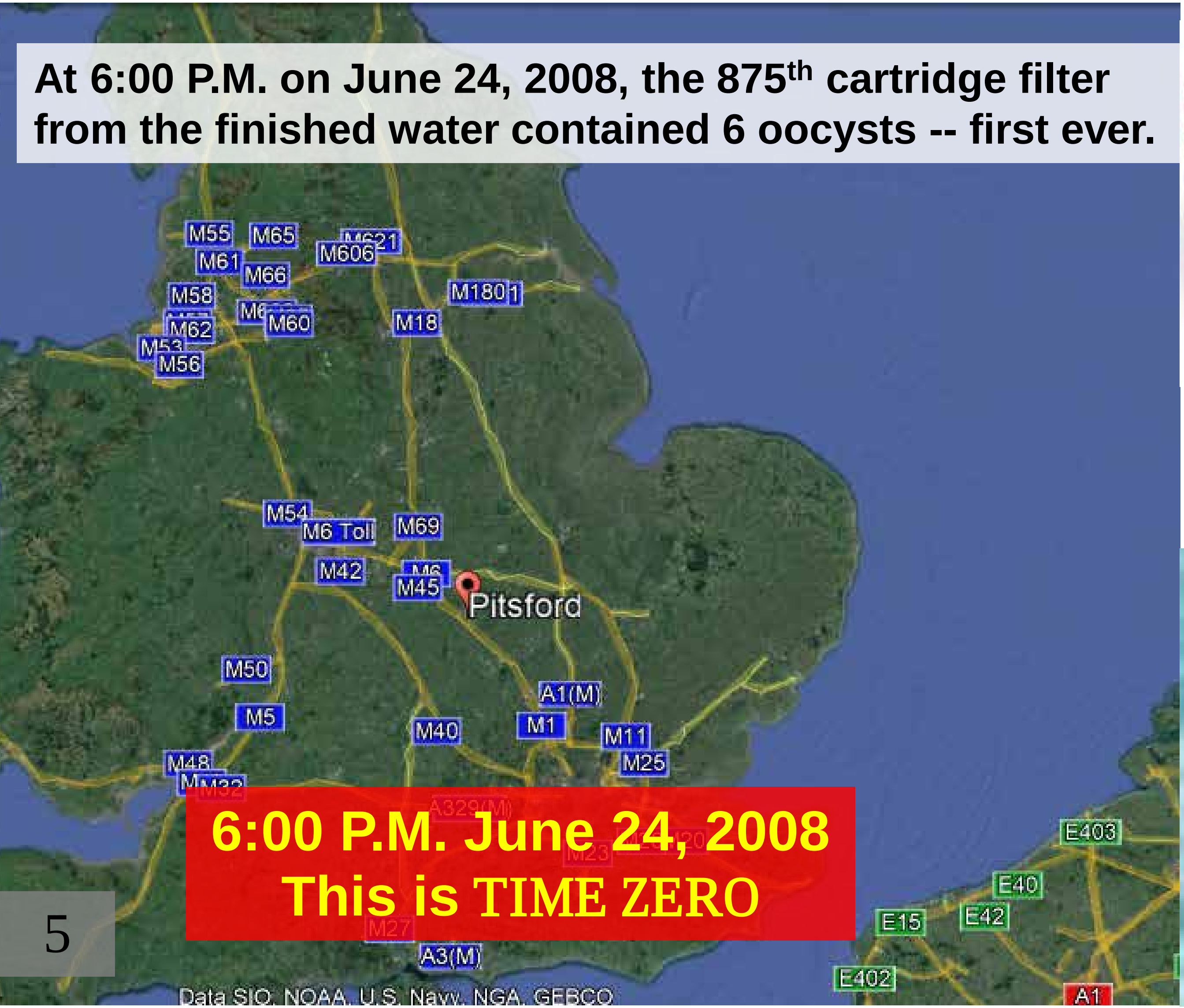
Highly awarded, Anglian Water operates 143 systems serving ~4.3 million in eastern UK.

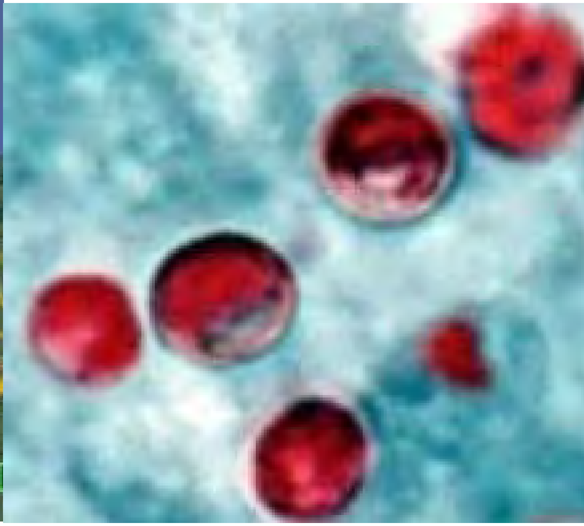
The event occurred in Northhamptonshire, at Pitsford WTP.

Exemplary action #1: Anglian Water voluntarily added continuous *Cryptosporidium* monitoring for the raw and finished water at Pitsford WTP in 2000.



At 6:00 P.M. on June 24, 2008, the 875th cartridge filter from the finished water contained 6 oocysts -- first ever.

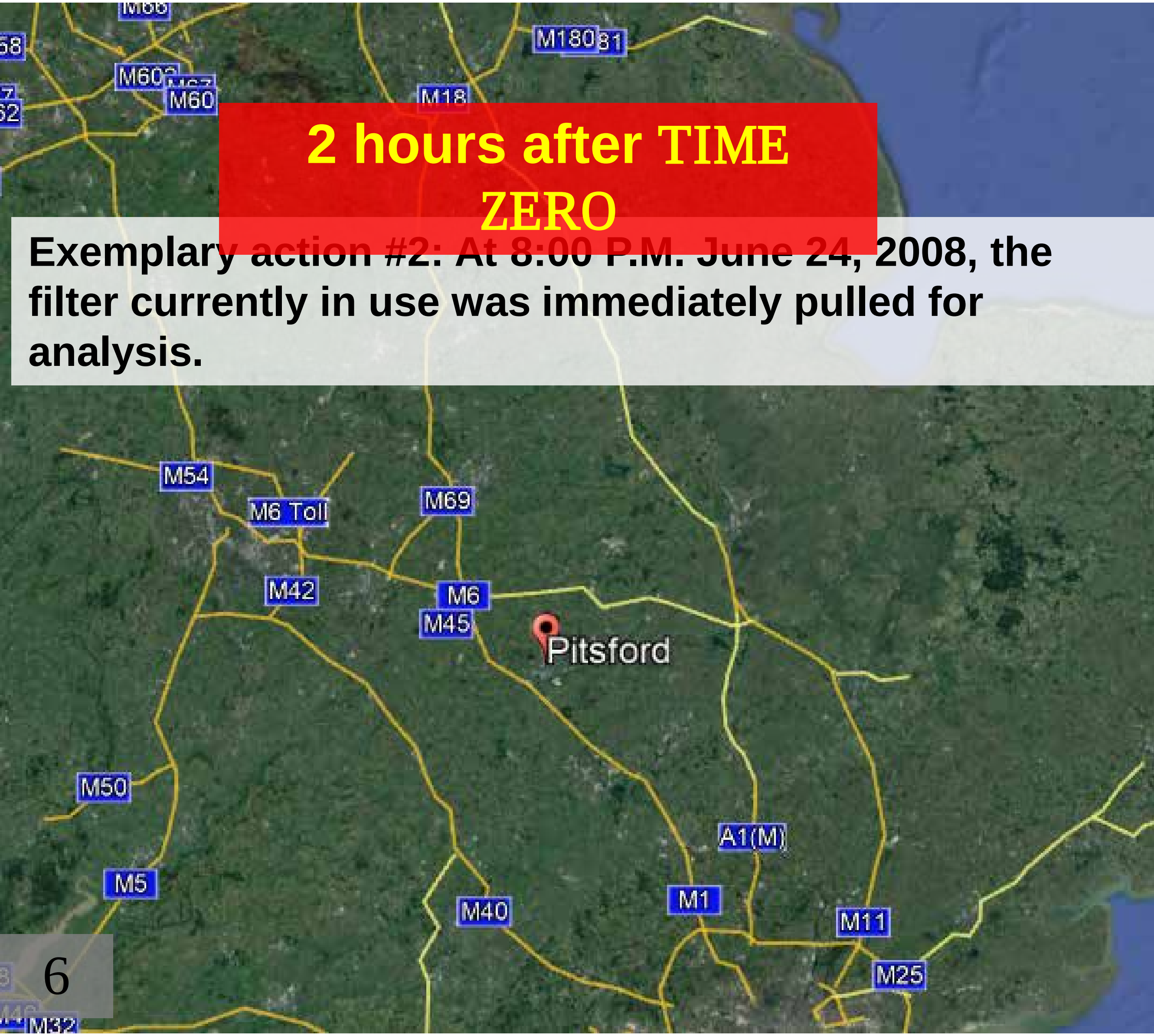


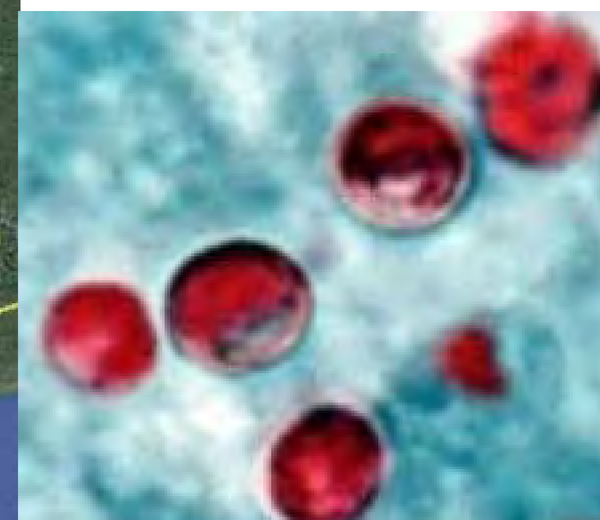


6:00 P.M. June 24, 2008
This is TIME ZERO

2 hours after TIME ZERO

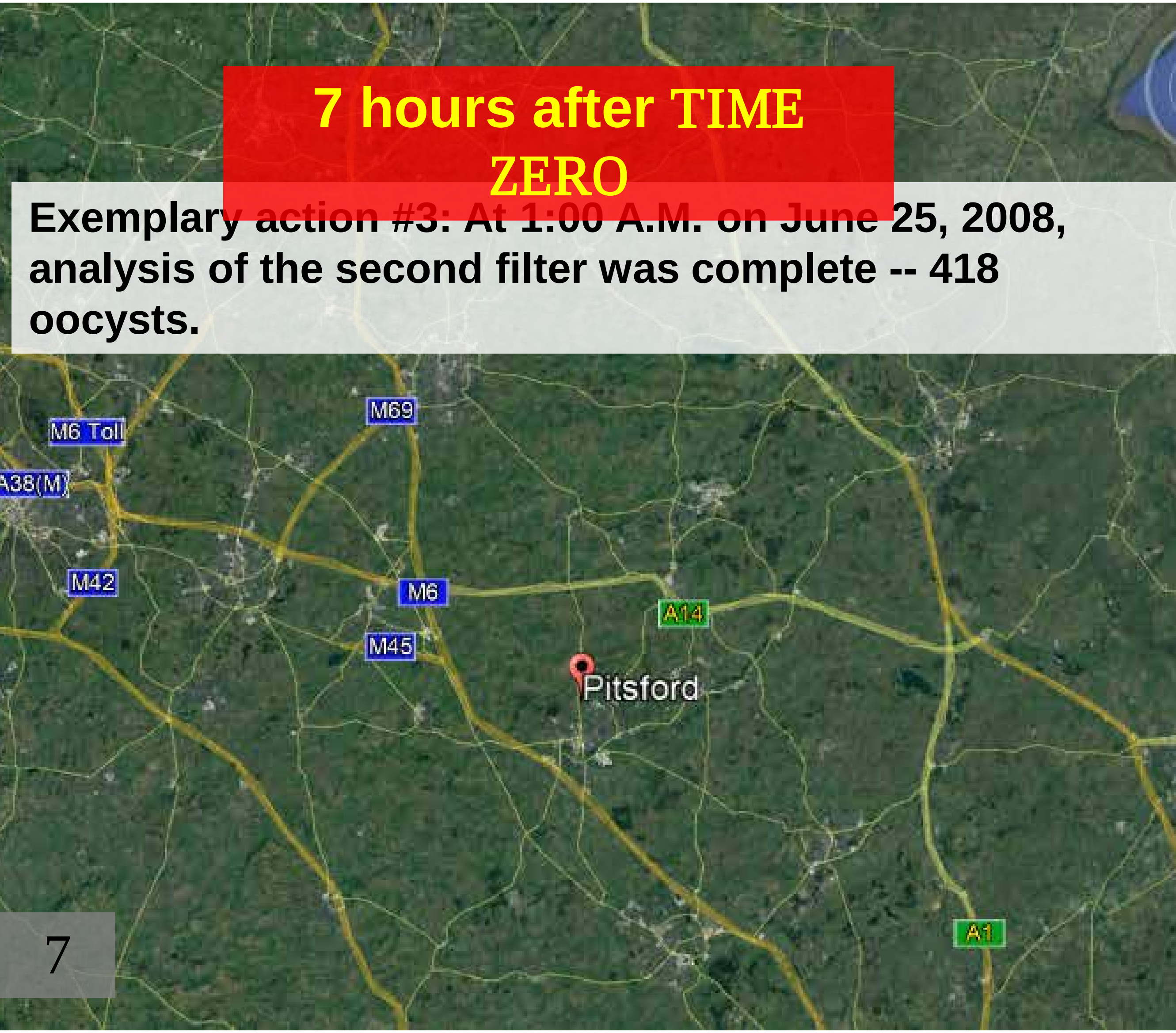
Exemplary action #2: At 8:00 P.M. June 24, 2008, the filter currently in use was immediately pulled for analysis.

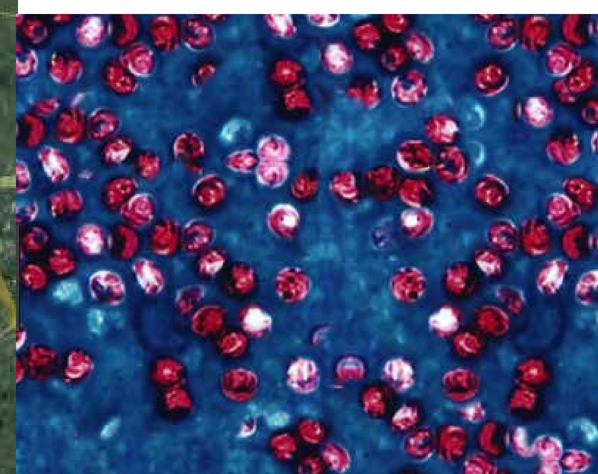




7 hours after TIME ZERO

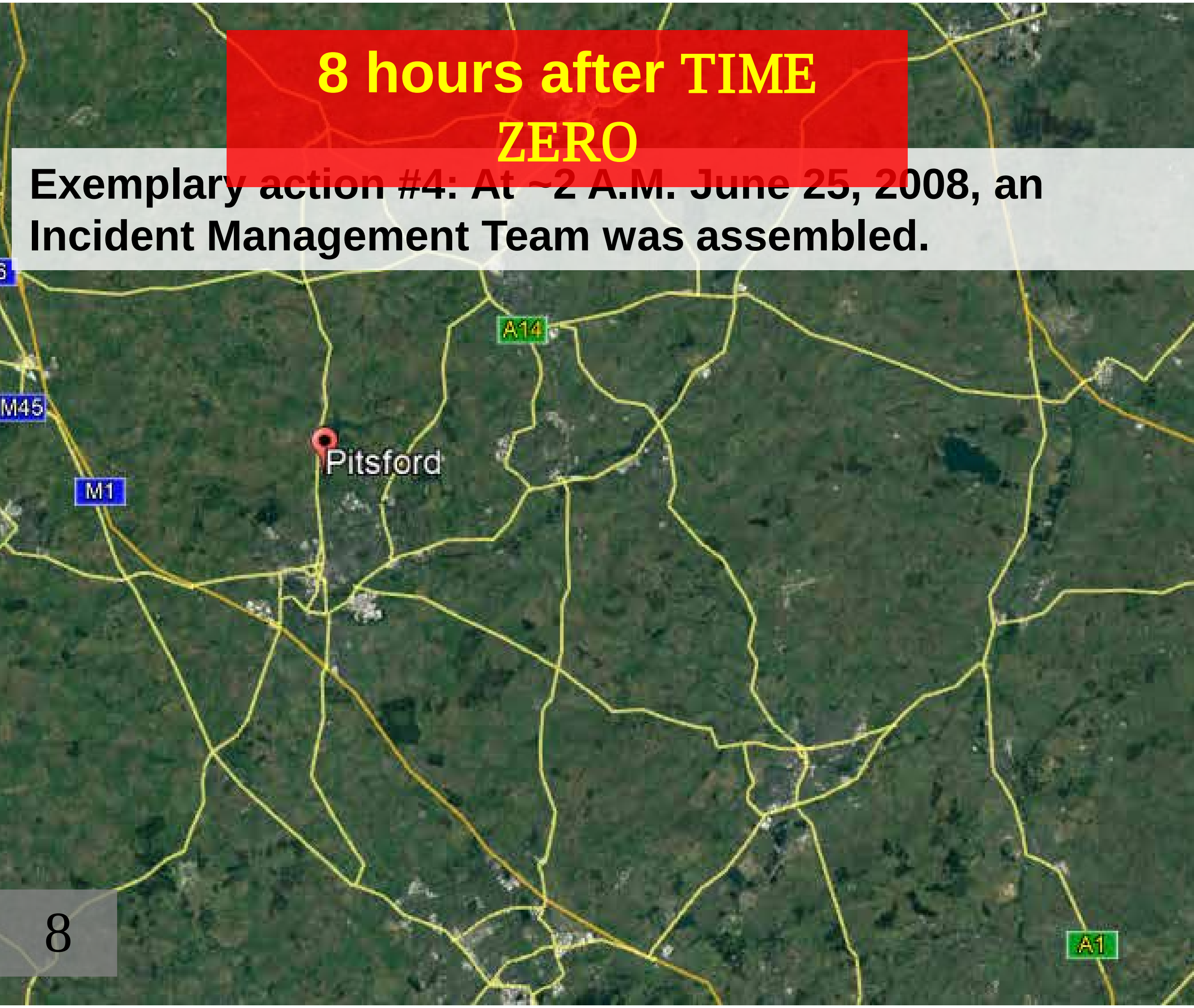
Exemplary action #3: At 1:00 A.M. on June 25, 2008, analysis of the second filter was complete -- 418 oocysts.

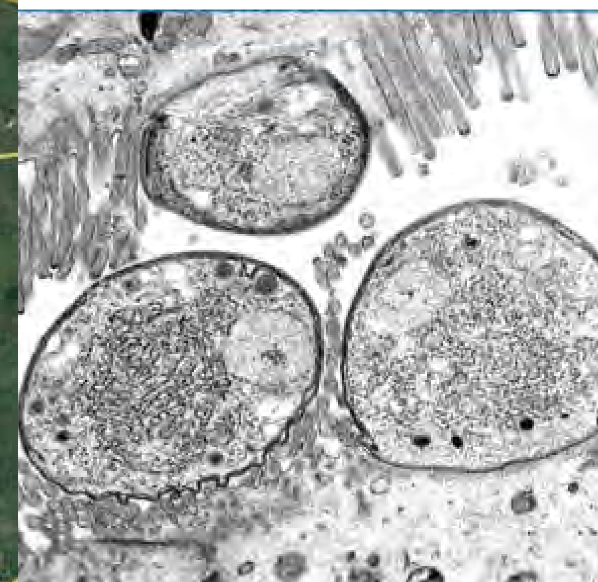




8 hours after TIME ZERO

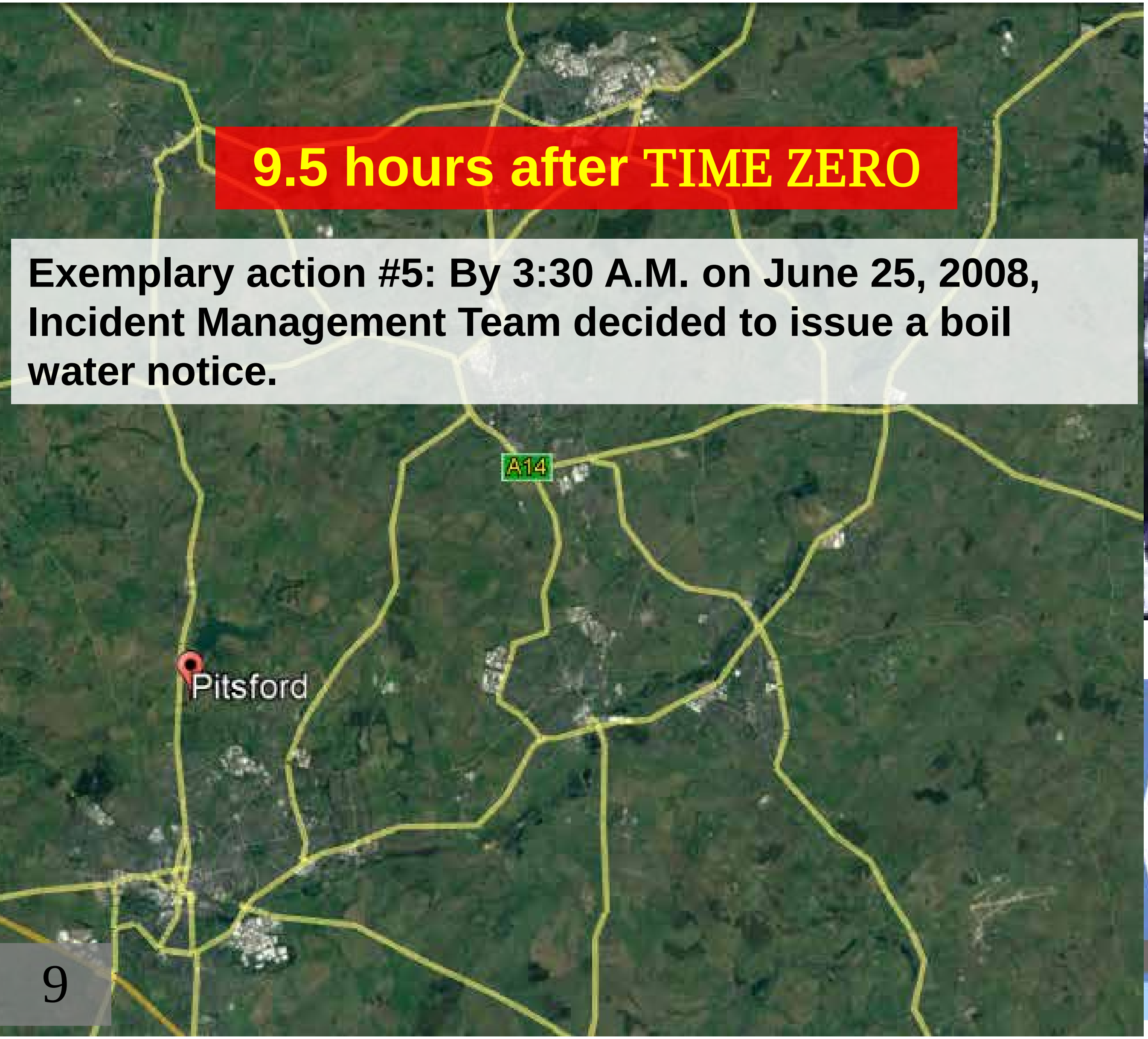
Exemplary action #4: At ~2 A.M. June 25, 2008, an Incident Management Team was assembled.

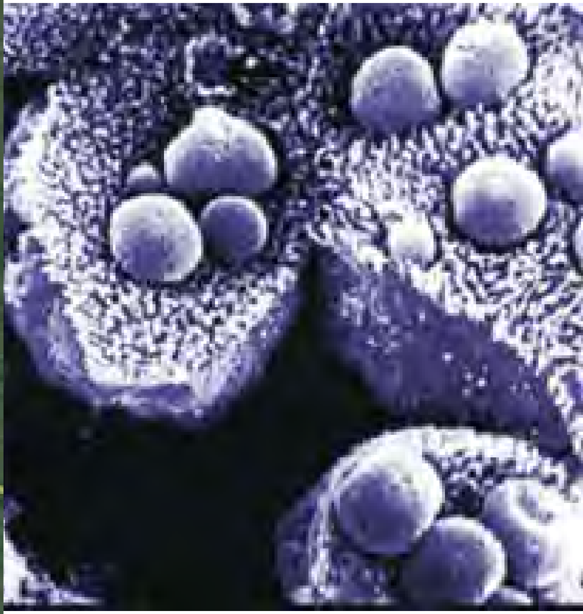




9.5 hours after TIME ZERO

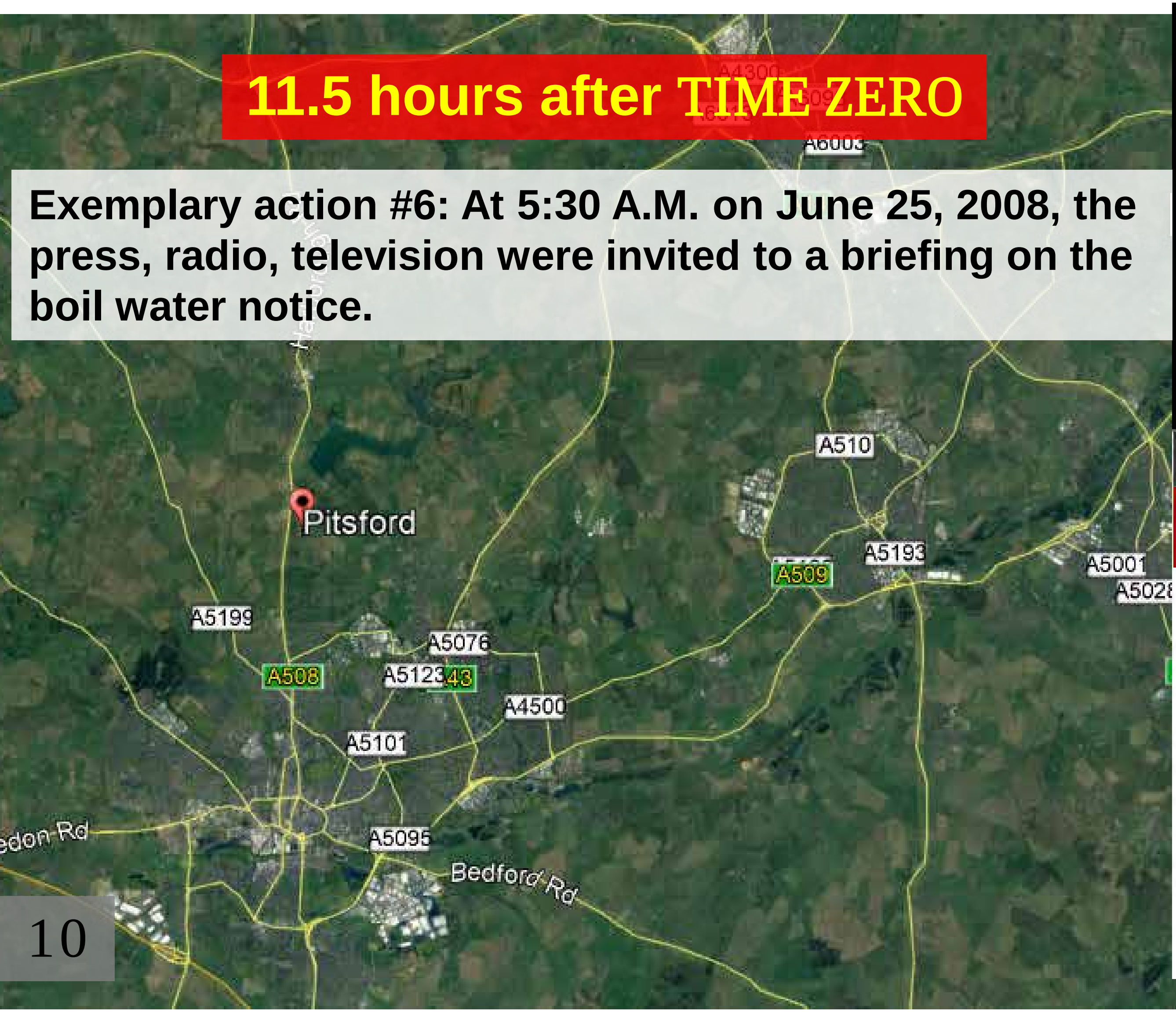
Exemplary action #5: By 3:30 A.M. on June 25, 2008, Incident Management Team decided to issue a boil water notice.

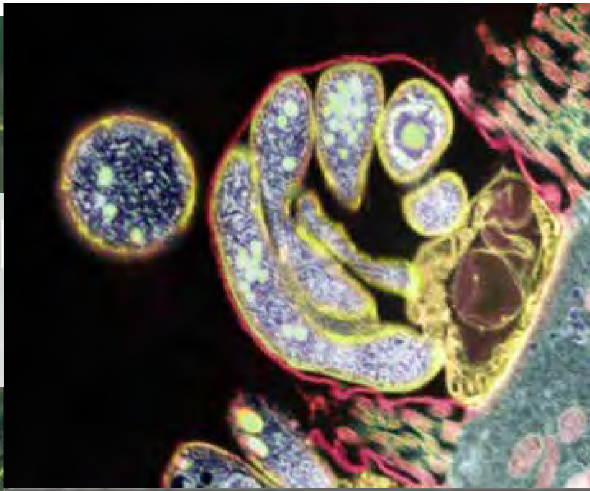




11.5 hours after TIME ZERO

Exemplary action #6: At 5:30 A.M. on June 25, 2008, the press, radio, television were invited to a briefing on the boil water notice.





Rabbit contaminated water supply

A rabbit has been named as the cause of a sickness bug which was found in water supplies in Northamptonshire.

Customers in 100,000 homes were told by Anglian Water to boil tap water for up to 10 days after the Cryptosporidium outbreak on 25 June.

Water supplies were declared safe on 4 July

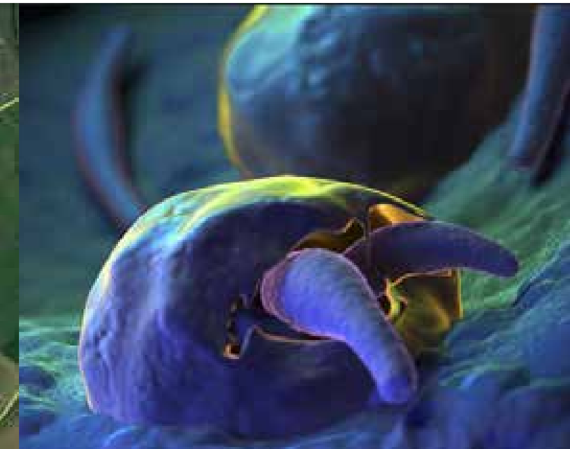
The firm said a rabbit gaining access to the treatment process led to the bug at Pitsford Treatment works.

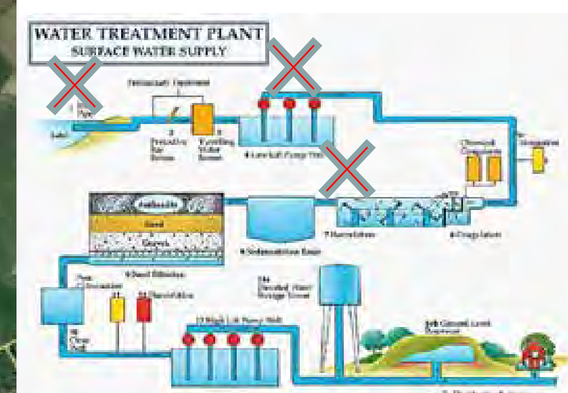
"We have already taken steps to ensure this cannot happen again," Peter Simpson, of Anglian Water, said.

"We have concluded that this occurrence was due to a combination of unusual circumstances."

14 hours after TIME ZERO

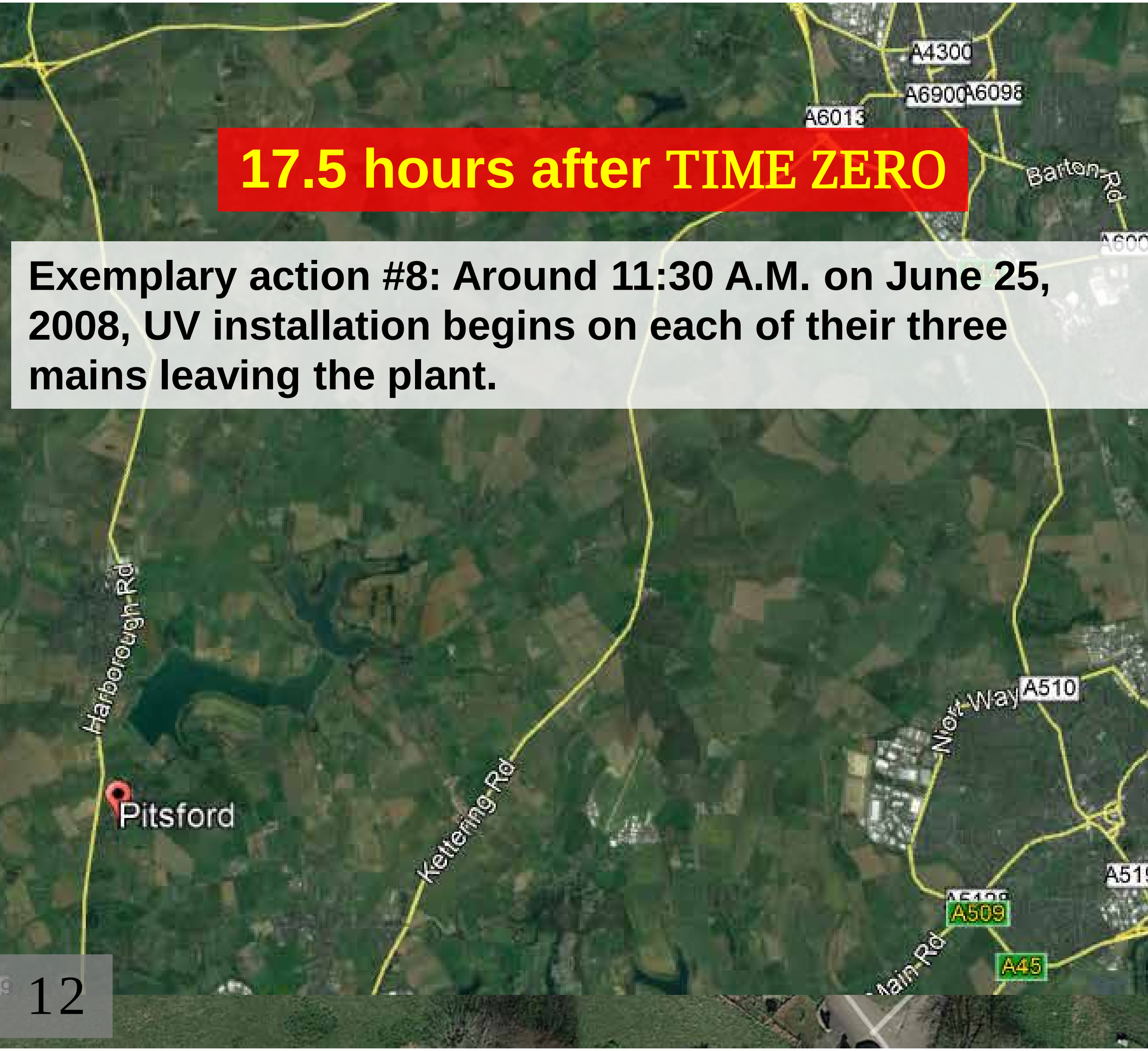
Exemplary action #7: At 8:00 A.M. (estimated) June 25, 2008, crypto sampling begins after each major unit process.

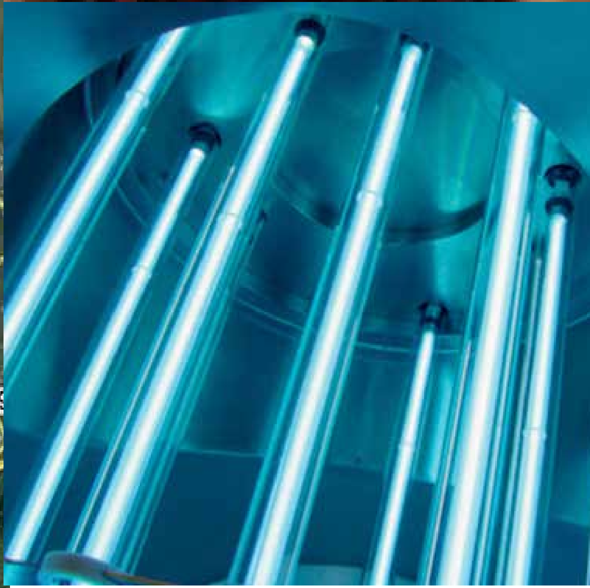




17.5 hours after TIME ZERO

Exemplary action #8: Around 11:30 A.M. on June 25, 2008, UV installation begins on each of their three mains leaving the plant.





24 hours after TIME ZERO

Exemplary action #9: By 6:00 P.M. on June 25, 2008, warning card delivery began and completed 24 hours later.

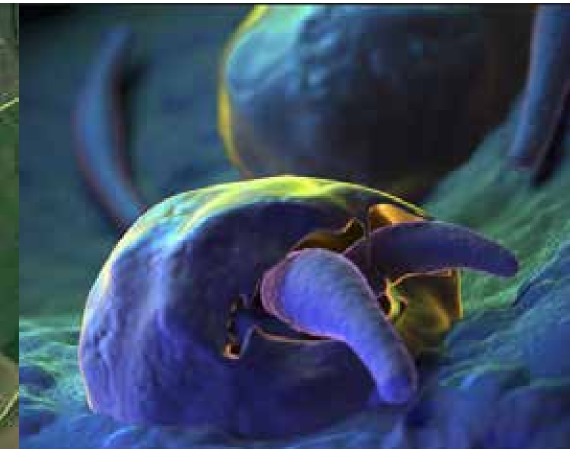
1 day 14 hours after TIME ZERO

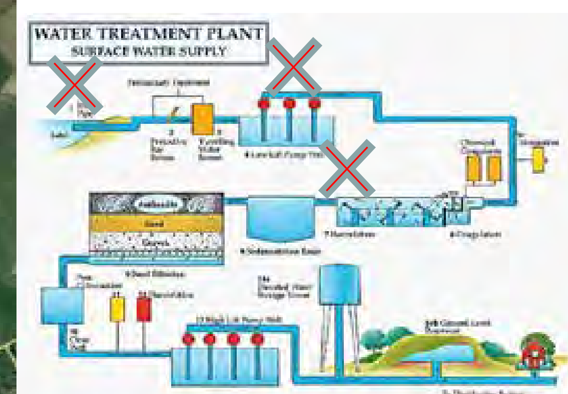
Exemplary action #10: By 8:00 A.M. (estimated) June 26, 2008, crypto sampling begins in homes and confirms oocyst contamination.

Distribution system

1 day 18 hours after TIME ZERO

Exemplary action #11: Noon (estimated) June 26, 2008, one positive crypto sample was found at both the outlet of the GAC and the chlorine contact basin.



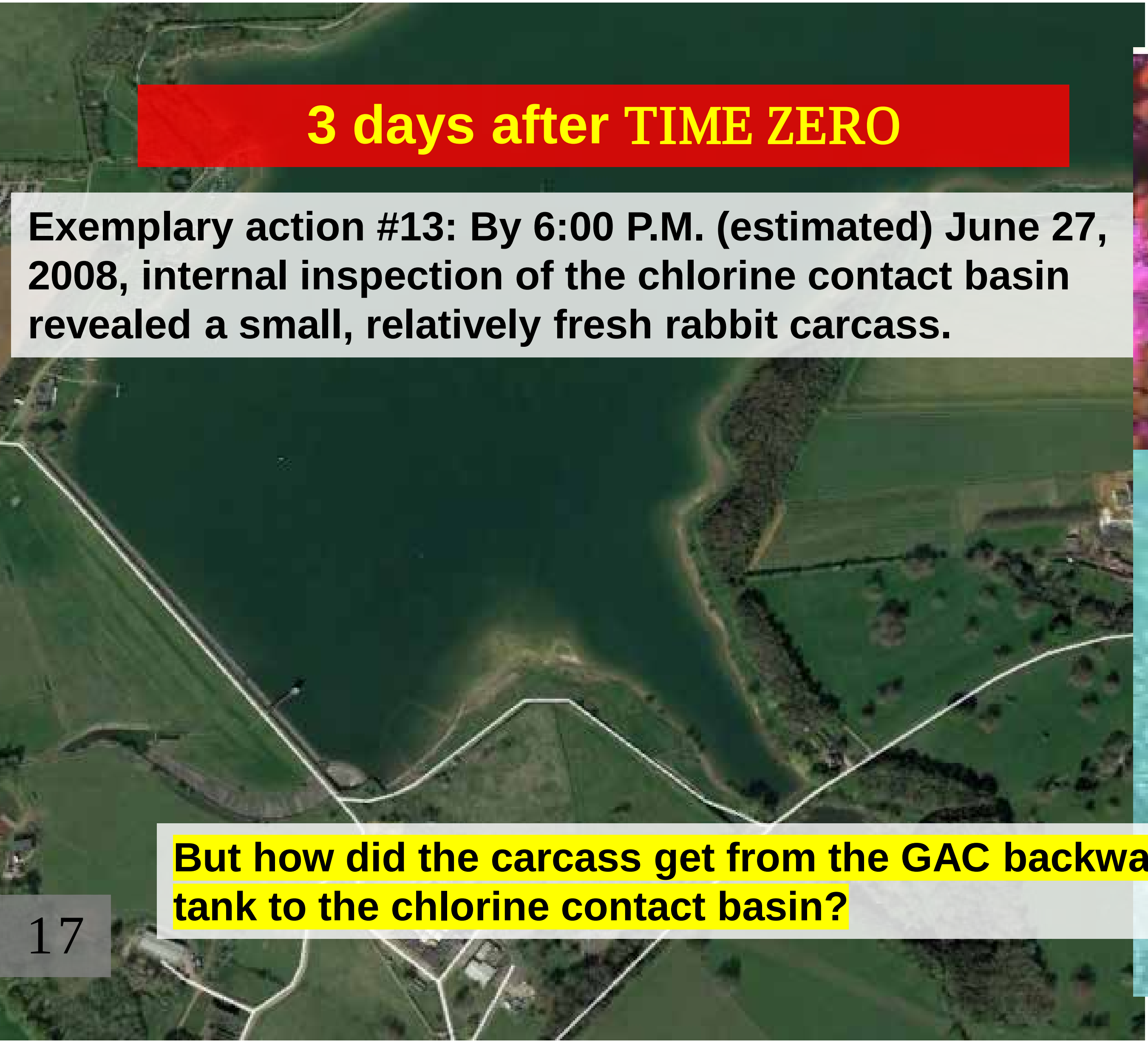


2 days after TIME ZERO

Exemplary action #12: By 6:00 P.M. (estimated) June 26, 2008, external inspection found a missing vent screen on the GAC backwash tank. No animals were found.

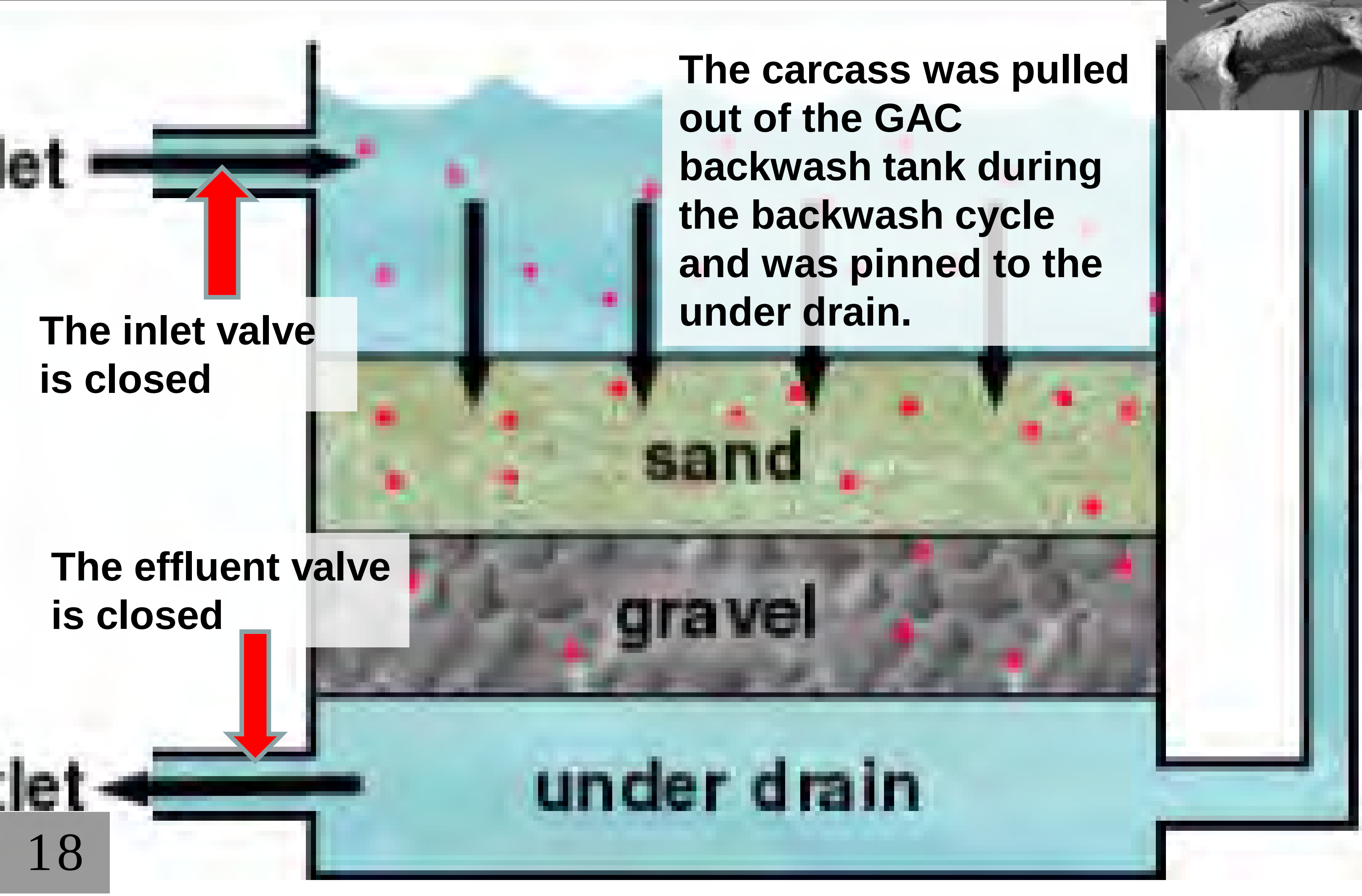
3 days after TIME ZERO

Exemplary action #13: By 6:00 P.M. (estimated) June 27, 2008, internal inspection of the chlorine contact basin revealed a small, relatively fresh rabbit carcass.



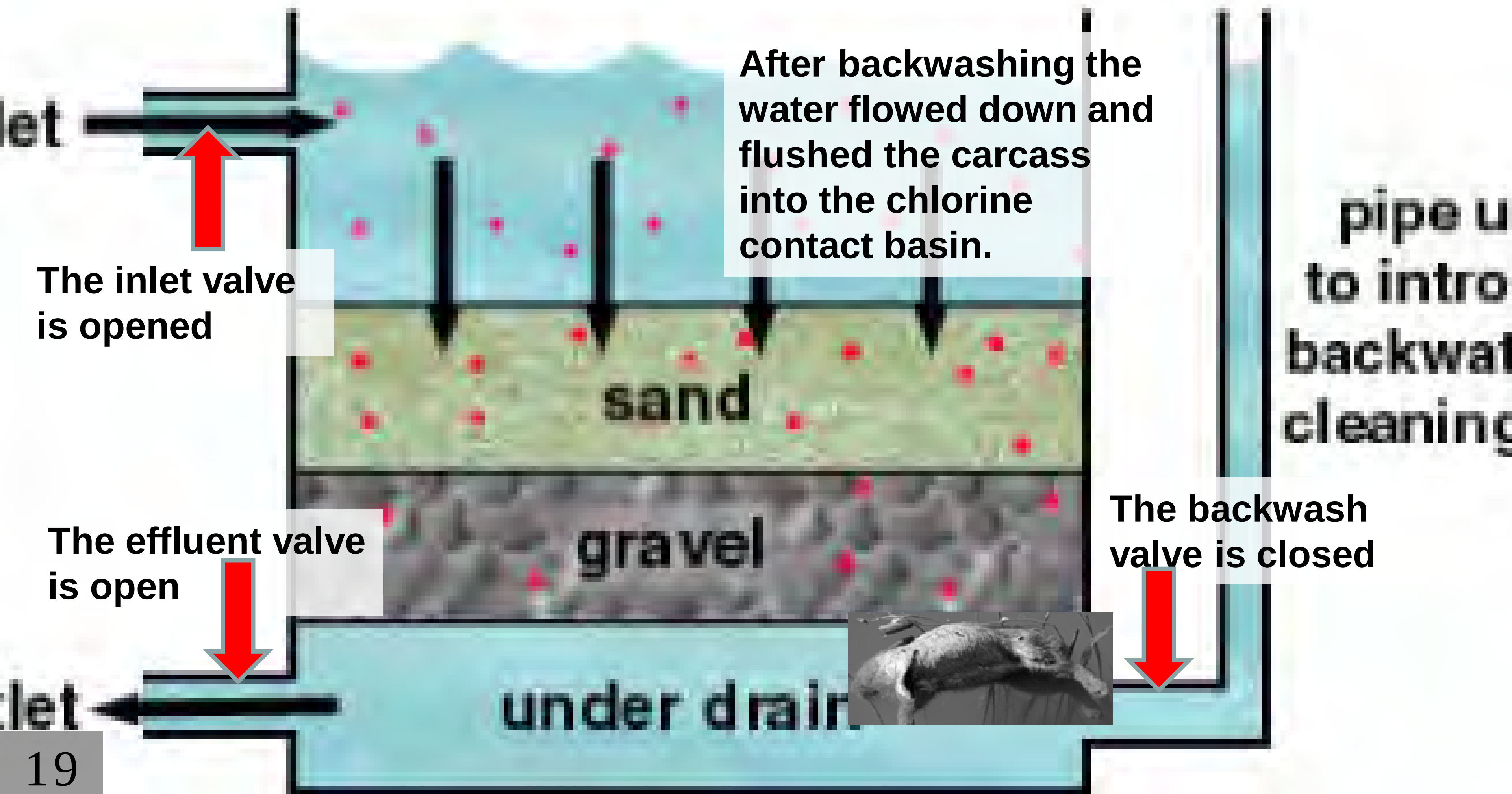
But how did the carcass get from the GAC backwash tank to the chlorine contact basin?

The carcass was pulled out of the GAC backwash tank during the backwash cycle and was pinned to the under drain.



The inlet valve is closed

The effluent valve is closed


After backwashing the water flowed down and flushed the carcass into the chlorine contact basin.
The inlet valve is opened
sand
gravel
The effluent valve is open
The backwash valve is closed
under drain

10 days after TIME ZERO

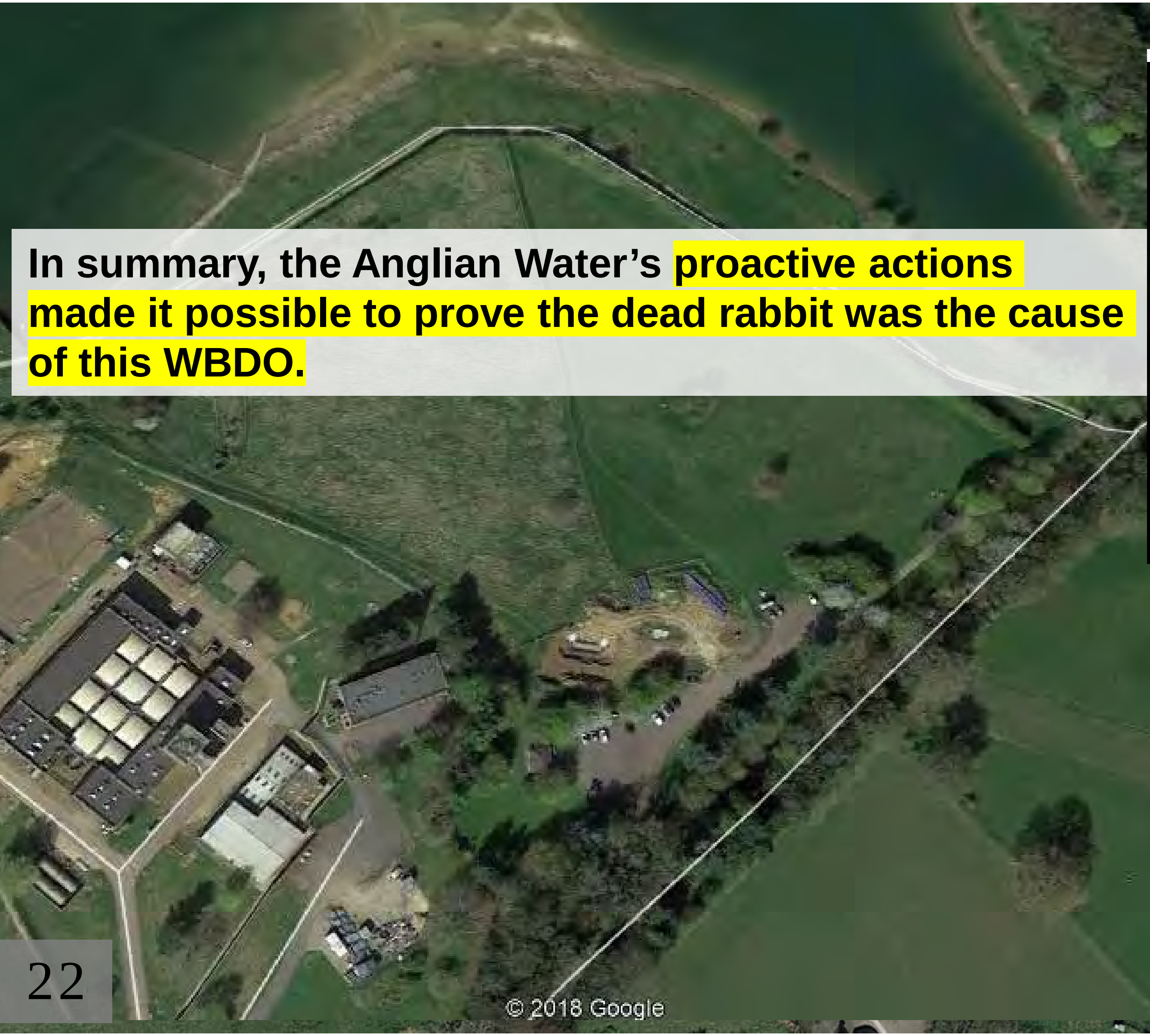
Exemplary action #14: Prior to the boil water notice being lifted on July 4, 2008, the following significant efforts were made to purge the oocysts:

- **All treatment processes and storage tanks were drained, flushed and disinfected.**
- **Over 1,000 miles of distribution pipes were flushed.**
- **Crypto levels decreased as the tanks and pipes were unilaterally cleaned.**

1 month 7 days after TIME ZERO

The final Incident Management meeting was held on July 31, 2008. In just 37 days their extraordinary efforts led to:

- **342 crypto samples being taken over a 12-day period.**
- **DNA analysis performed by the UK reference laboratory on the oocysts from the rabbit carcass, the oocysts from 7 water samples collected in the distribution system and the oocysts collected from 9 stool samples all showed the same genotype (DNA) from the rabbit.**
- **This evidence directly linked the rabbit to the cause of cryptosporidiosis in these 22 cases of human illness.**
- **This is the first time rabbit *Cryptosporidium* has been demonstrated to cause illness in humans.**



In summary, the Anglian Water's proactive actions made it possible to prove the dead rabbit was the cause of this WBDO.

BBC Sign in News Spor

NEWS LIVE BBC NEWS CHANNE

Rabbit contaminated water supply

A rabbit has been named as the cause of a sickness bug which was found in water supplies in Northamptonshire.

Customers in 100,000 homes were told by Anglian Water to boil tap water for up to 10 days after the Cryptosporidium outbreak on 25 June.

Water supplies were declared safe on 4 July

The firm said a rabbit gaining access to the treatment process led to the bug at Pitsford Treatment works.

"We have already taken steps to ensure this cannot happen again," Peter Simpson, of Anglian Water, said.

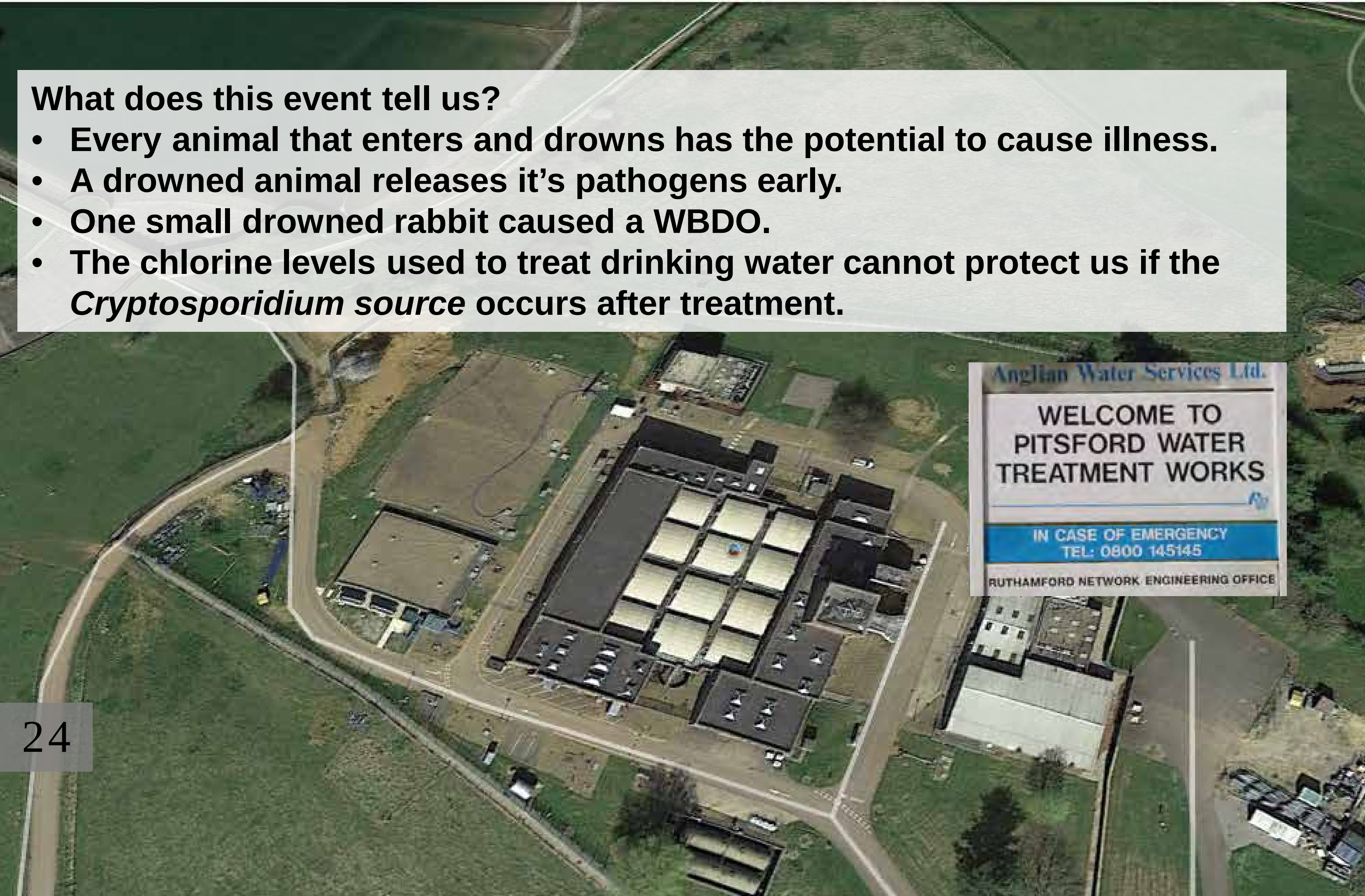
"We have concluded that this occurrence was due to a combination of unusual circumstances."

Think of all the pieces of the puzzle that had to come together to give the drinking water industry this picture; this powerful direct cause-and-effect link between a rabbit drowning in a storage tank and a WBDO.

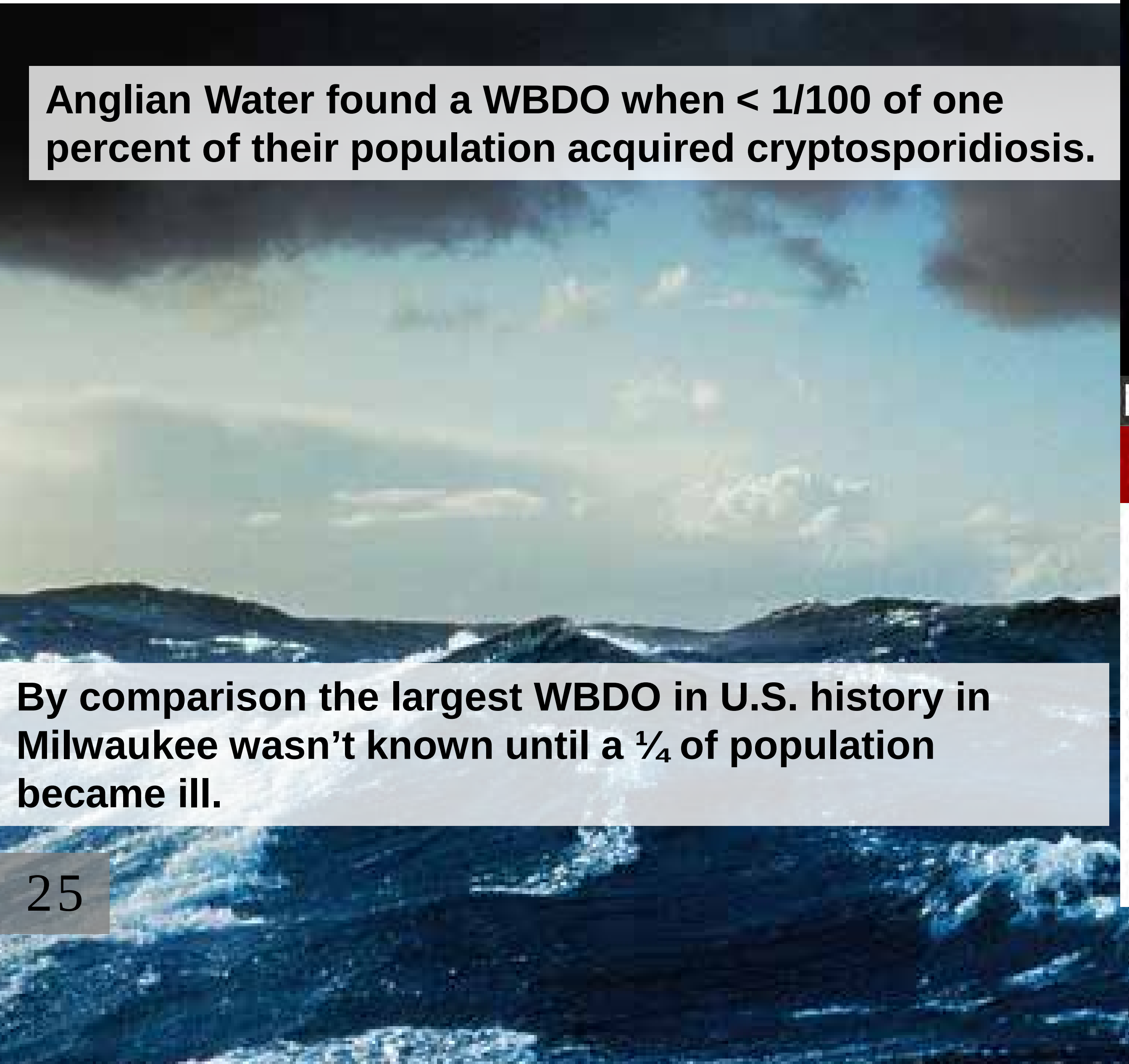
- **The screen on a vent to a storage tank had to be missing**
- **The rabbit that drowned had to be infected with *Cryptosporidium***
- **The storage tank had to be within the processes of the plant that was conducting continuous monitoring for *Cryptosporidium* on the finished water.**
- **Analysts, operators and managers had to act with lightening speed to caught the slug of pathogens**
- **They had to take crypto samples at the plant, tanks and in the dist. system to find if it had entered peoples homes.**
- **They had to take stool samples.**
- **They had to perform DNA analysis on the oocysts in the rabbit, water and stool samples.**
- **And this occurred at a system that disinfects.**

What does this event tell us?

- **Every animal that enters and drowns has the potential to cause illness.**
- **A drowned animal releases it’s pathogens early.**
- **One small drowned rabbit caused a WBDO.**
- **The chlorine levels used to treat drinking water cannot protect us if the *Cryptosporidium source* occurs after treatment.**



Anglian Water found a WBDO when < 1/100 of one percent of their population acquired cryptosporidiosis.



By comparison the largest WBDO in U.S. history in Milwaukee wasn't known until a ¼ of population became ill.

BBC Sign in News Sport

NEWS LIVE BBC NEWS CHANNEL

Rabbit contaminated water supply

A rabbit has been named as the cause of a sickness bug which was found in water supplies in Northamptonshire.

Customers in 100,000 homes were told by Anglian Water to boil tap water for up to 10 days after the Cryptosporidium outbreak on 25 June.

Water supplies were declared safe on 4 July

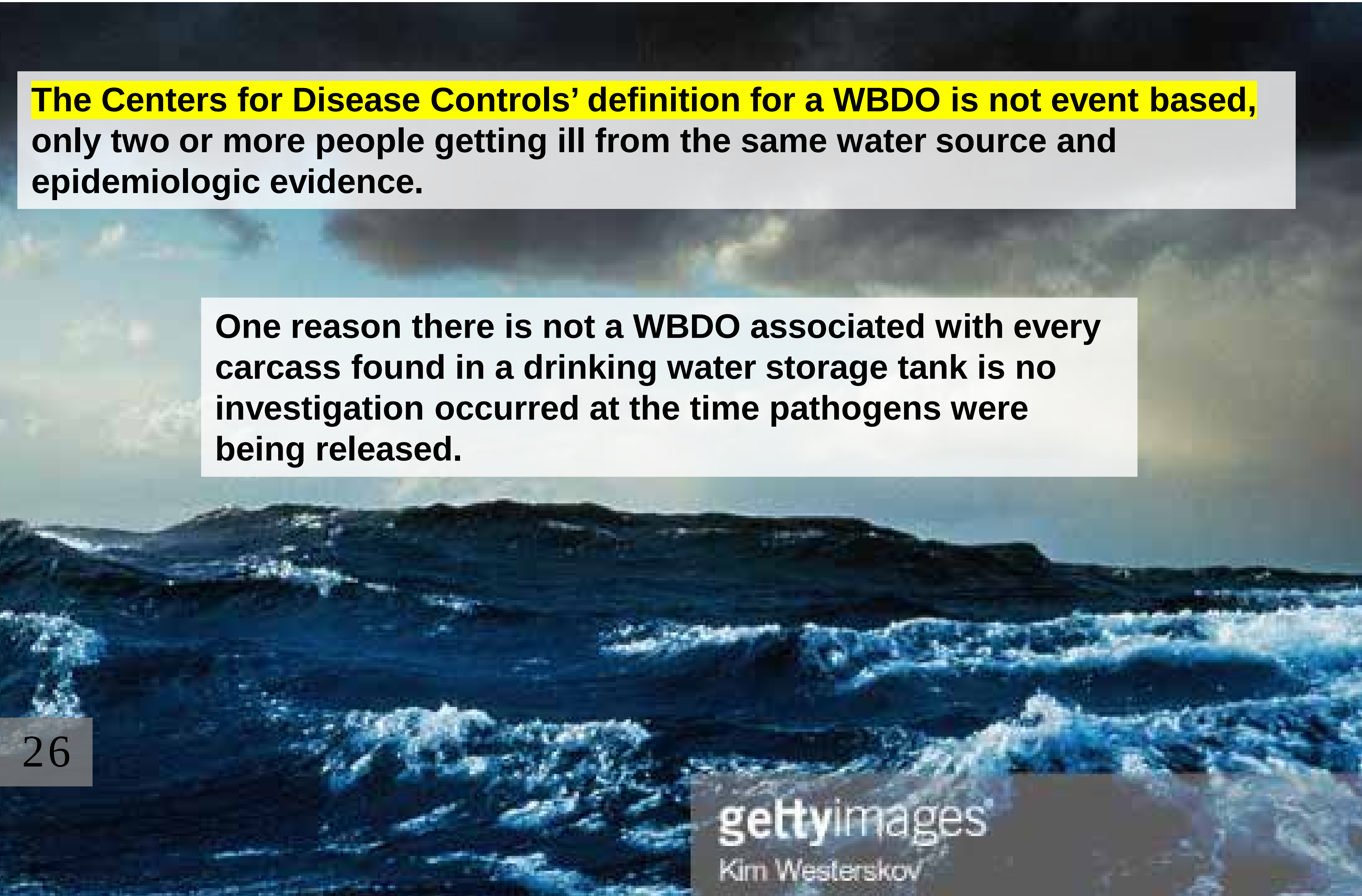
The firm said a rabbit gaining access to the treatment process led to the bug at Pitsford Treatment works.

"We have already taken steps to ensure this cannot happen again," Peter Simpson, of Anglian Water, said.

"We have concluded that this occurrence was due to a combination of unusual circumstances."

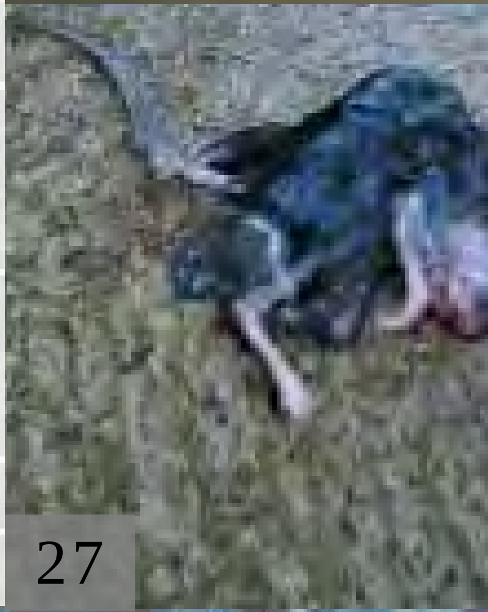
The Centers for Disease Controls’ definition for a WBDO is not event based, only two or more people getting ill from the same water source and epidemiologic evidence.

One reason there is not a WBDO associated with every carcass found in a drinking water storage tank is no investigation occurred at the time pathogens were being released.



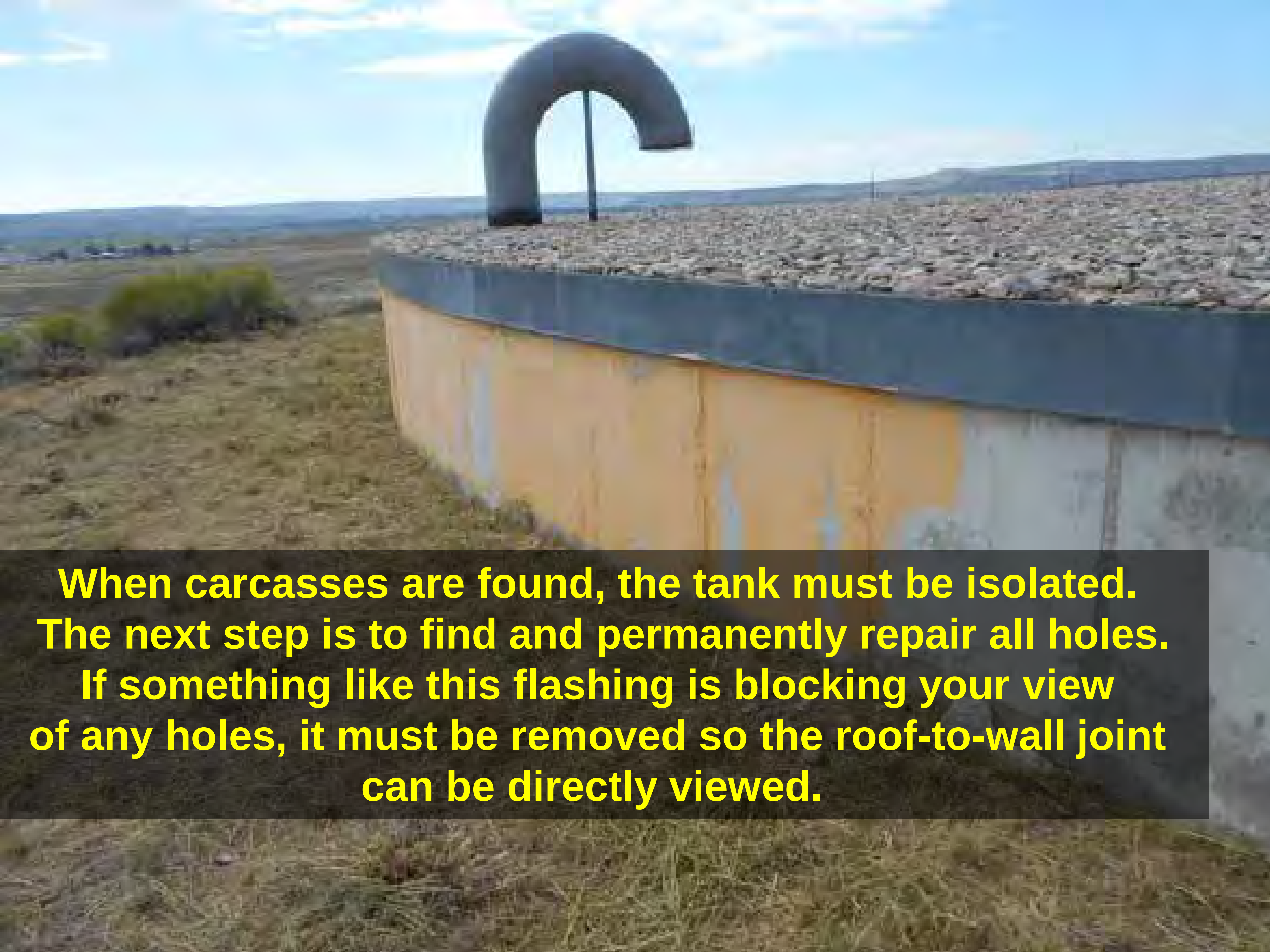
What if it’s too late and a carcass has released its pathogens? Based on this example, here are some suggested actions:

- **Contact your state epidemiologist and strongly recommend that a retroactive epidemiologic study be conducted at your system for the past year.**
- **The carcass is evidence of a potential WBDO. Save the freshest ones. Preserve them on ice and contact CDC or EPA to find a lab that can analyze it for pathogens.**
- **Isolate the tank. According to Ten State Standards tanks shall be designed so they can be isolated while maintaining pressure in the distribution system.**
- **Drain the tank and use a high pressure stream of water to dislodge any microscopic particles of flesh that may be attached to the walls (divers are not sufficient).**
- **Disinfect using AWWA guidance.**
- **Flush the affected sections of the distribution system.**

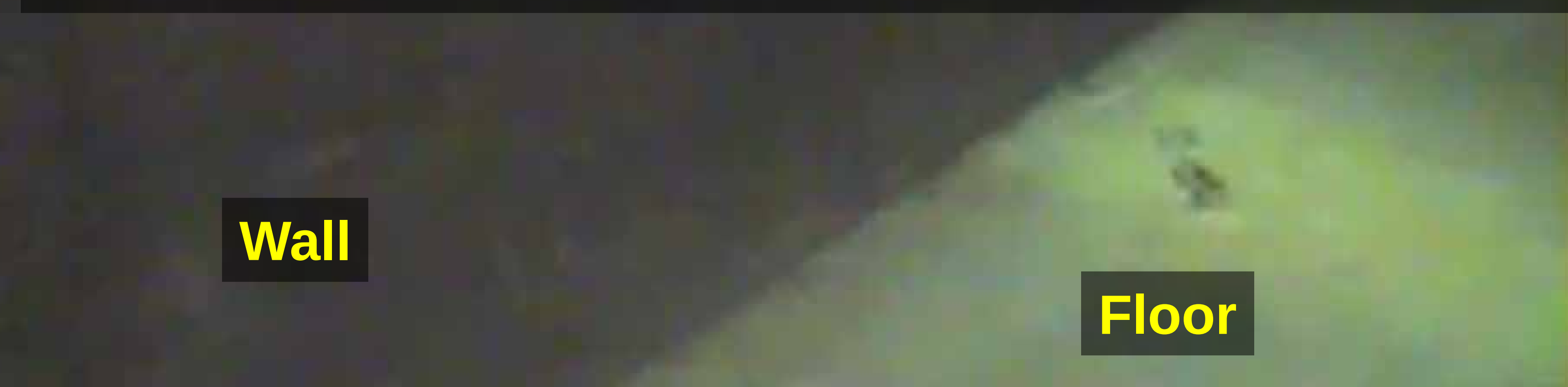


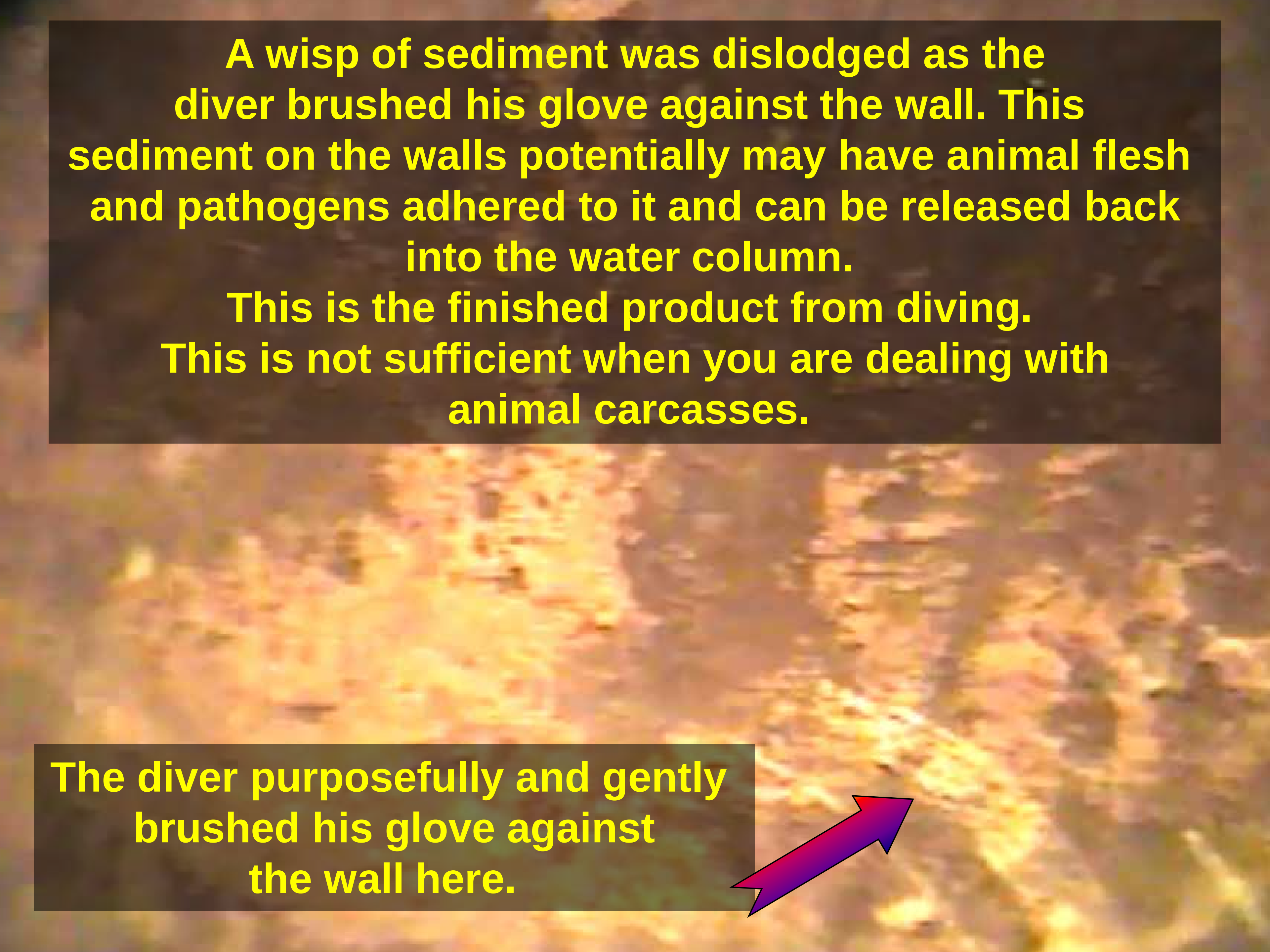
The tremendous effort and cost of a WBDO can be avoided if the following efforts are implemented in concert with the greatest attention to details:

1. **Perform biweekly inspections of tanks.**
2. **Make repairs immediately after you notice them developing (e.g., caulk beginning to separate from the gap it is filling).**
3. **Use a #24 mesh screen on vents and overflows: all tanks 2018 Ten State.**
4. **Ensure the vent is at least 24 inches above the roof or ground.**
5. **Ensure the overflow is not attached to the tank drain or any other drain: clarified 2018 Ten State.**
6. **Terminate the overflow two feet above a splash plate and have it be visible.**
7. **Ensure the hatch is fitted tight (no light).**
8. **Fix any openings in the roof-to-side wall joints or anywhere else.**
9. **Suggest using cameras for 24 hour surveillance (vents, overflows, hatches).**
10. **Redundant alarms on the overflow.**
11. **Clean and inspect tanks every three years per industry guidance.**

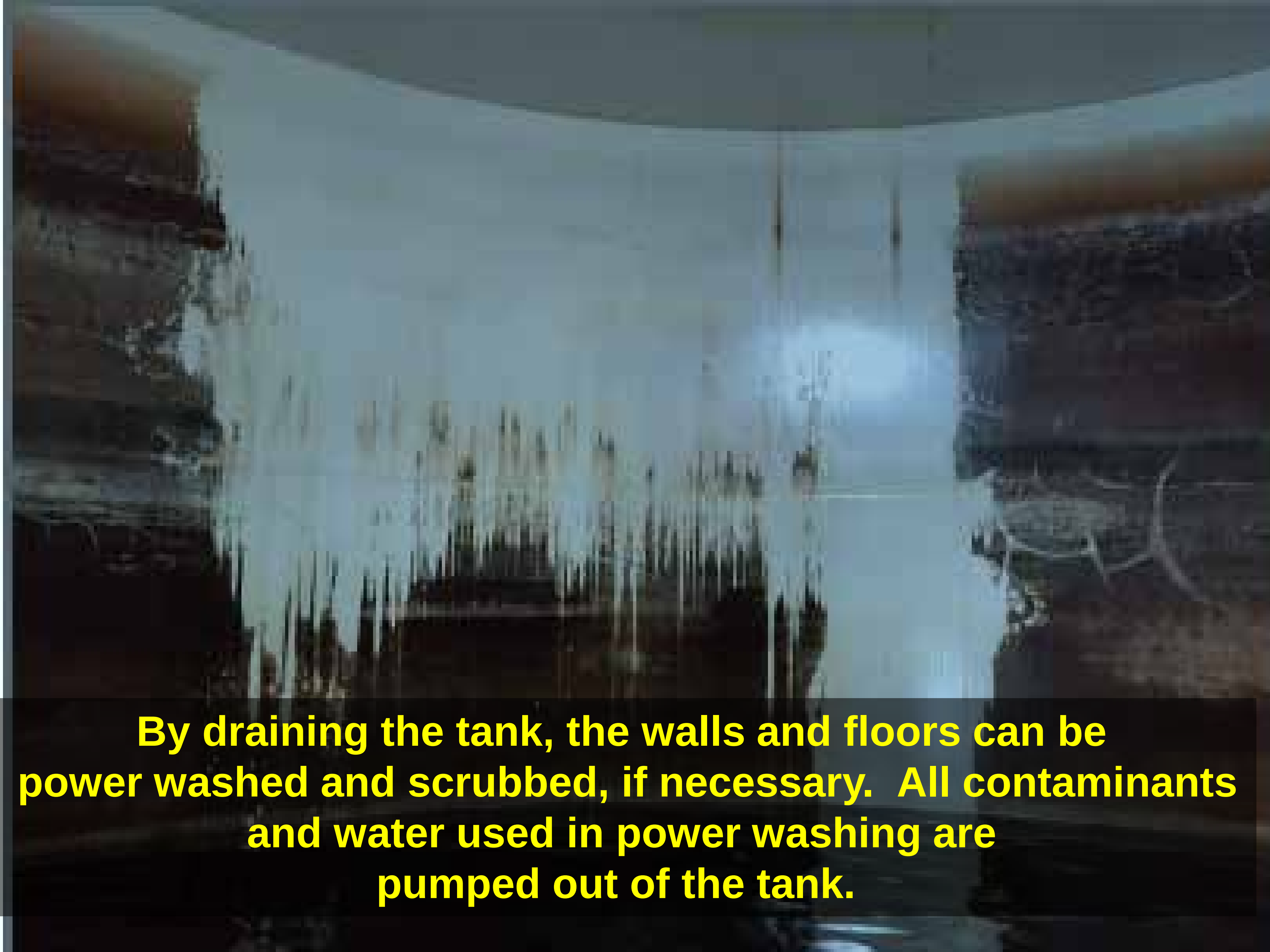

When carcasses are found, the tank must be isolated.
The next step is to find and permanently repair all holes.
If something like this flashing is blocking your view
of any holes, it must be removed so the roof-to-wall joint
can be directly viewed.

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.



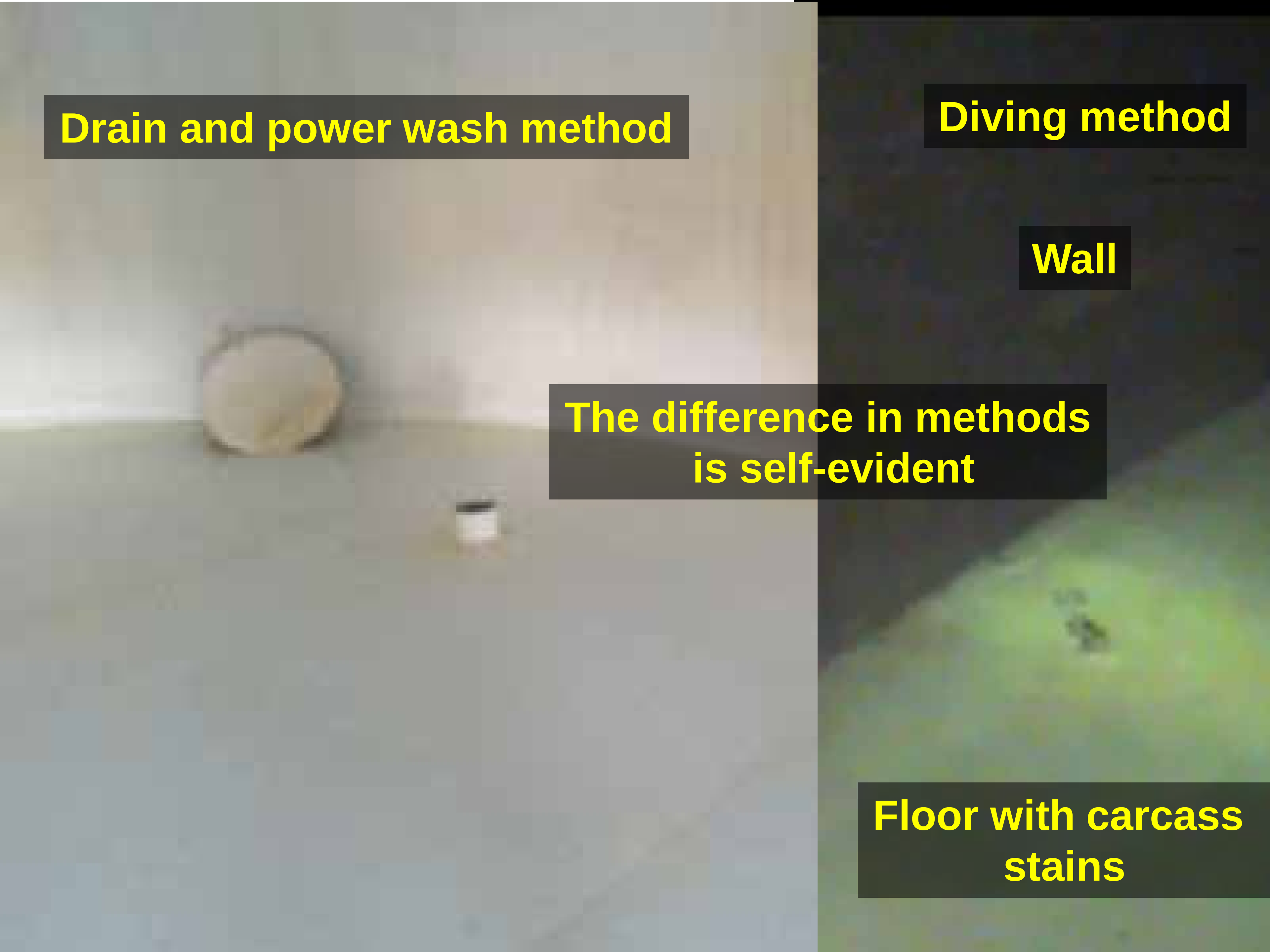

A wisp of sediment was dislodged as the diver brushed his glove against the wall. This sediment on the walls potentially may have animal flesh and pathogens adhered to it and can be released back into the water column.
This is the finished product from diving.
This is not sufficient when you are dealing 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.

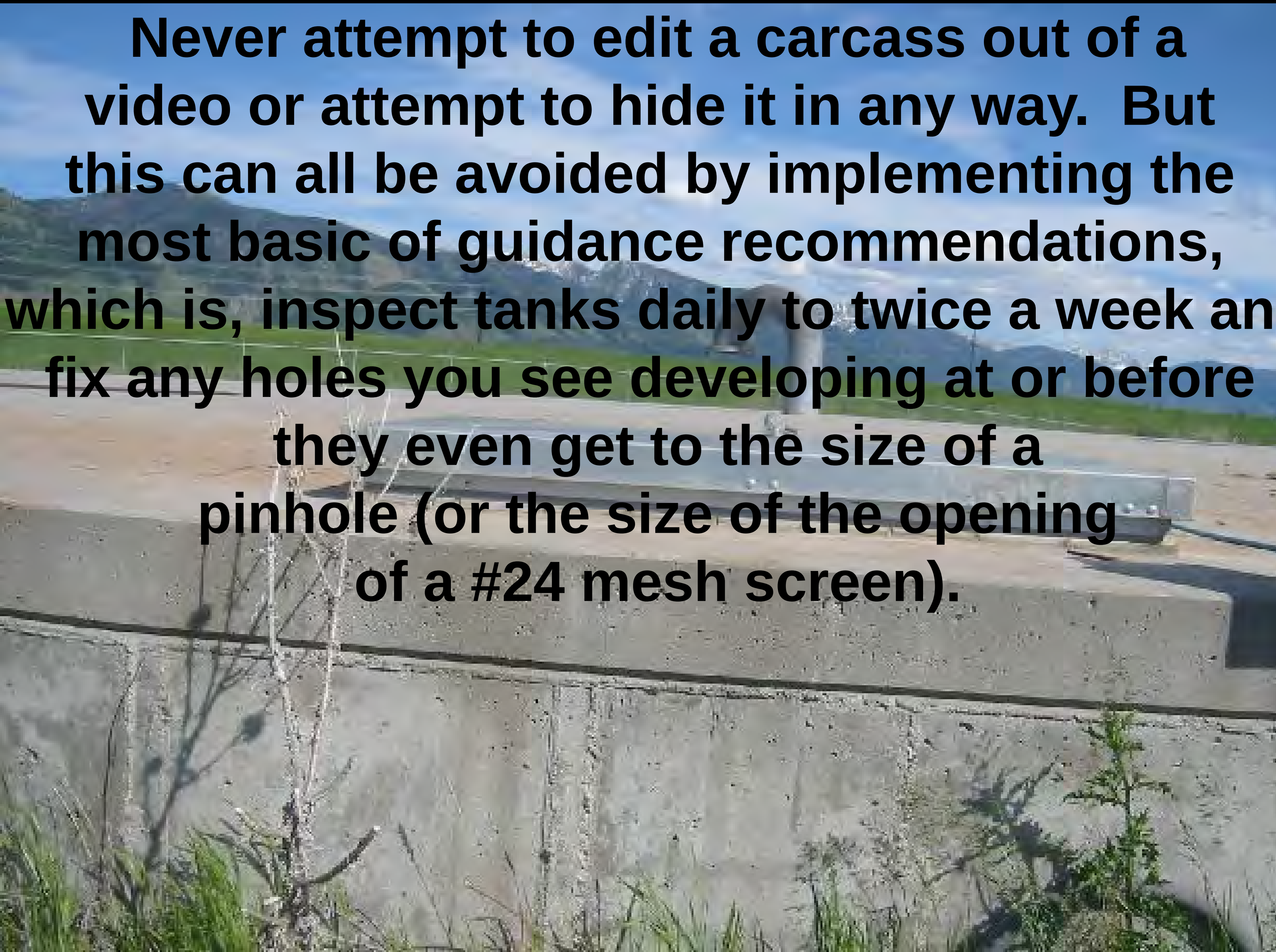


By draining the tank, the walls and floors can be power washed and scrubbed, if necessary. All contaminants and water used in power washing are pumped out of the tank.

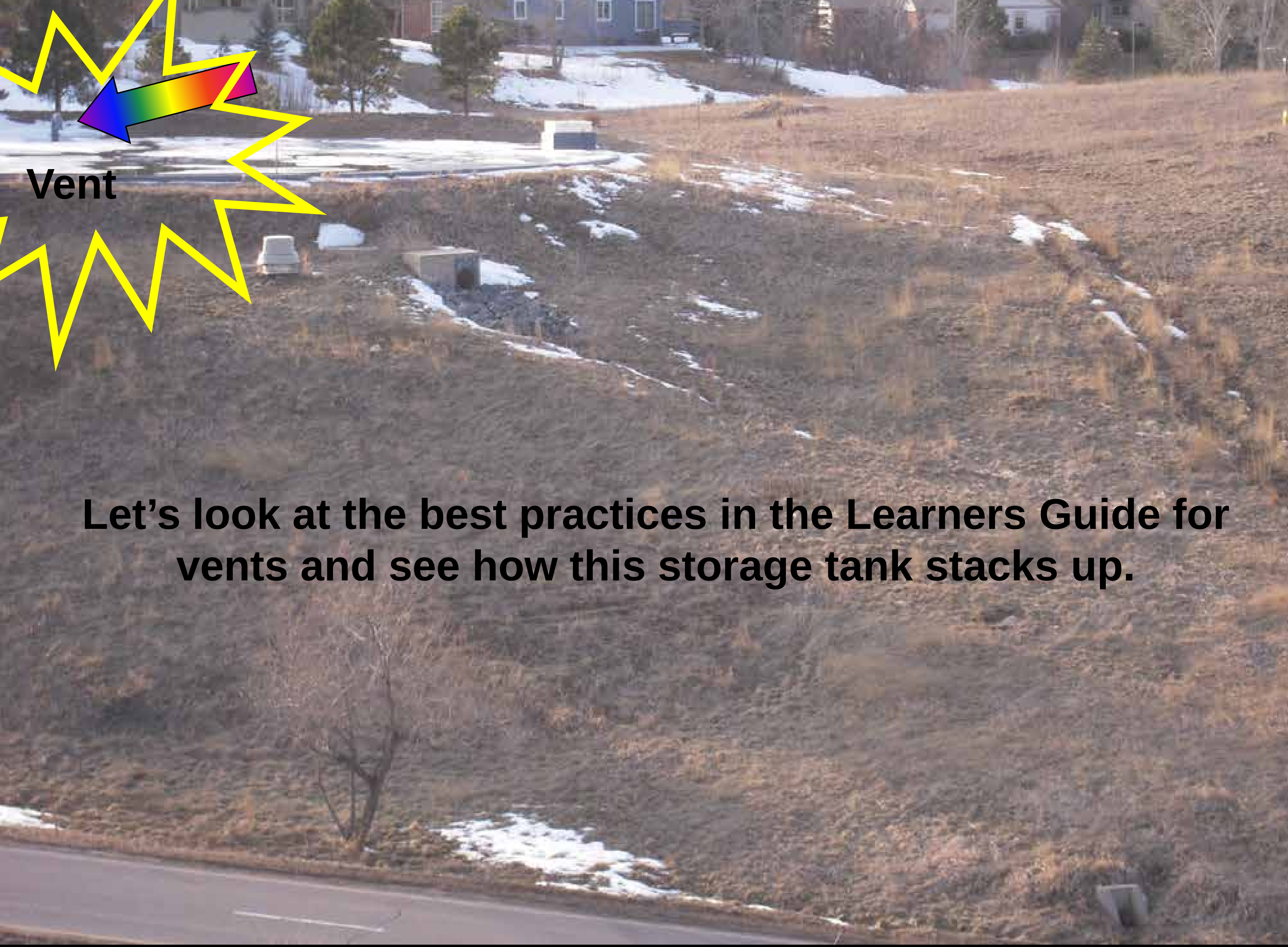
With a drain and clean method, all sediment and pieces of flesh from the decaying carcass are removed from walls and floor. This is the process that Anglian Water used to clean its tanks and it correlated with decreasing cryptosporidium levels.


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.



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 an 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).



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

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

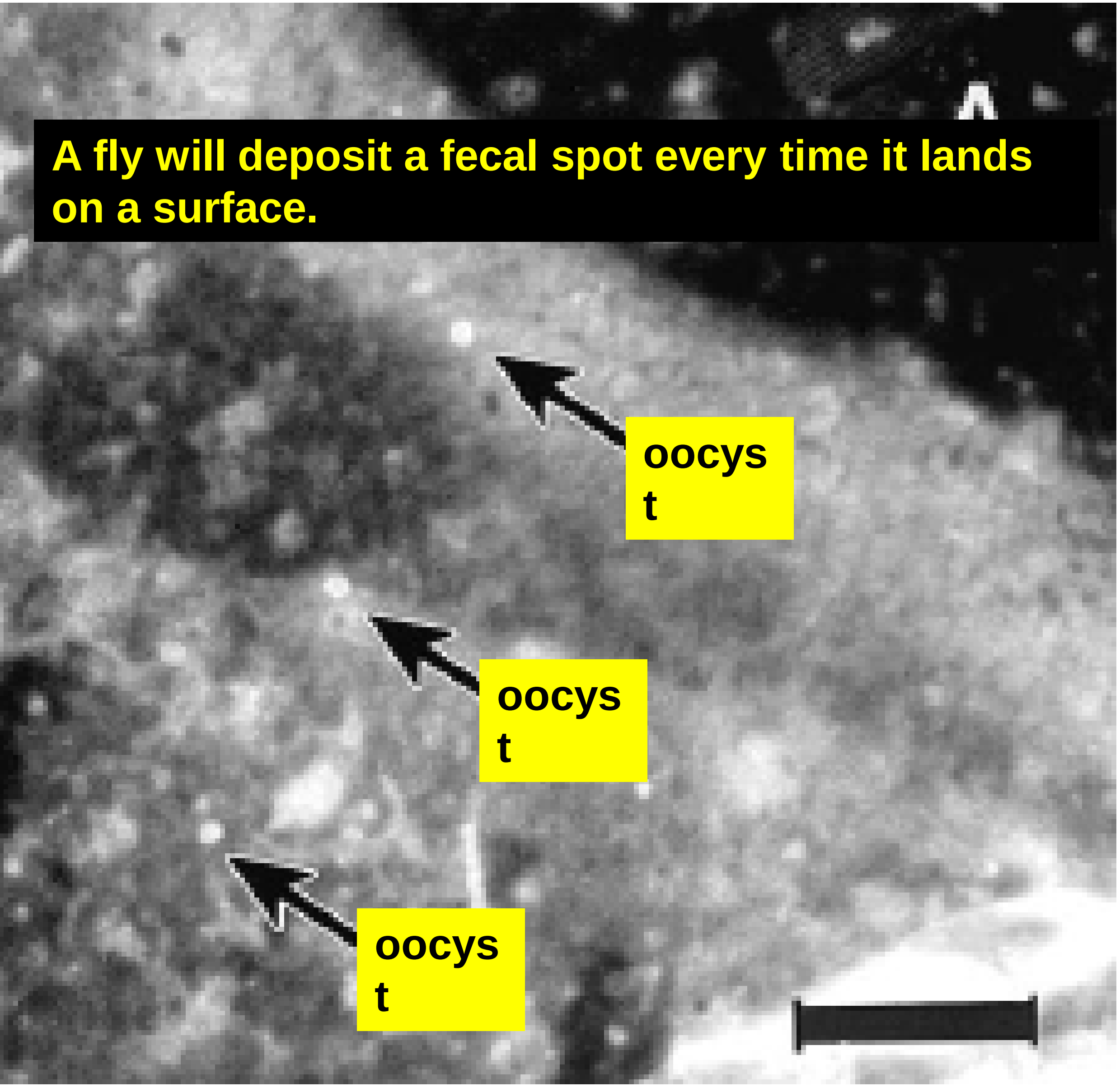
{Section 10.4.10, #14 Air Vents, a} <u>All vents (ground and elevated) must have a #24 mesh screen, to keep living organisms down to the size of insects, and any pathogens they may harbor out of the tank.</u> Metal elevated tanks must have a pressure/vacuum relief mechanism (e.g., movable palette, flexible 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

A Learner's Guide

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

 # 24 mesh non-corrodible screen
severs the link of disease transmission
from insects and any diseases they may be harboring
that enter our
Finished Drinking Water Storage Tanks
via vents and overflows.

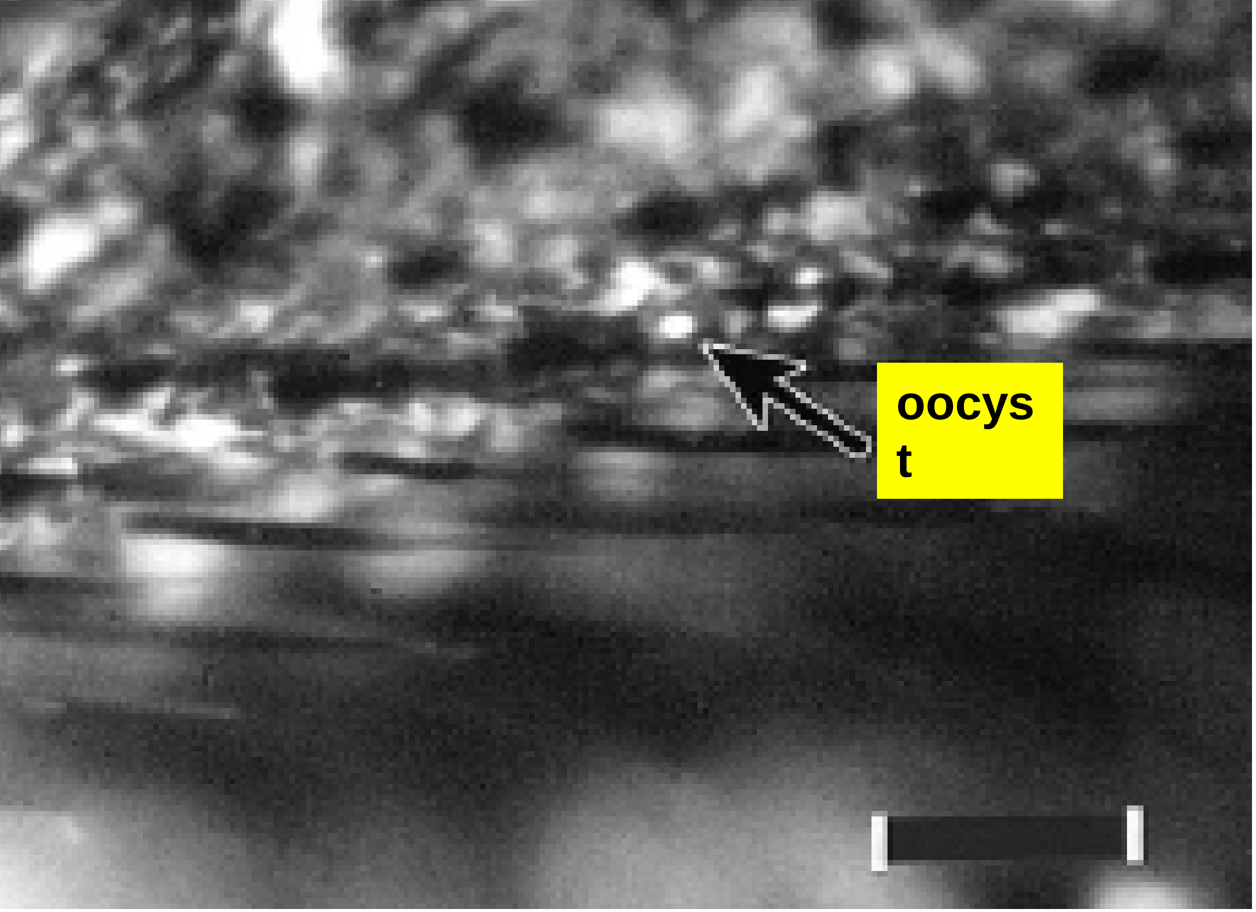


HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM* *by*

THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER American Journal of Tropical Medicine Hygiene 61(3), 1999, pp. 500–504

A: Fly fecal spot

C. Parvum **oocysts (arrows) were detected by immunofluorescent antibodies in the fecal spots of flies exposed to bovine diarrheal feces containing oocysts.**



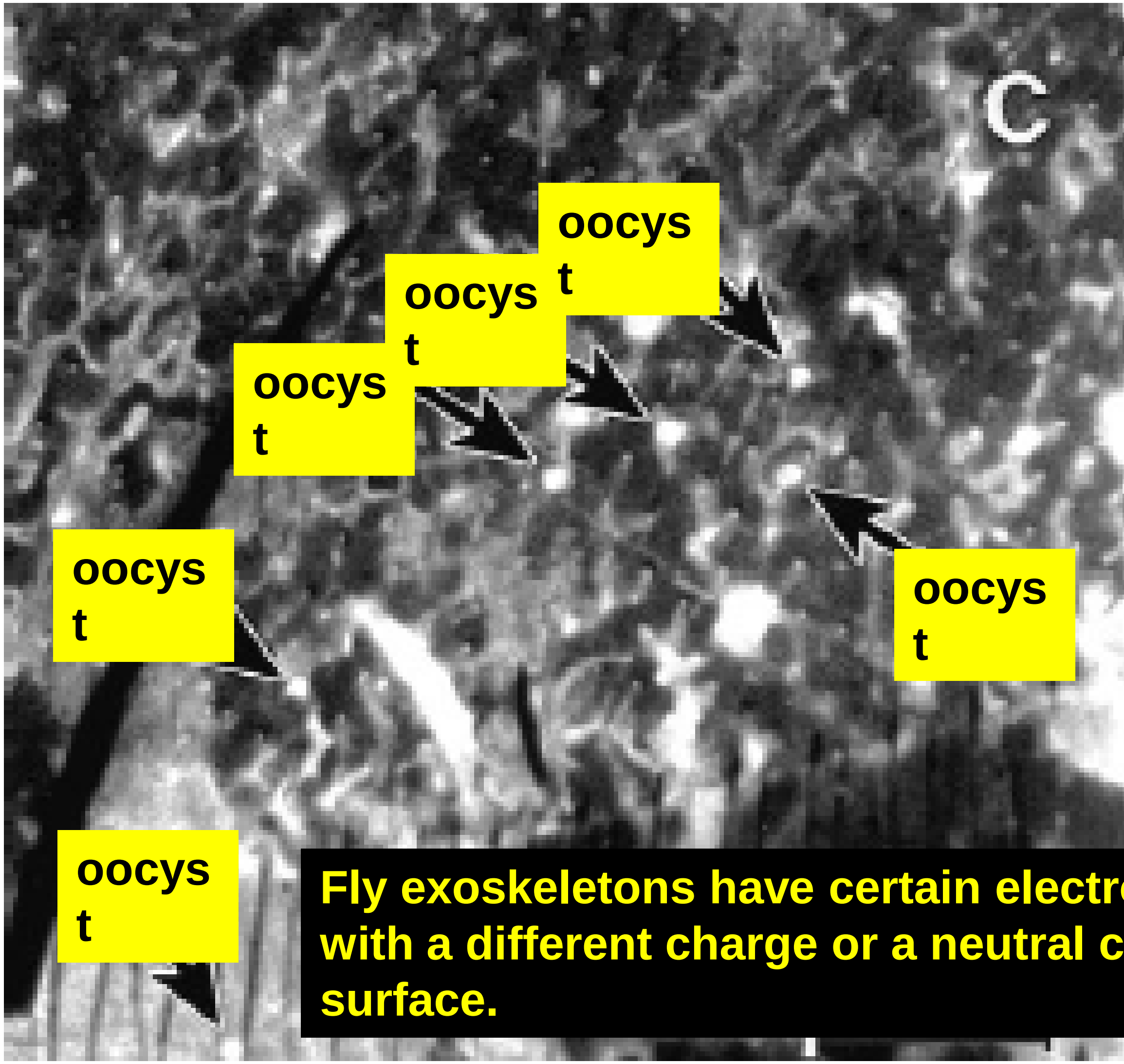
HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM* by

THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER American Journal of Tropical Medicine Hygiene 61(3), 1999, pp. 500–504

B: Leg (tibia)

C. Parvum **oocysts (arrows) were detected by immunofluorescent antibodies on the hairs on the leg (exoskeleton) of a house fly.**

The fine hairs on the fly's feet are coated with a sticky substance enhancing the adhesion of viruses, bacteria and protozoans which then can be directly transported to the next visited surface and dislodged.



HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM* *by*

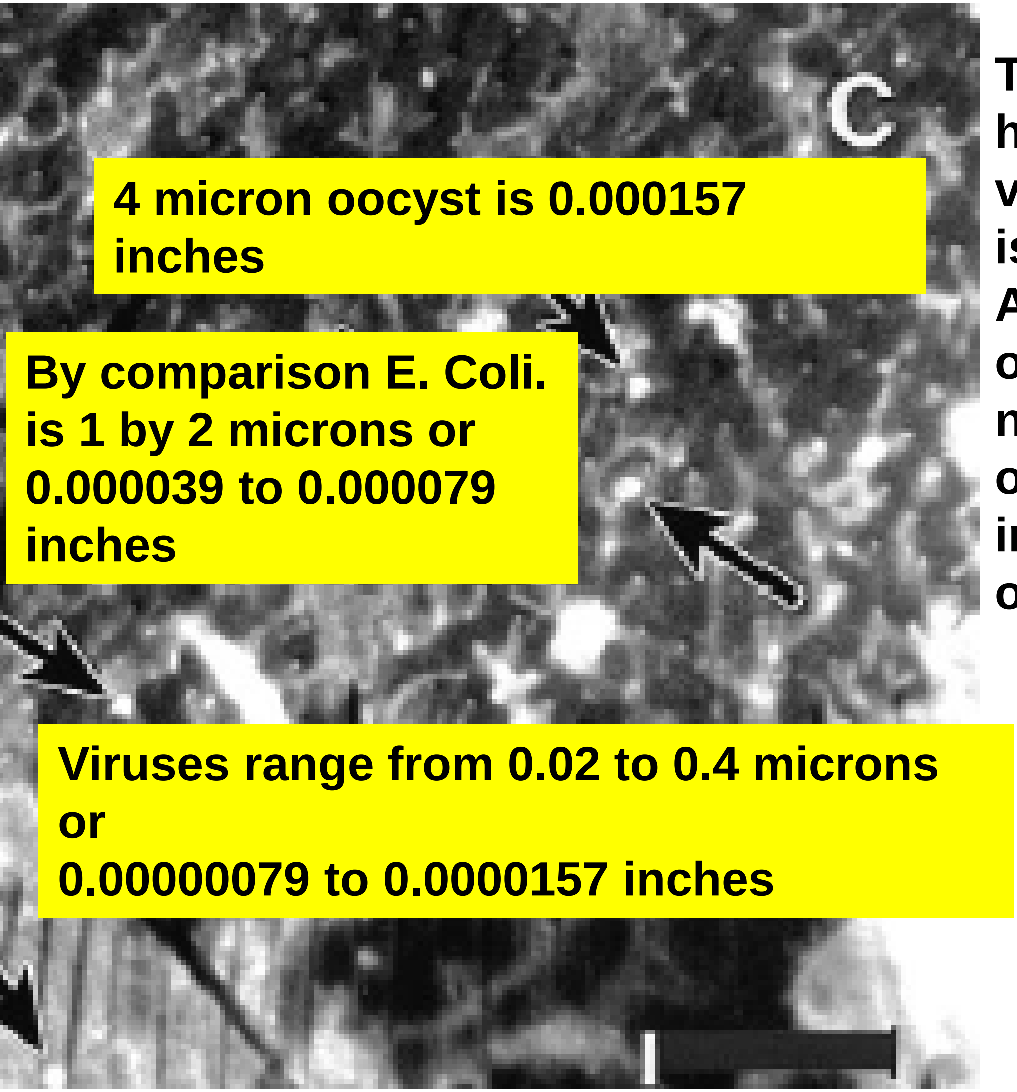
THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER

American Journal of Tropical Medicine Hygiene 61(3), 1999, pp. 500–504

C: Posterior margin of the wing

C. Parvum **oocysts were detected by immunofluorescent antibodies on the wing bristles of a fly (exoskeleton)**

Fly exoskeletons have certain electrostatic charges, any particles with a different charge or a neutral charge will adhere to the fly surface.

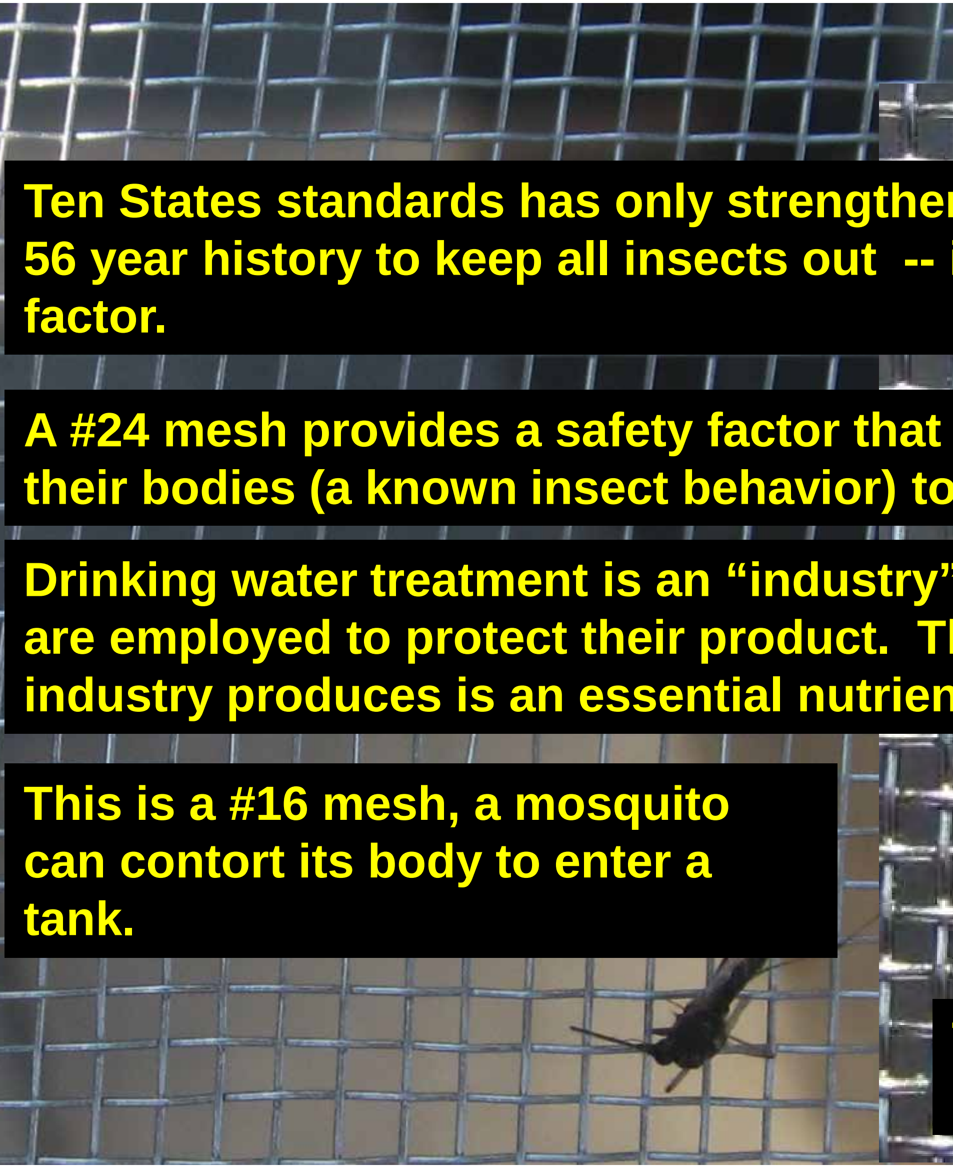


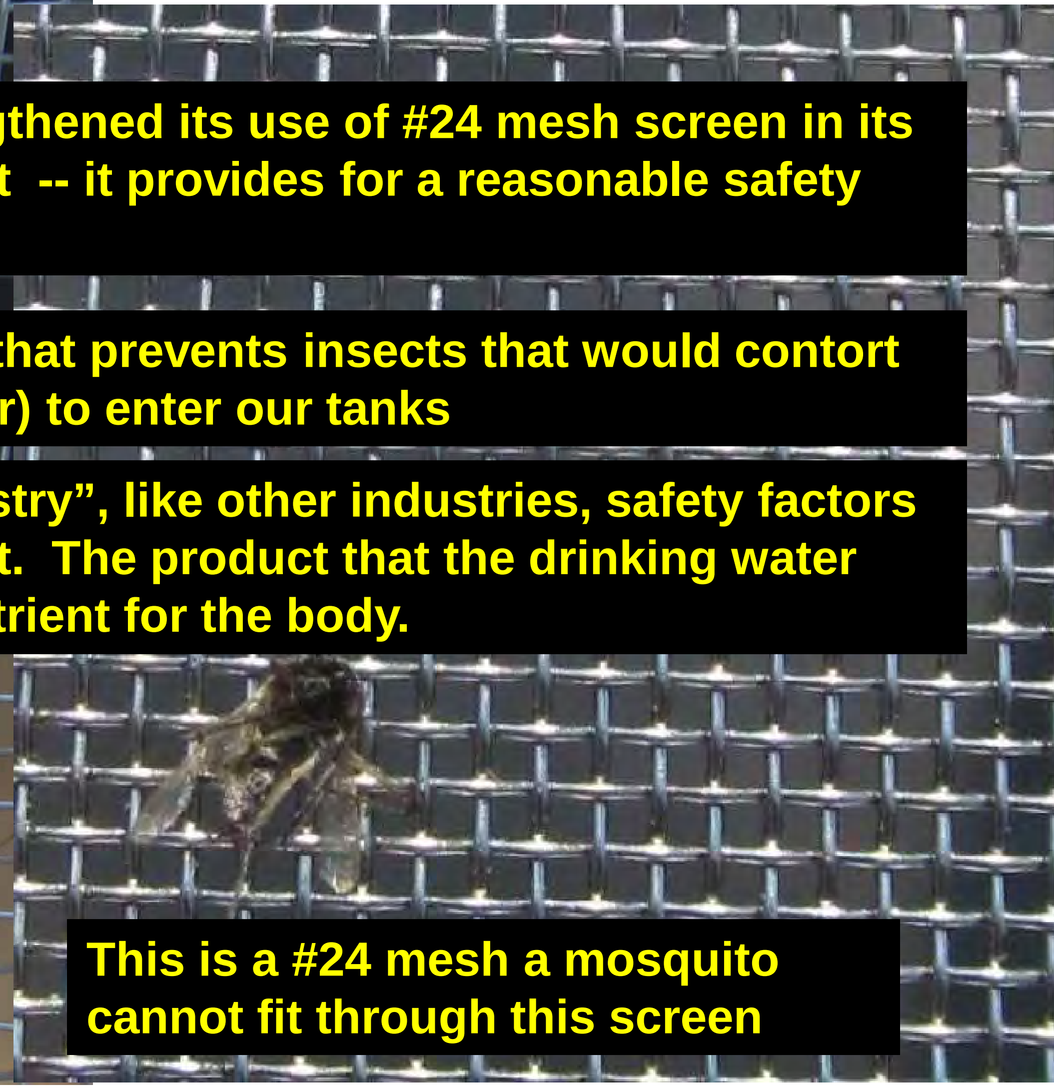
This research has demonstrated that house flies are efficient mechanical vectors of C. Parvum - a protozoan that is known to cause disease in humans. A 3-day exposure of flies to feces with oocyts resulted in deposition for the next 8 days of an average of 100 oocysts/cm^2 through feces alone and, in addition, carried more than 200 oocyts on its exoskeleton.

The flight range for a fly is as far as 20 miles.

This study eluted 267, 131, 32, 19 and 14 oocysts off of flies exoskeleton on days 3, 5, 7, 9, and 11, from feces that had only
2×10^5 or 200,000 oocyst/ml. That means by the 11th day, 243 oocysts had dislodged from the exoskeleton.

How many more oocysts can be transported when there are 10^{10} – five times the number in the study?





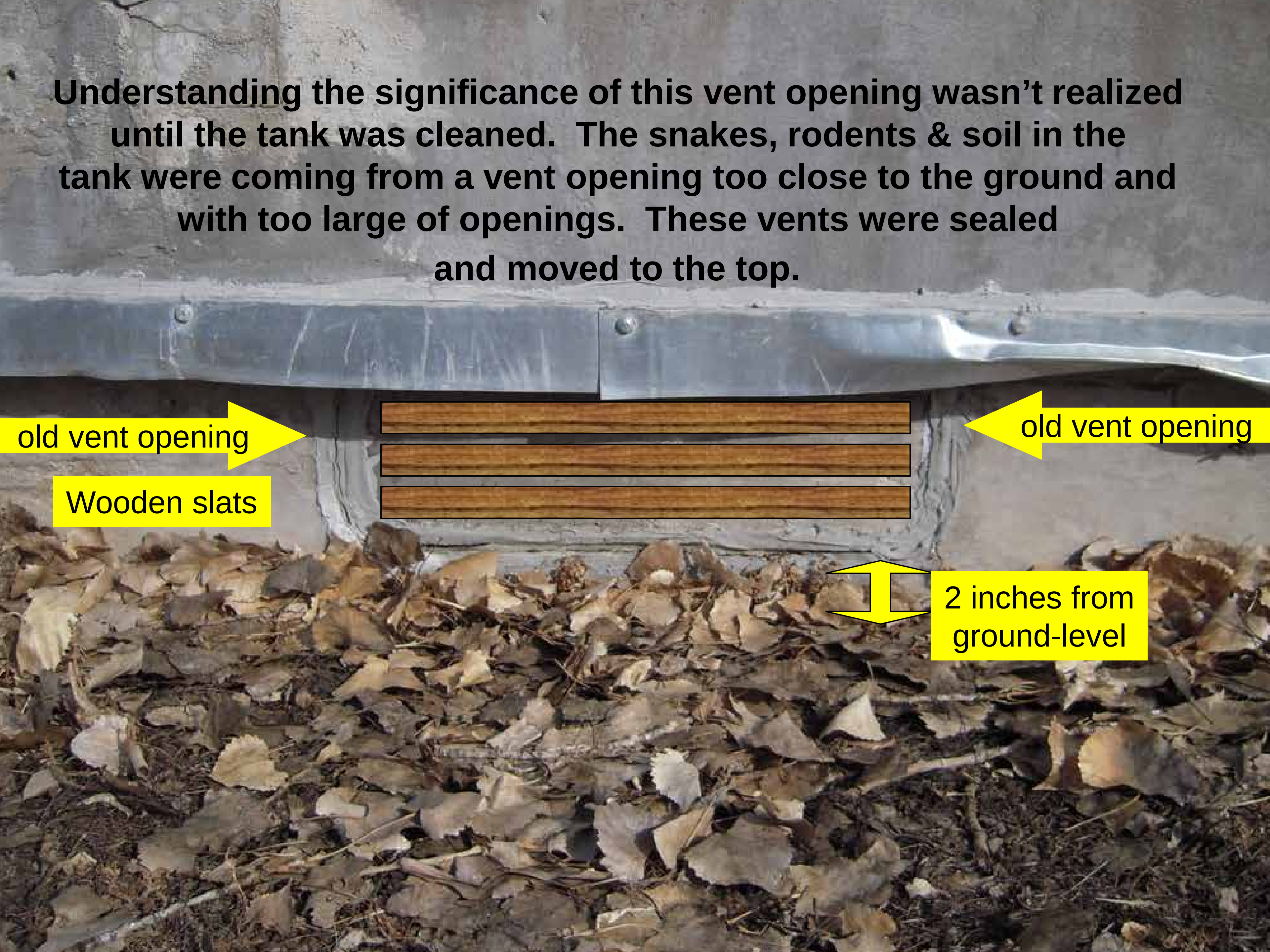
Ten States standards has only strengthened its use of #24 mesh screen in its 56 year history to keep all insects out -- it provides for a reasonable safety factor.

A #24 mesh provides a safety factor that prevents insects that would contort their bodies (a known insect behavior) to enter our tanks

Drinking water treatment is an "industry", like other industries, safety factors are employed to protect their product. The product that the drinking water industry produces is an essential nutrient for the body.

This is a #16 mesh, a mosquito can contort its body to enter a tank.

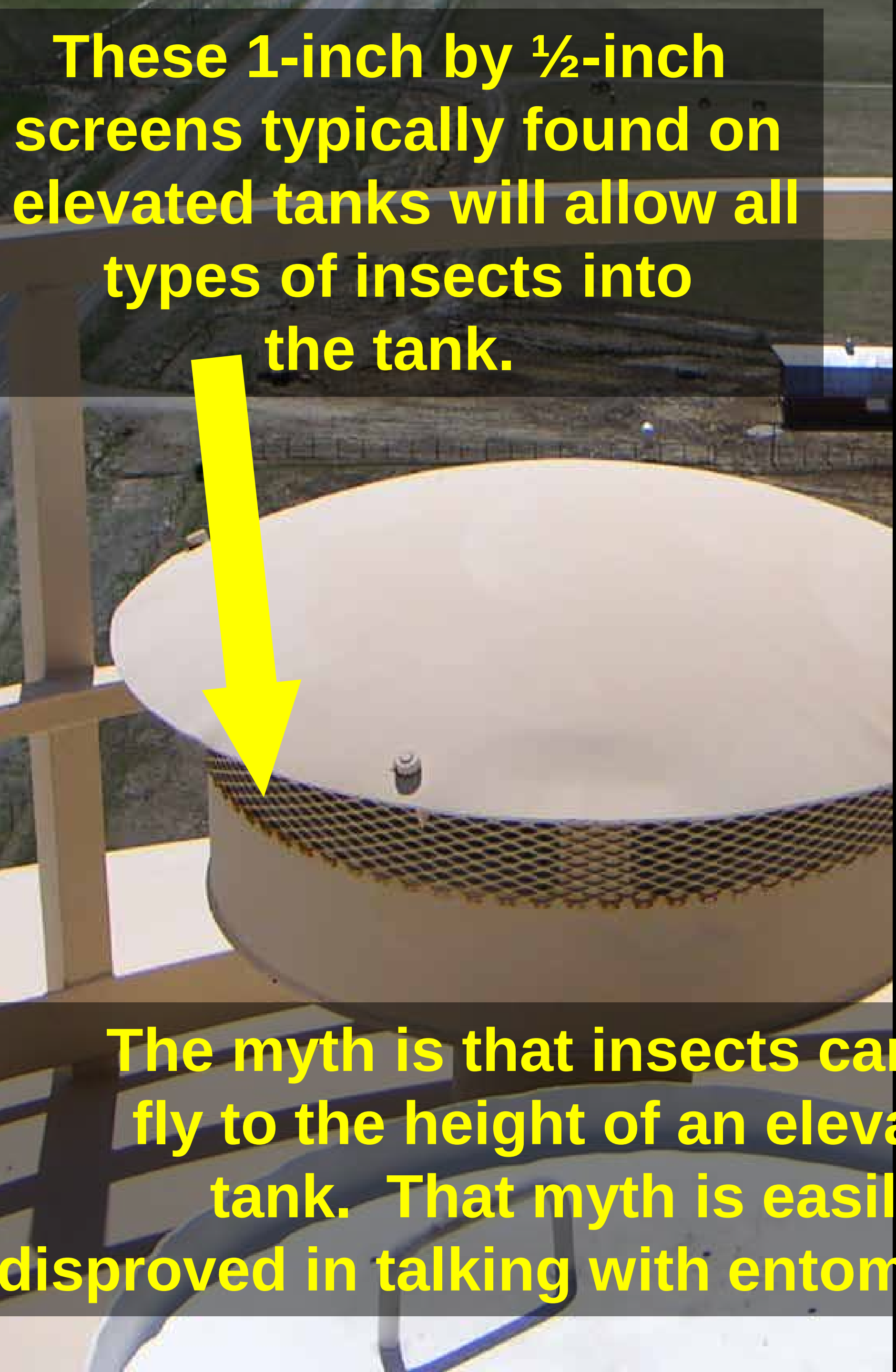
This is a #24 mesh a mosquito cannot fit through this screen


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.
old vent opening
old vent opening
Wooden slats
2 inches from ground-level

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.

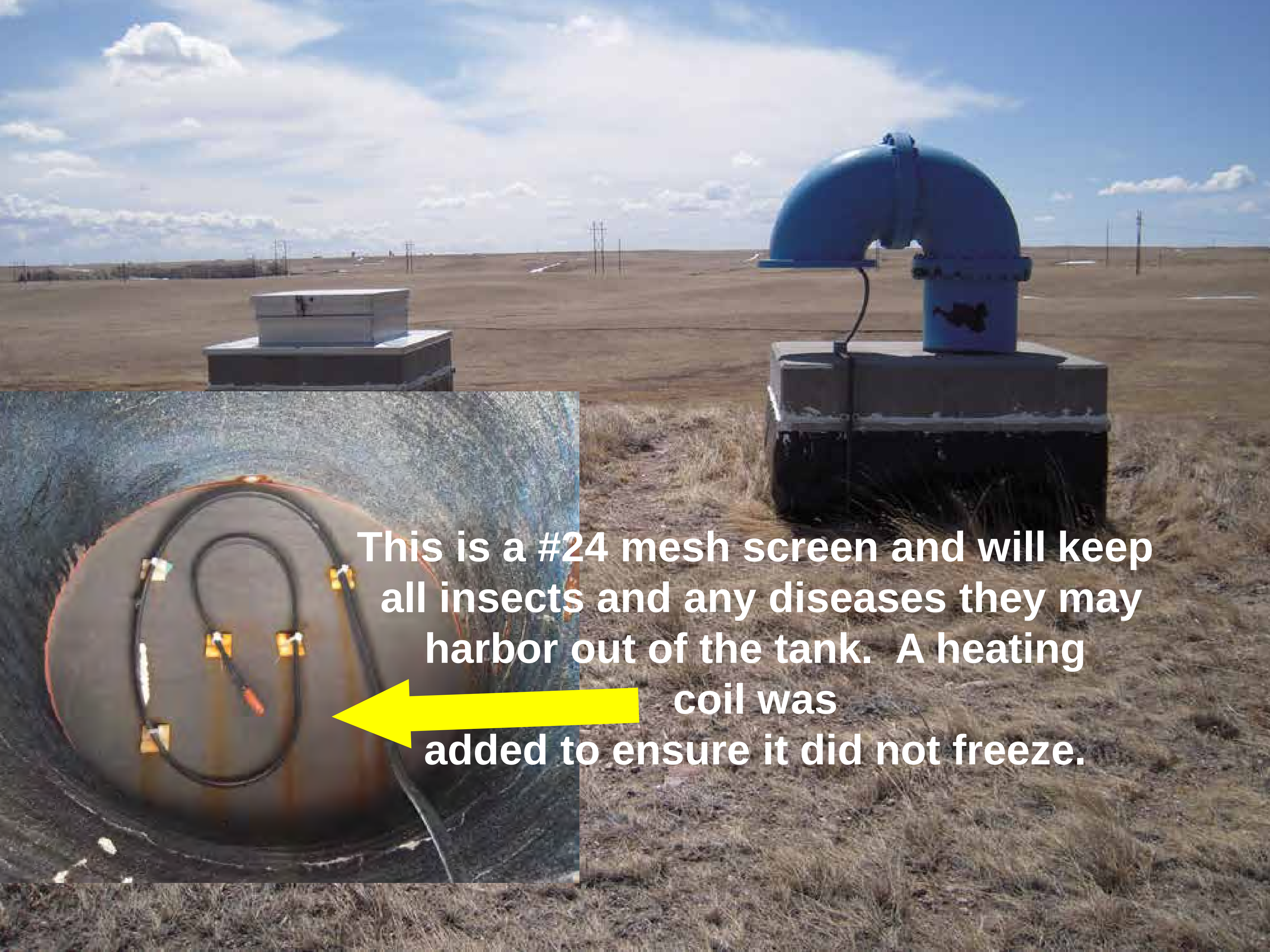
Elevated tanks may have blinking lights on top so planes don't fly into them. The lights can attract a high concentration of flying insects around a vent that is inadequate to prevent them from entering.

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

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

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.

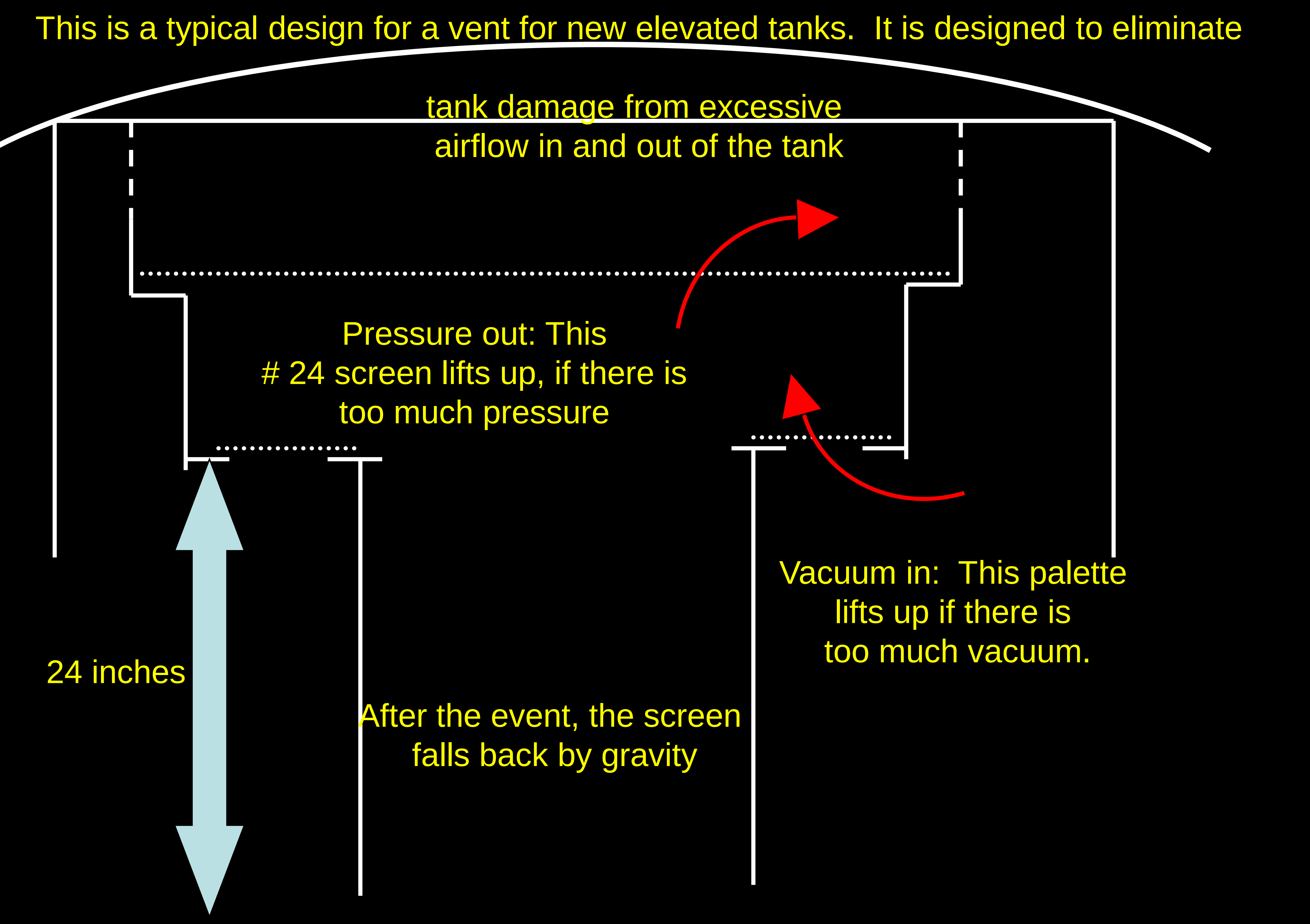

This is a #24 mesh screen and will keep
all insects and any diseases they may
harbor out of the tank. A heating
coil was
added to ensure it did not freeze.

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

SANITARY SURVEY TRAINING COURSE


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.
24 inches
After the event, the screen
falls back by gravity

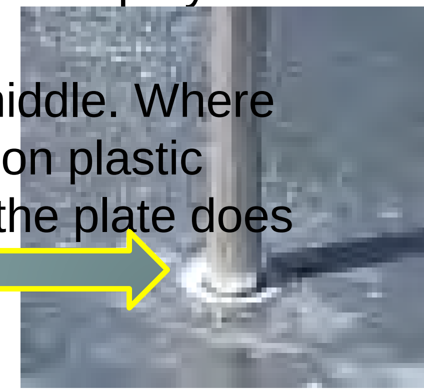
This is a floating palette type vent. It is typically installed at least 24 inches above the roof of the elevated tank to avoid inhalation hazards.

Many of these types of vents have been installed in Wyoming and none have been reported to be blown off the roof. They are attached by welds or bolts.

To look inside this vent th
step is to undo the bolt h

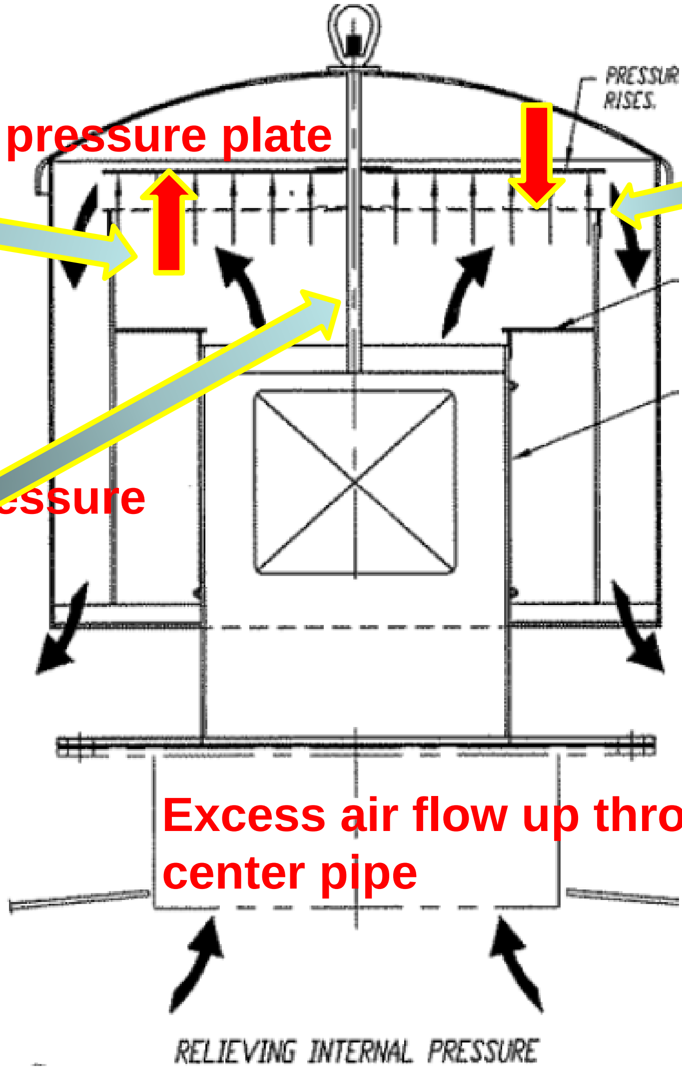
Remove the top that overla
side and set aside. This do
top and vertical shroud prot
rain, snow and minimizes s
and dust. Protecting agains
snow is a shall requirement
and is logically correct. By
dust and sunlight will be mi

When you remove the top you see the pressure pal
~ ten pounds so when it is pushed up by air it falls b



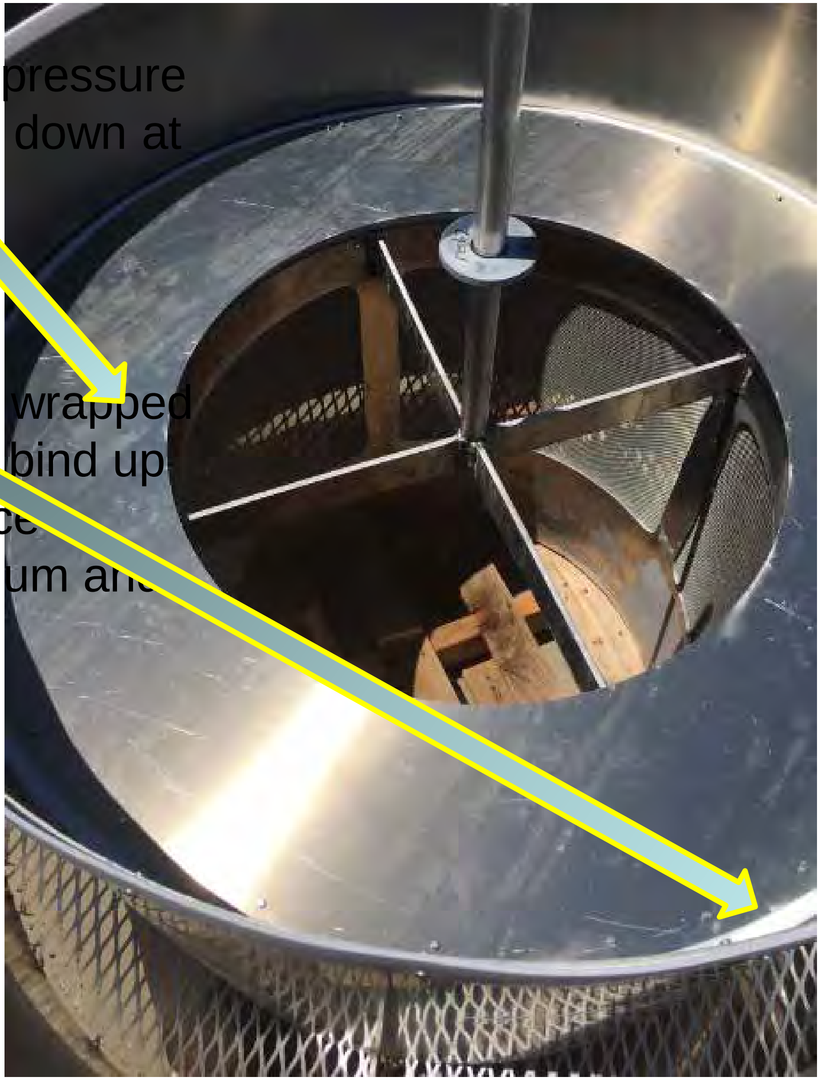
It is guided by the bolt in the middle. Where
the plate goes through bolt teflon plastic
surrounds the plate to ensure the plate does

The plate sits on a teflon wrapped edge
so it can’t freeze to the edge.


The air out pushes the pressure plate up.
Once the pressure is reliev
of the palette brings it back
the teflon wrapped edge.
PRESSUR RISES.
The bolt guides the pressure plate.
Excess air flow up through center pipe
RELIEVING INTERNAL PRESSURE

When you remove the pressure palette you are looking down at the vacuum palette.

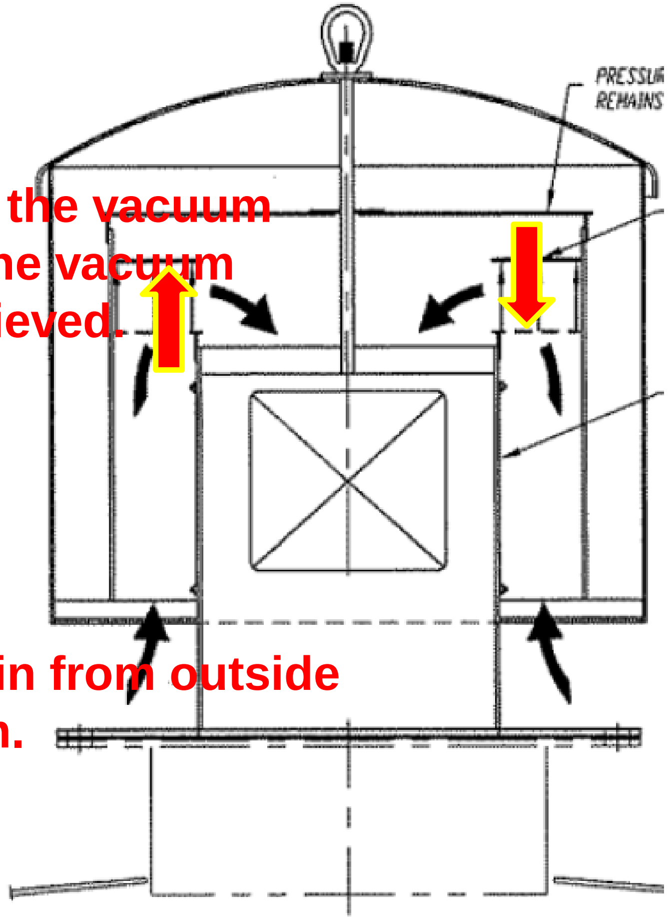
The vacuum palette is wrapped in teflon so it does not bind up along the circumference as it pulled up by vacuum and drops down by gravity.



The vacuum palette rests on this lip and this edge is wrapped in teflon.

The vacuum pulls the vacuum ring up allowing the vacuum pressure to be relieved.

After the vacuum event the v palette falls back by its own

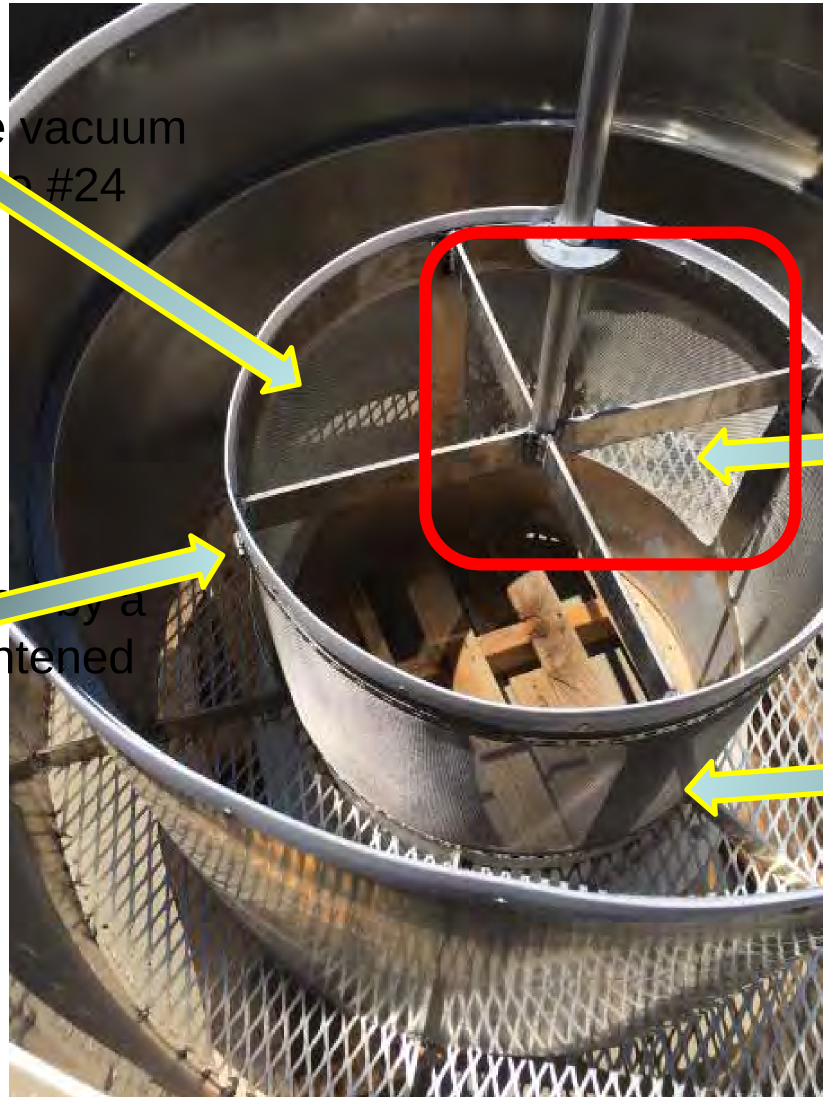


Excess air flow in from outside due to a vacuum.

RELIEVING VACUUM PRESSURE

When you remove the vacuum palette you can see the #24 mesh.

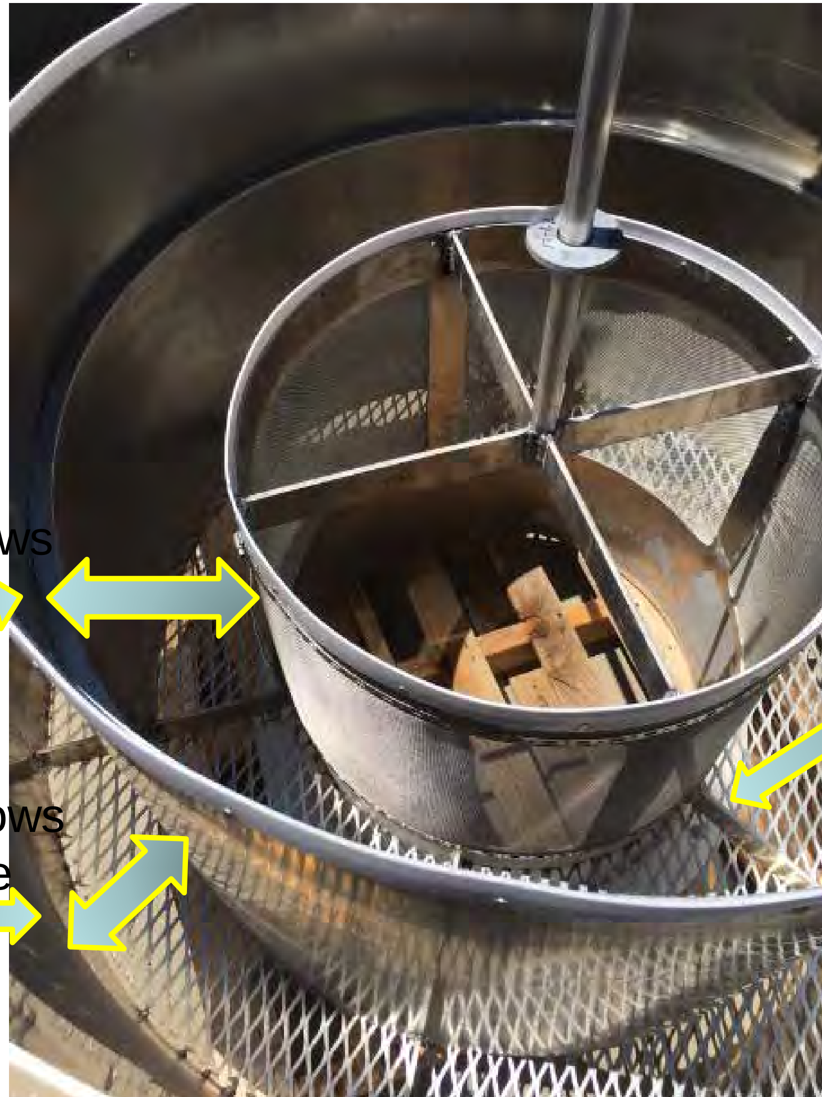
The screen is wrapped vertically around the pipe with windows cut out for the screen.



The screen is attached by a large band that is tightened with this screw.

These one inch strips of p
provide support for the ve

This separation allows
air flow for vacuum
air relief.

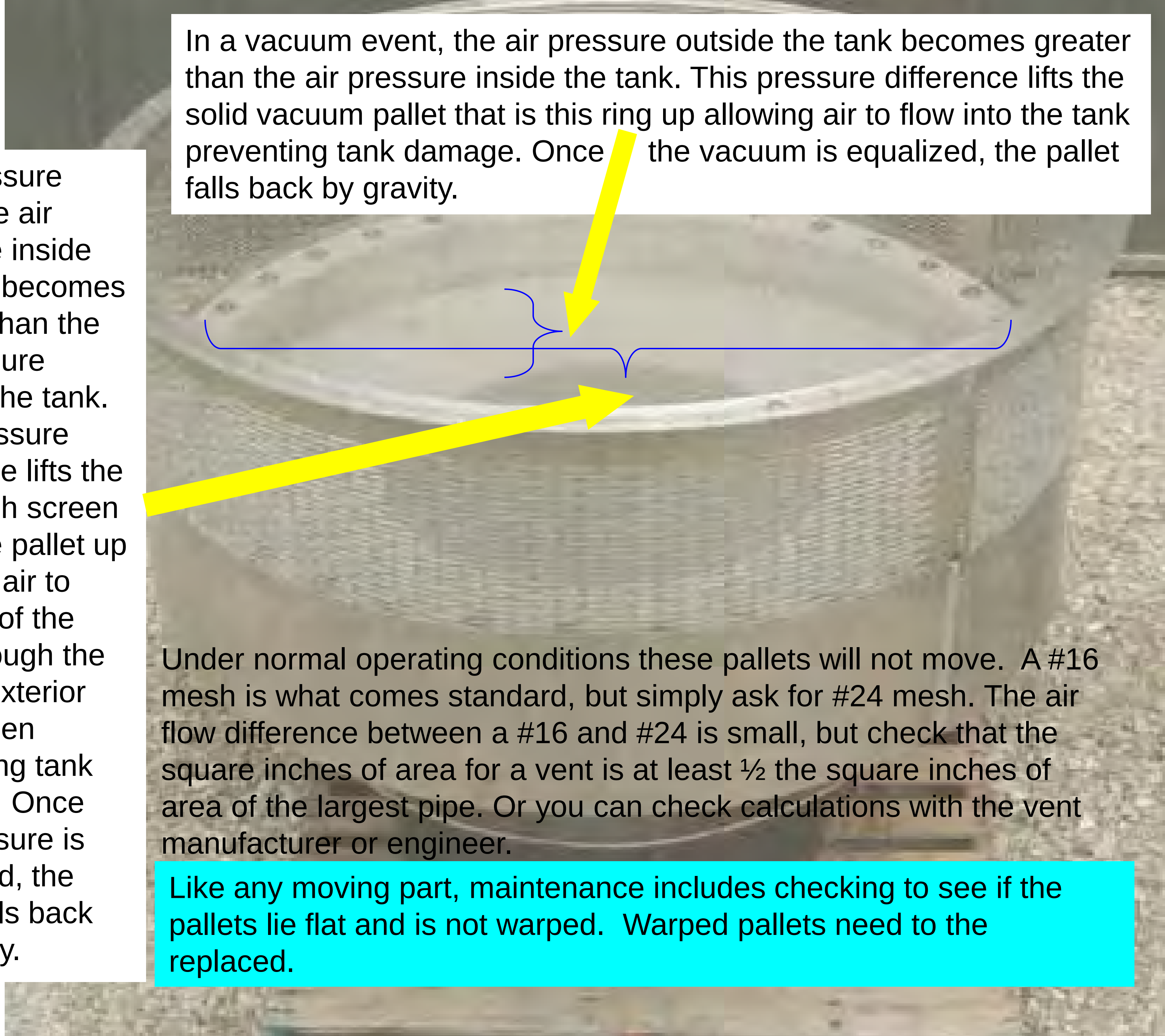


The sides are supported b
these vertical pieces of me
the vertical cylindrical shro
stays an equal distance fr
the vent pipe.

This separation allows
air flow for pressure
air relief.

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 ½ 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 the replaced.

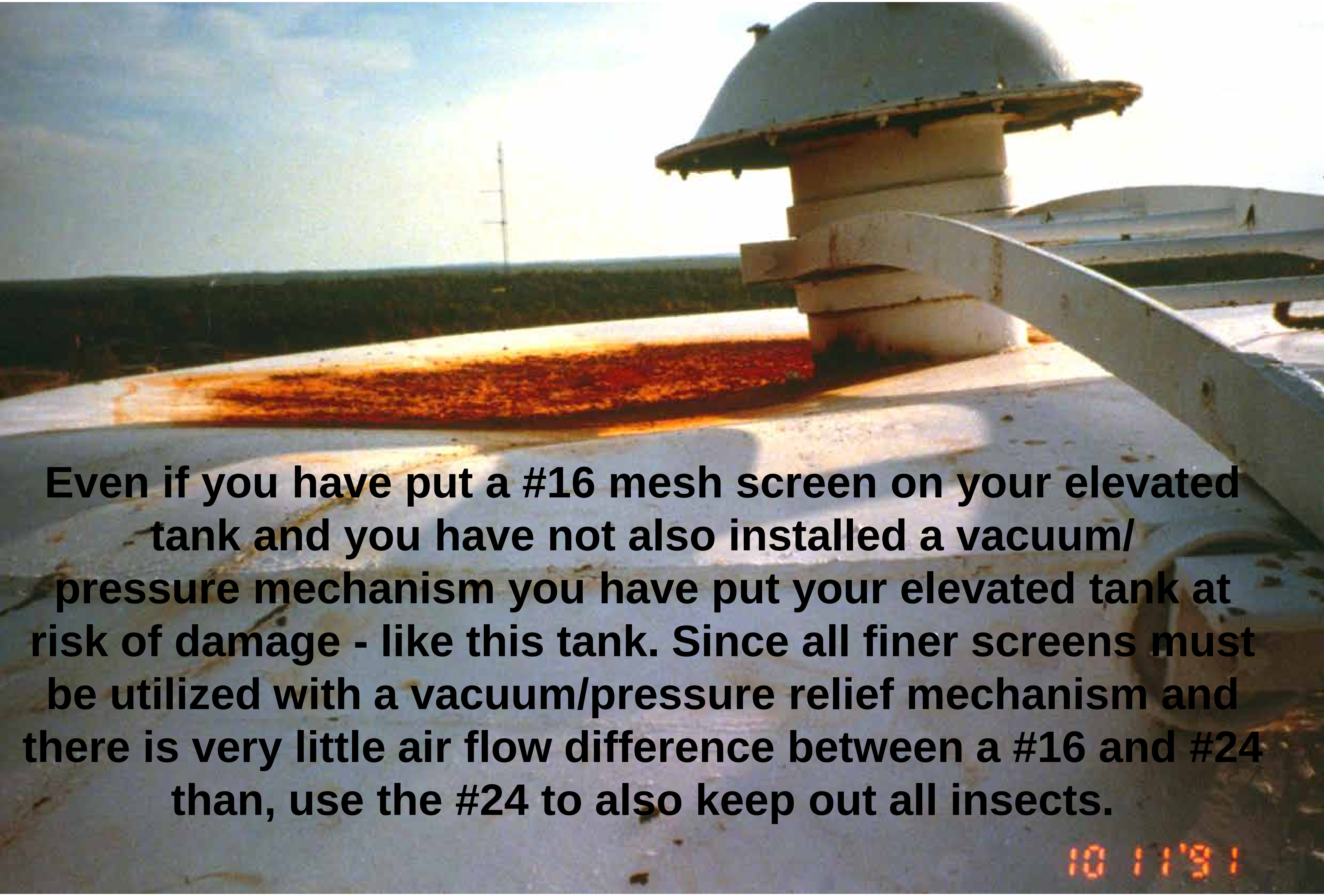
For a flexible screen vent, ask that the flexible inner screen be #24 mesh. The flexible screen is typically wrapped twice, the vertical seam needs to be sealed. When frost builds up on the flexible screen, vacuum and pressure will move the screen breaking up frost buildup.

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.

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

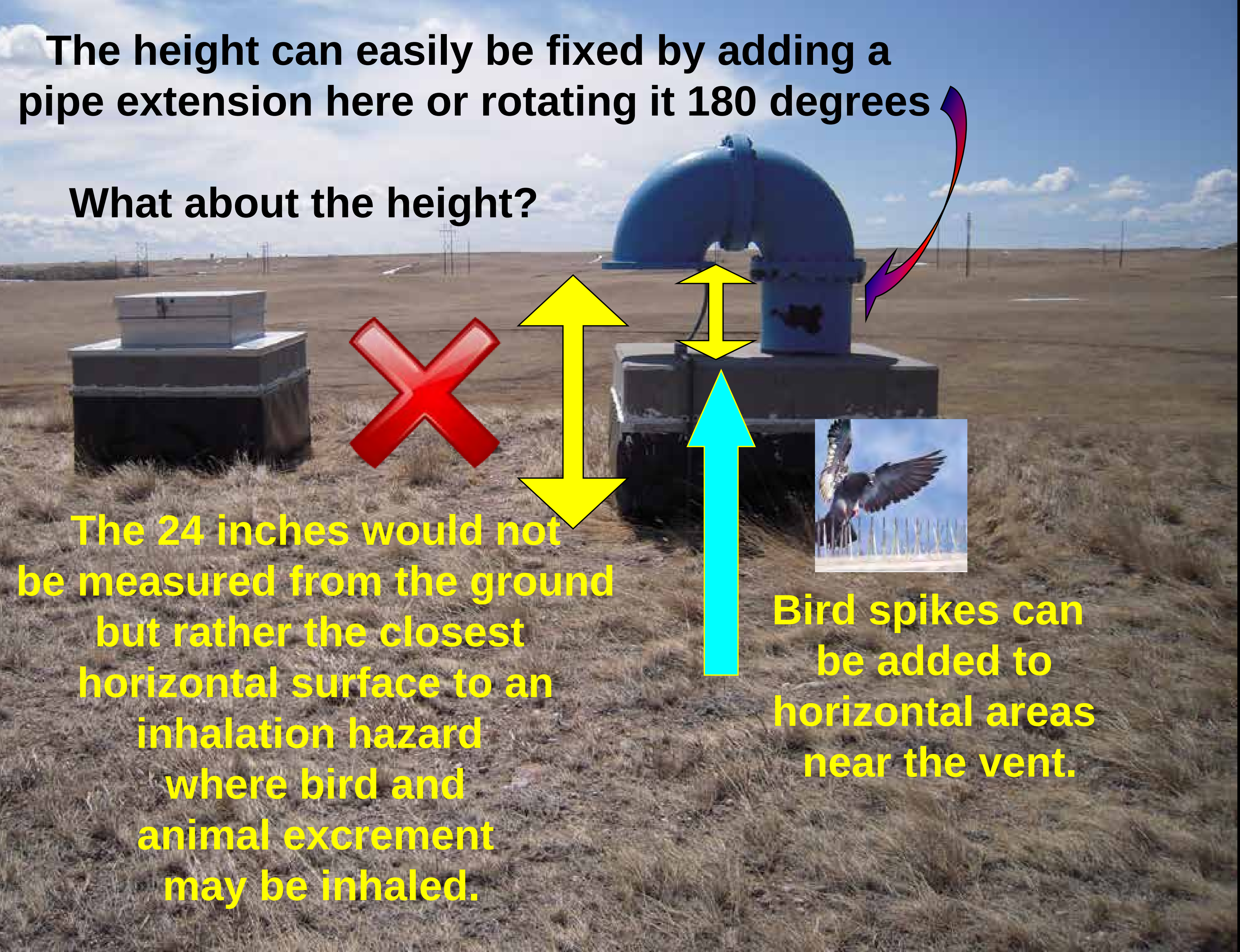
How to Conduct a Sanitary Survey of Drinking Water Systems

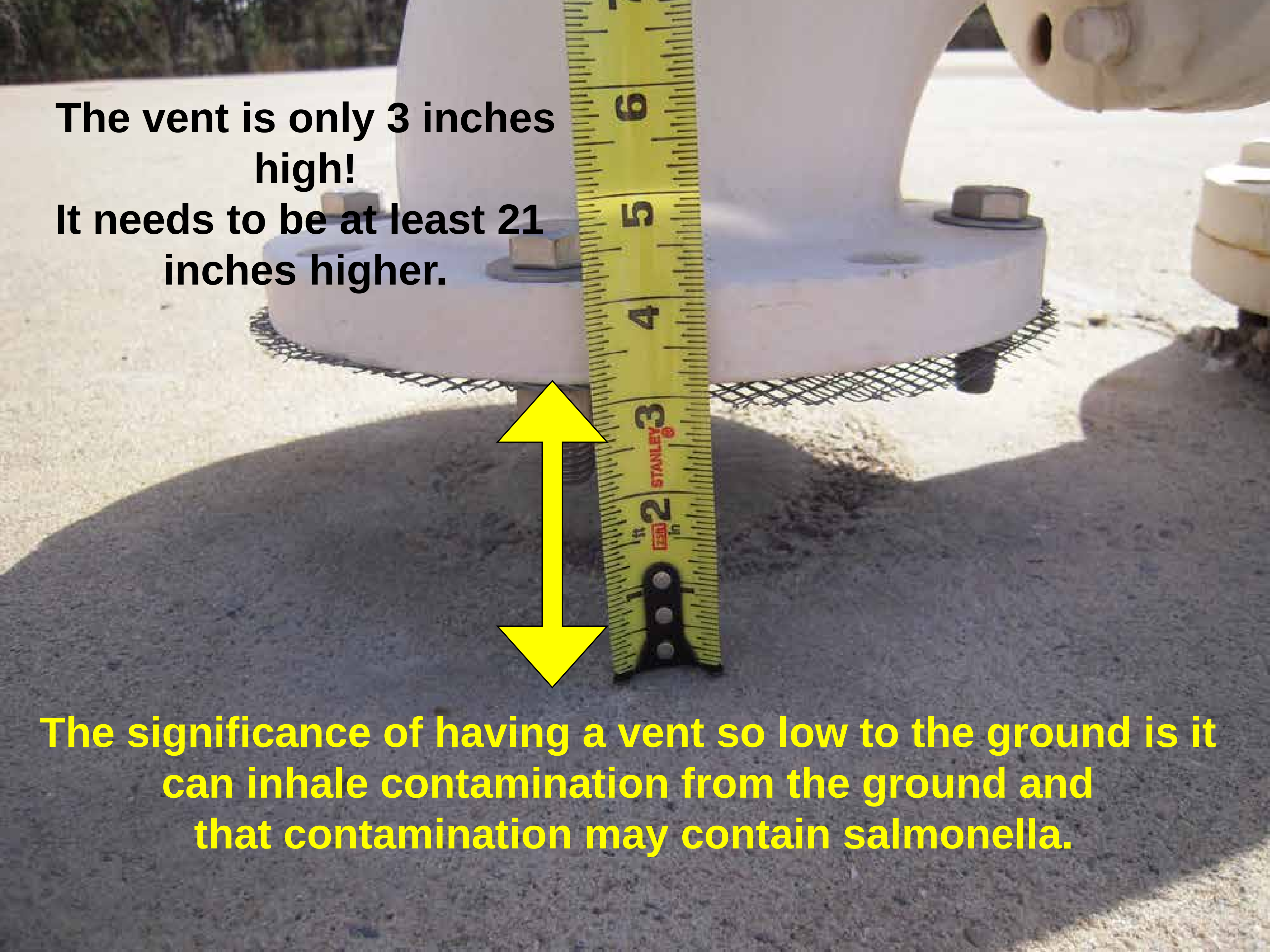
{Section 10.4.10, #14 Air Vents, b (1st paragraph)} Vents breathe air in and out of the tank and can inhale contaminants into the finished water; therefore, the screen must be at least 24 inches (ground or elevated) above the roof or ground. The vent must also protect against rain and snow, and minimize 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

A Learner's Guide

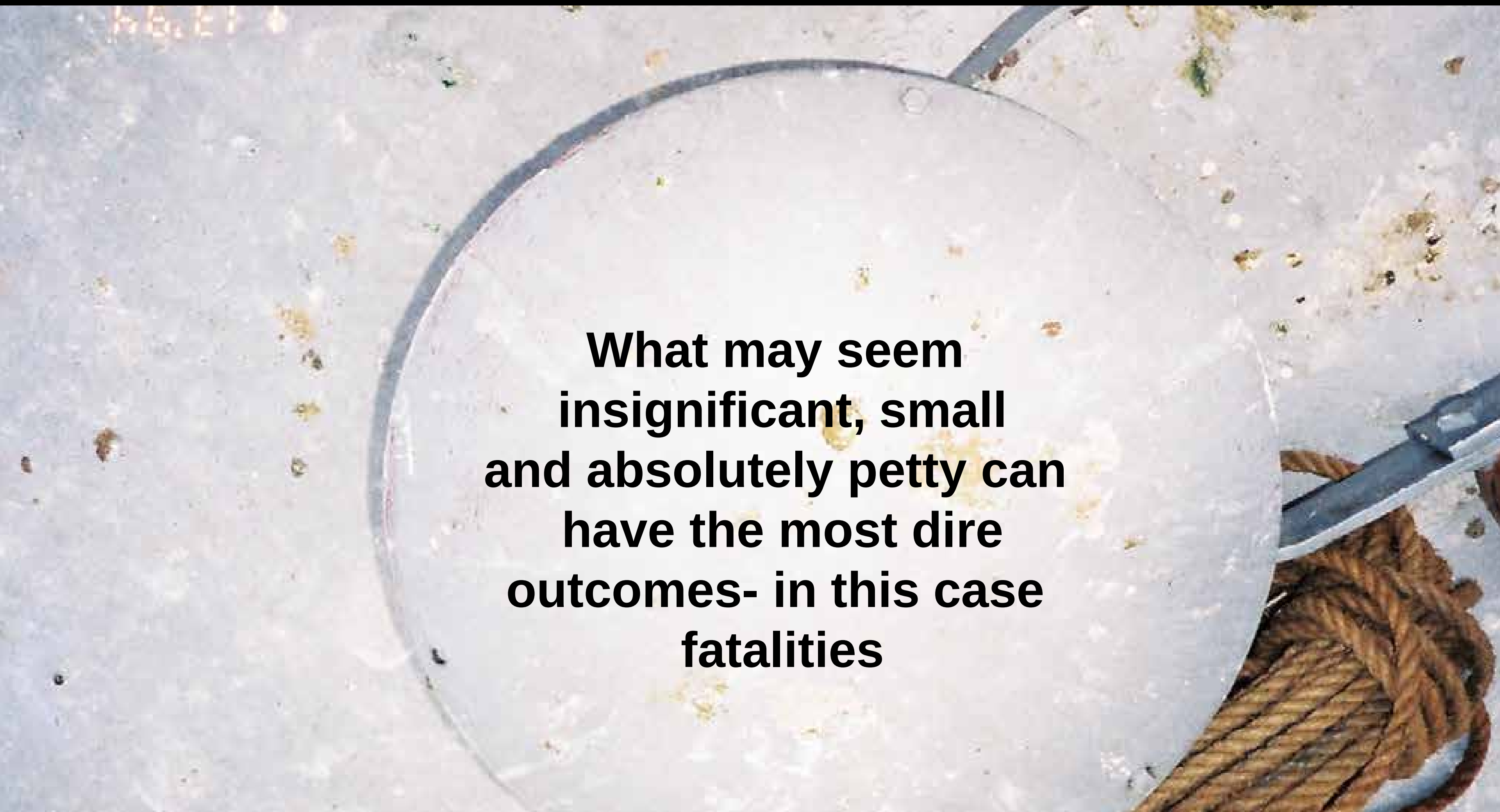
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE


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

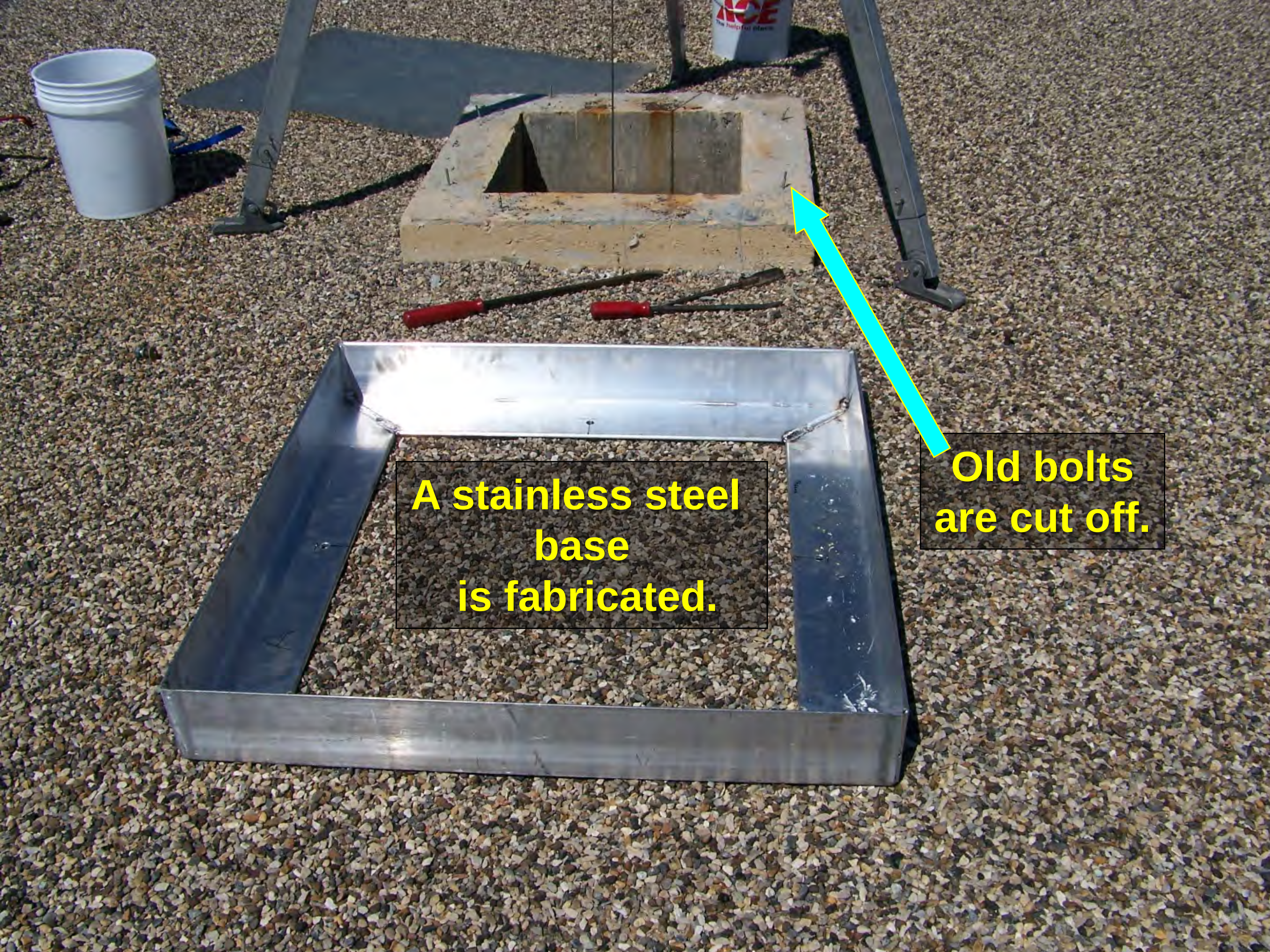
This is the vent for Gideon, Missouri one of the cities that had a major waterborne disease outbreak. You can see the pigeon droppings and the vent very low to the roof which will inhale these Salmonella laden droppings into the tank.




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


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.
ACE


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

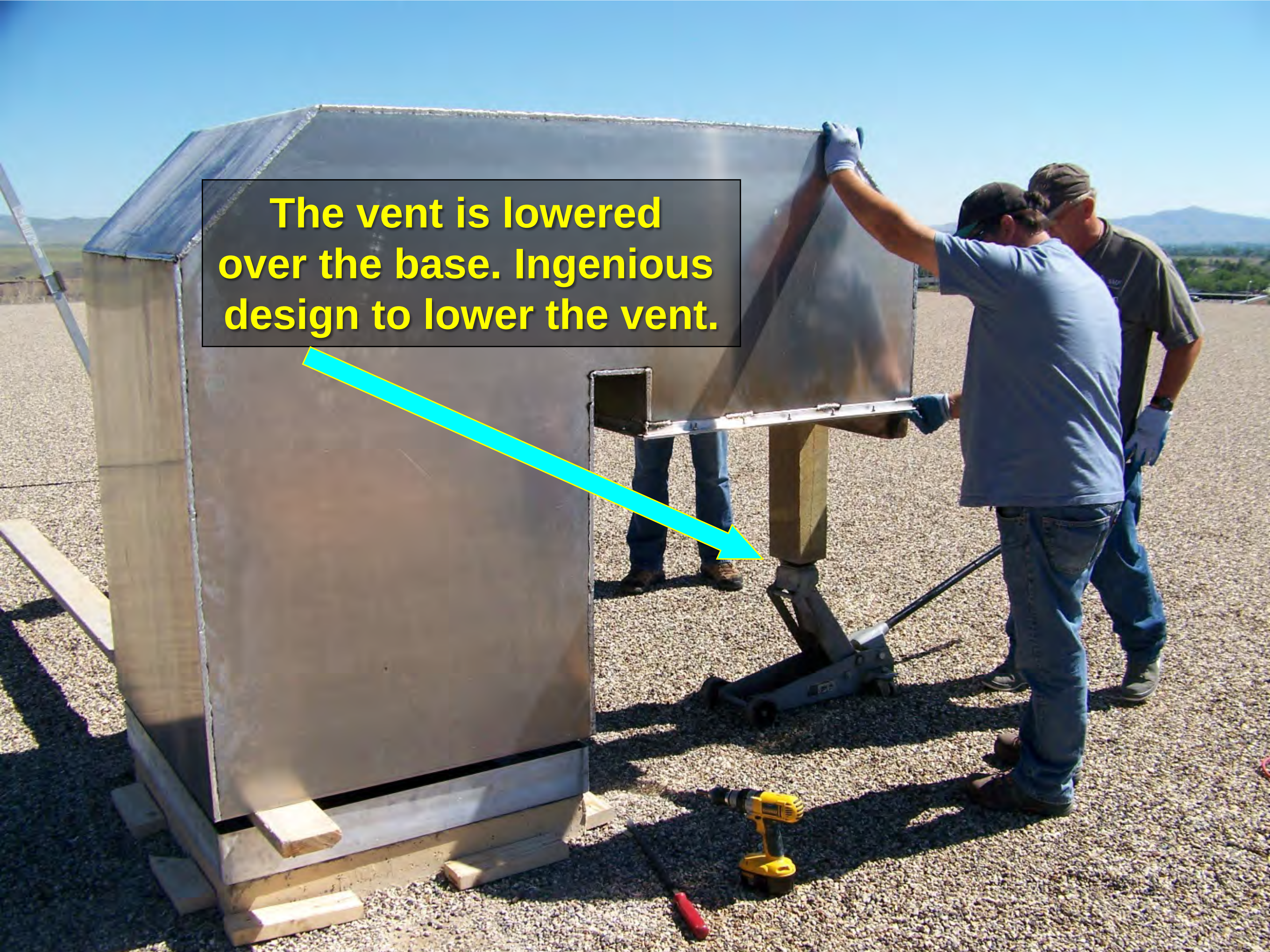

Anchor rods are glued into the concrete.
HILTI
Anchor rod HAS-R
20

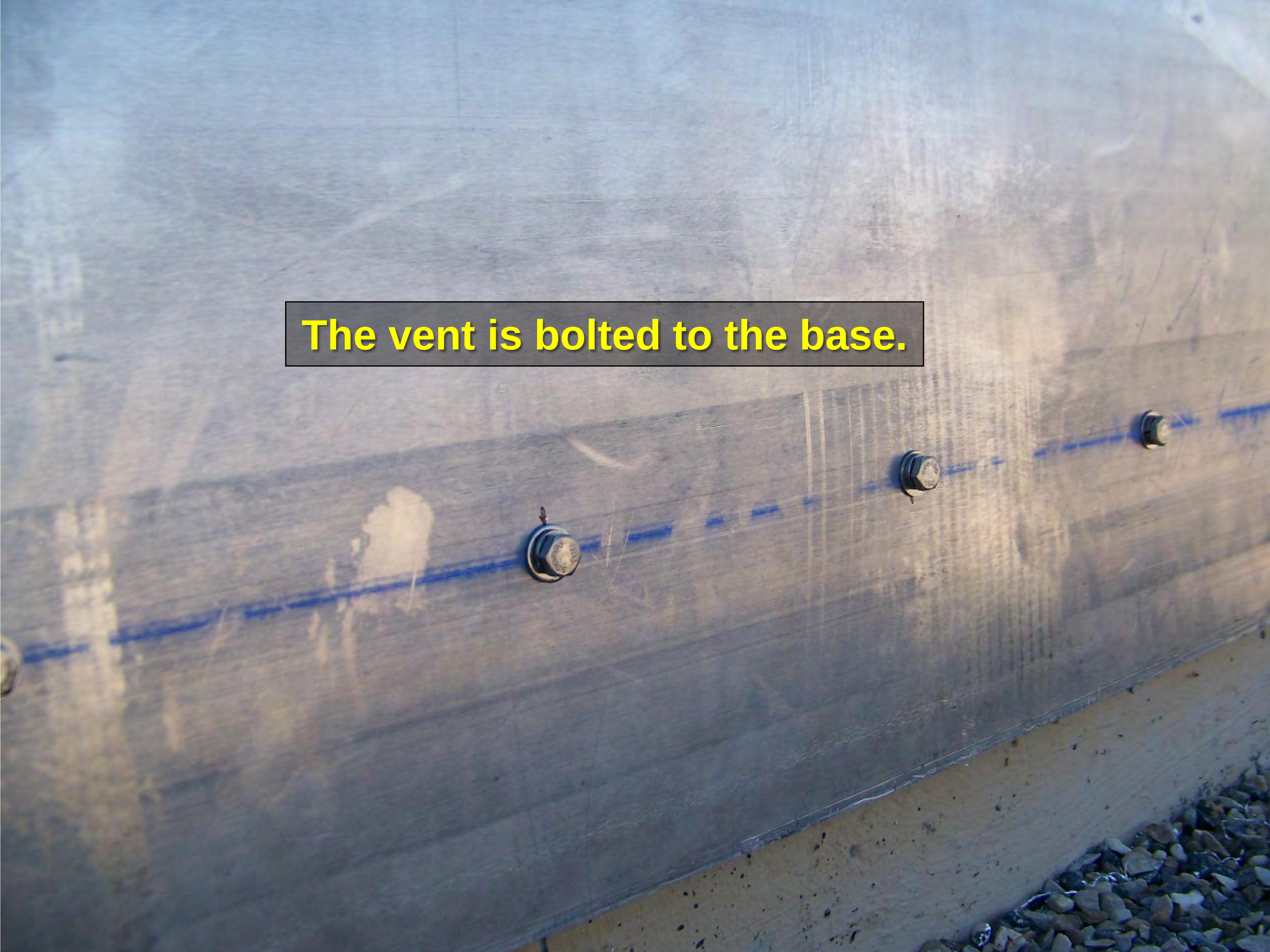

Sealant is placed along the rough concrete base to create a good seal.
Anchor bolts installed.

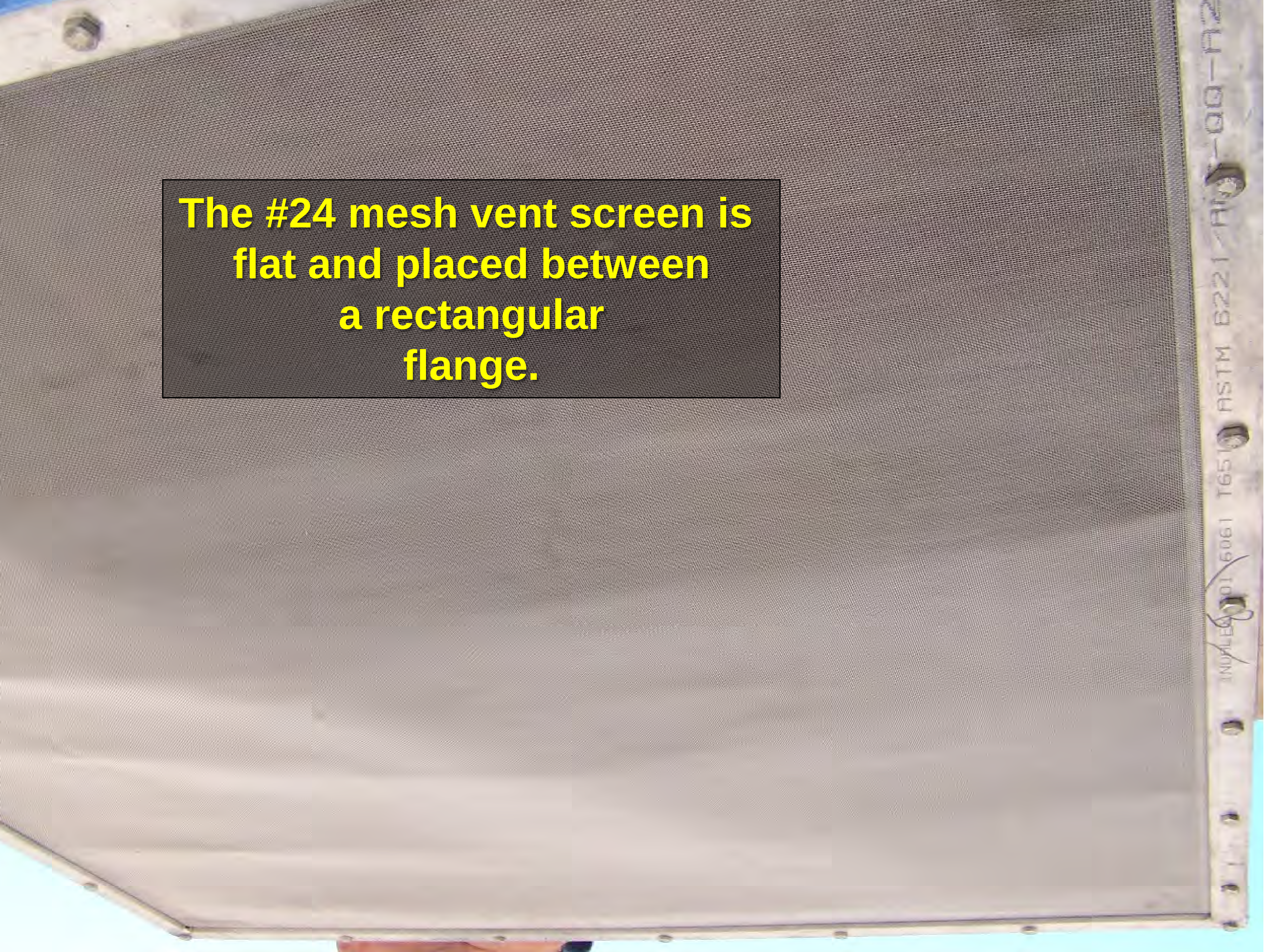

Rubber seal is placed over the sealant.


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.


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.

The inhalation hazard is mitigated <u>permanently.</u> 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

A Learner's Guide

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

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.

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

A Learner's Guide

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

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.

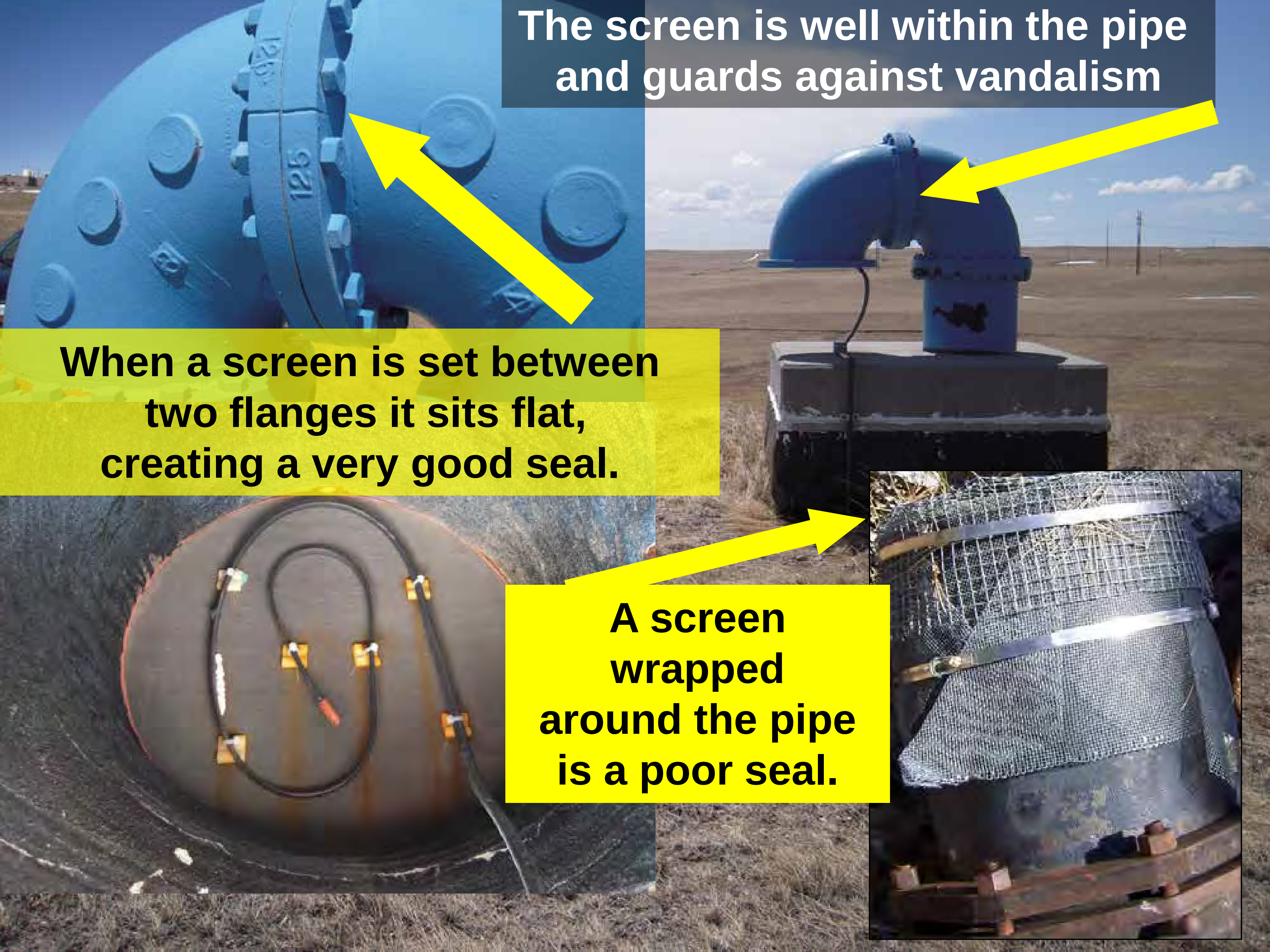
How to Conduct a Sanitary Survey of Drinking Water Systems

{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

A Learner's Guide

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


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.
125
125

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.

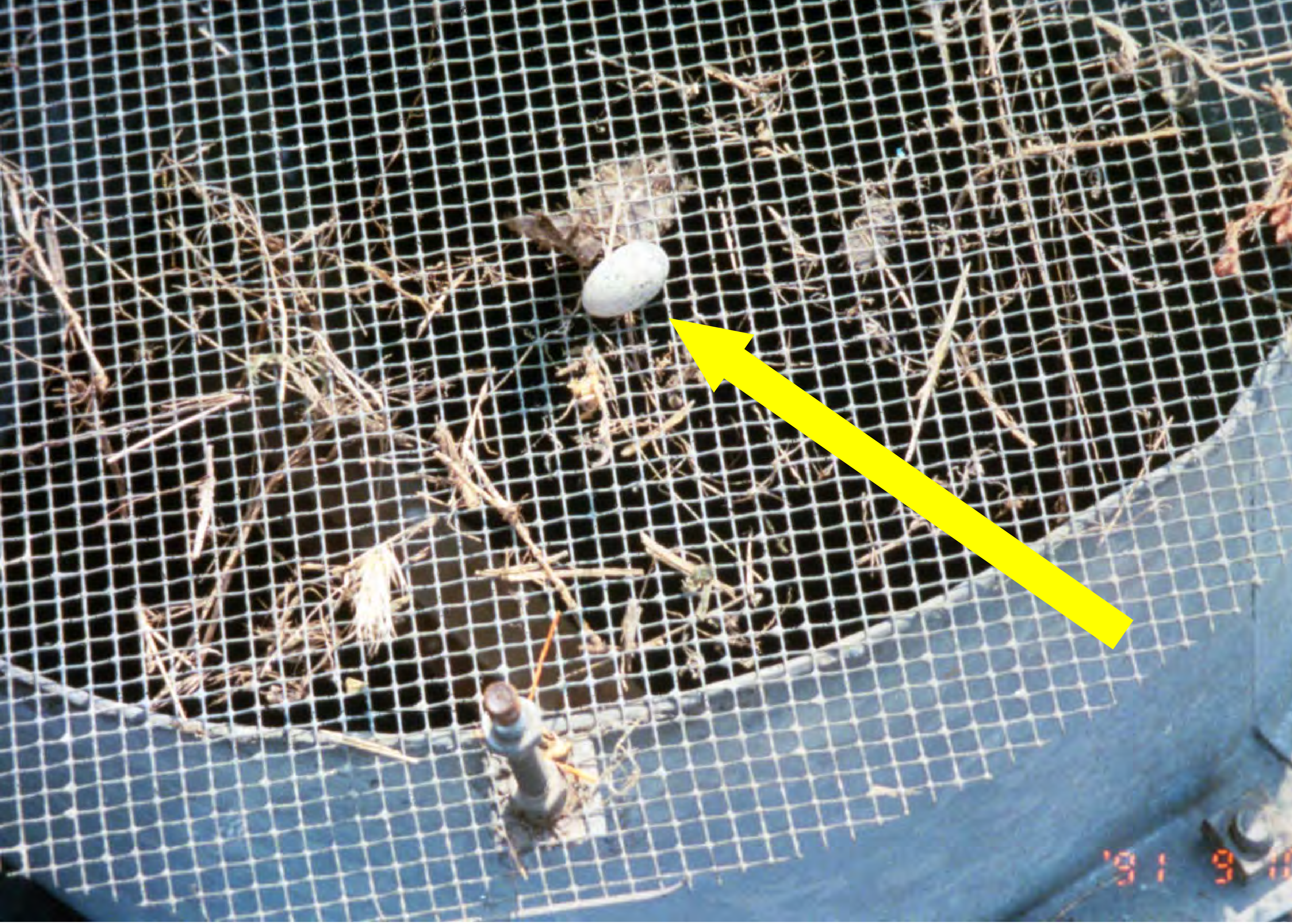
Also see, Section 10.4.8 Components

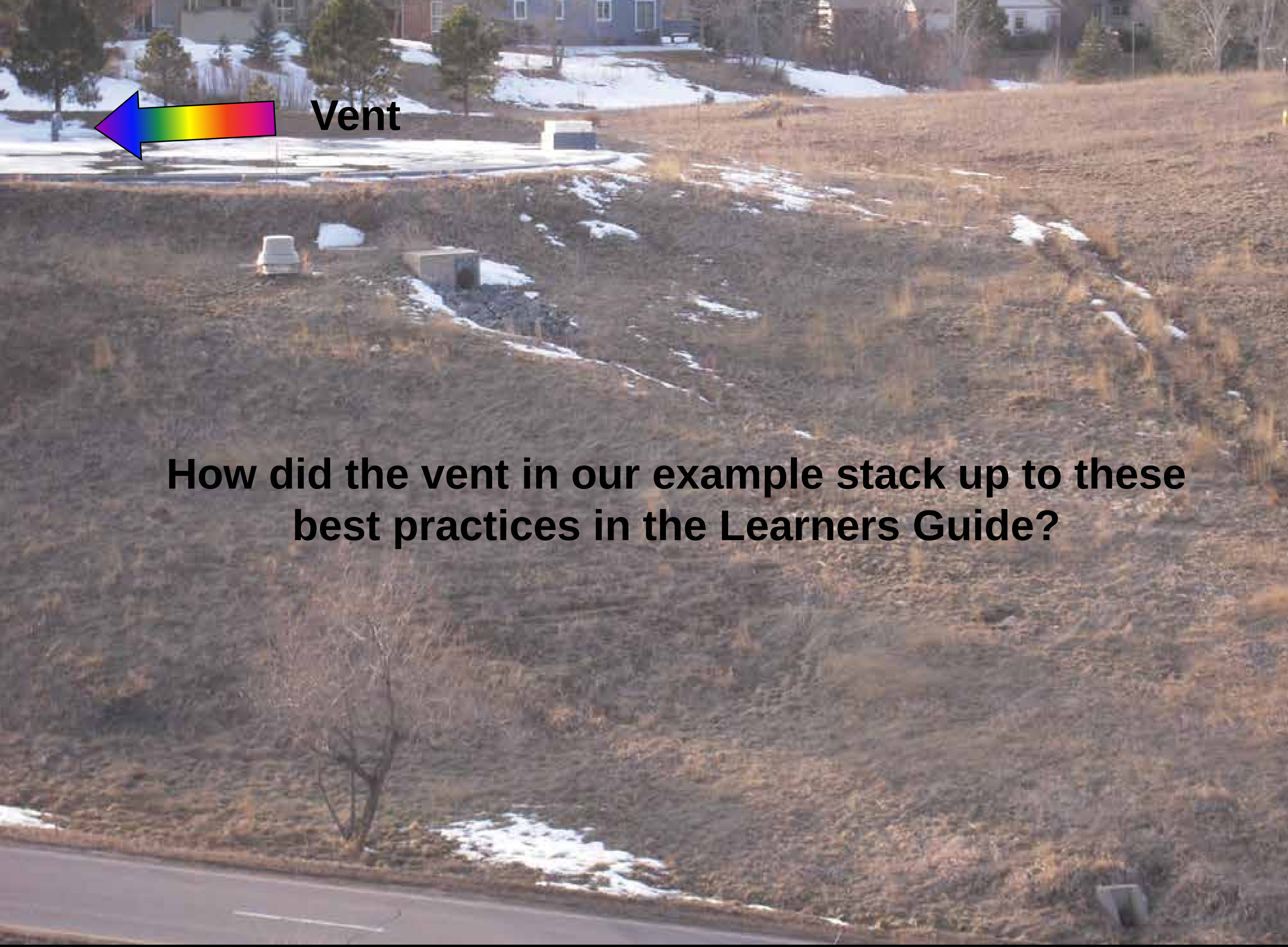
A Learner's Guide

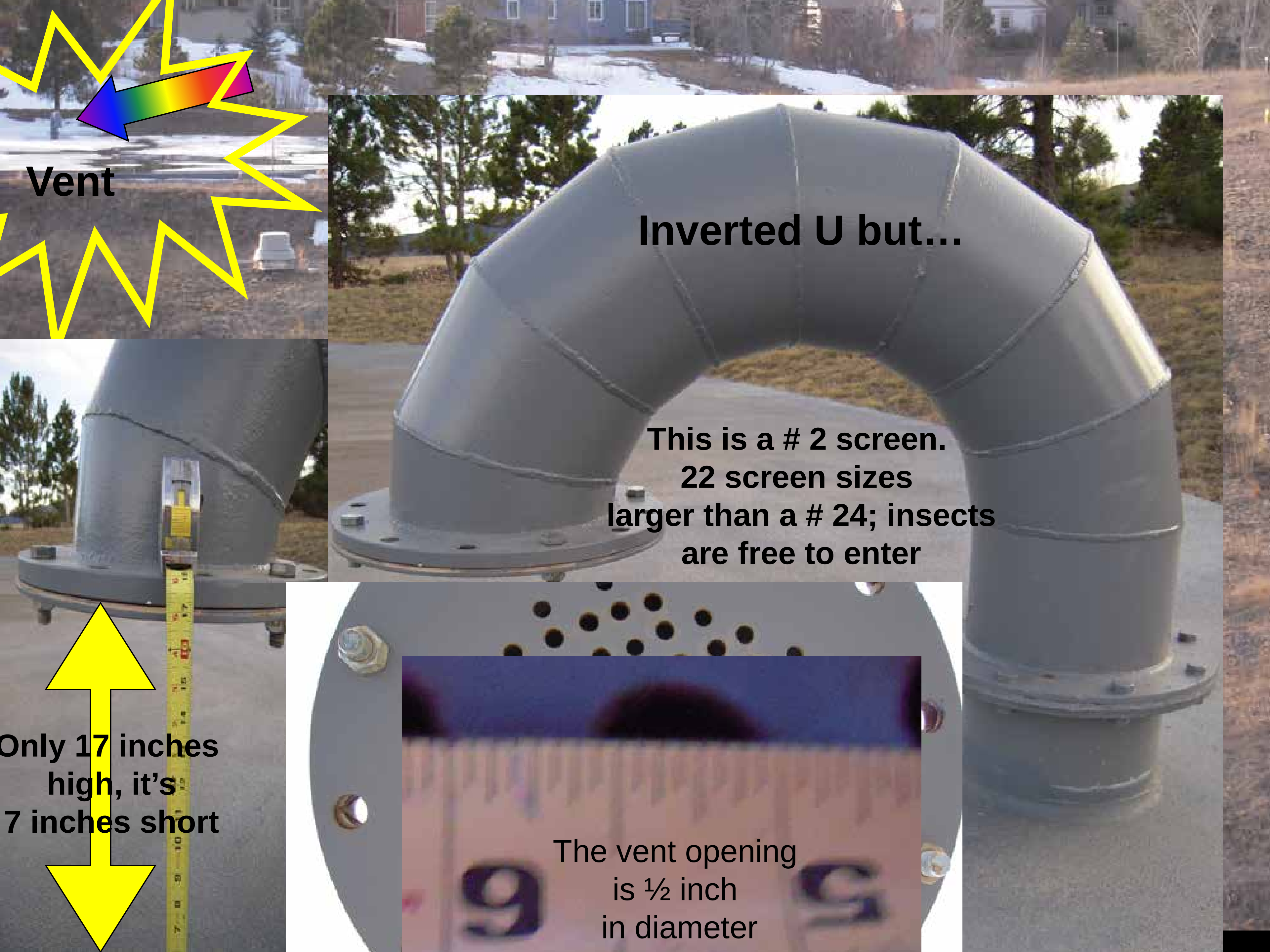
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE


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 ½ inch
in diameter


Failed!
Vent

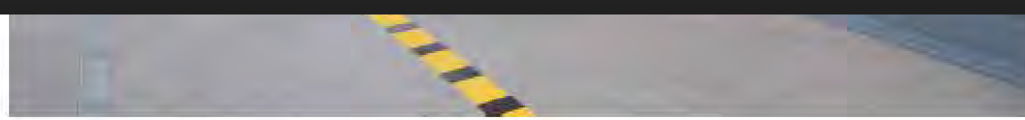

Overflow
Let’s look at the best practices in the Learners Guide for overflows and see how our storage tank stacks up.

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. <u>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.</u>

Also see, Section 10.4.8 Components



A Learner's Guide

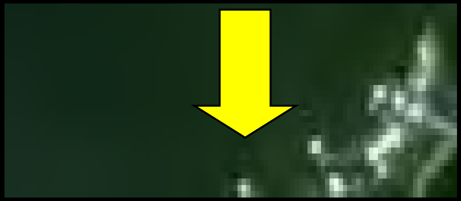
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE

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.




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.
'91 9 12

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.

Journal American Water Works Association

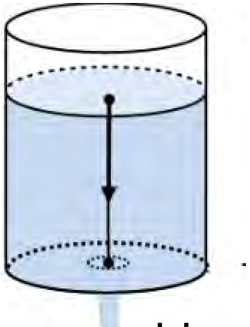
Peer Reviewed

Understanding the Impact of Mesh on Tank Overflow System Capacity

Jonathan B. Burkhardt, James A. Goodrich, Jeff Szabo, John Hall, Jake Crosby, Seth Tourney, Robert Clement

First published: 17 October 2018 | https://doi.org/10.1002/awwa.1162

Weir limited flow: As flow inc. the air gap collapses causing water in tank to rise.



Pressure driven flow: The height of the water above the pipe inc. flow through the pipe.

This research demonstrated that as flow increases into the tank it can overwhelm the overflow's capacity to get rid of the water and lead to increased water rise in the tank to the roof (tank design only calls for 6 to 12 inches of clearance between the roof and overflow) causing damage to the roof. For example a 4-inch overflow at 450 gpm was able to keep up with the flow into the tank but at 465 gpm the tank level rose 4 inches. When the flow was increased above 465 gpm the water level continued to rise and that flow had to be terminated due to fears that the open tank was going to overflow. There was a mere 15 gpm difference between keeping up with the flow in, to a rise in the water level above the 6 to 12 inches. This rise of water level occurred independent whether a #24 mesh screen was installed on the overflow or not. The key to protecting tanks from damage is redundant alarms (consider cameras).

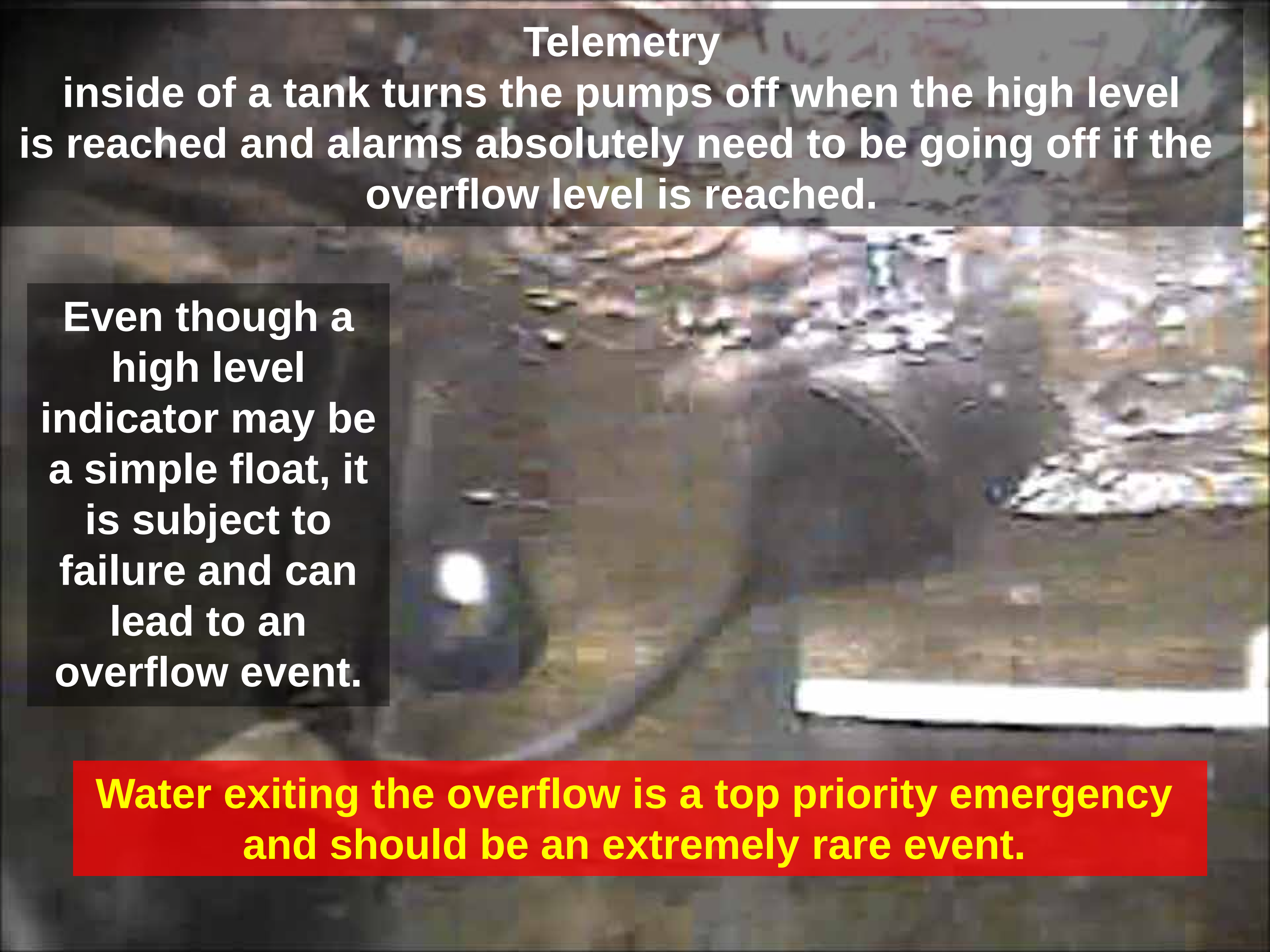
How to Conduct a Sanitary Survey of Drinking Water Systems

{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.

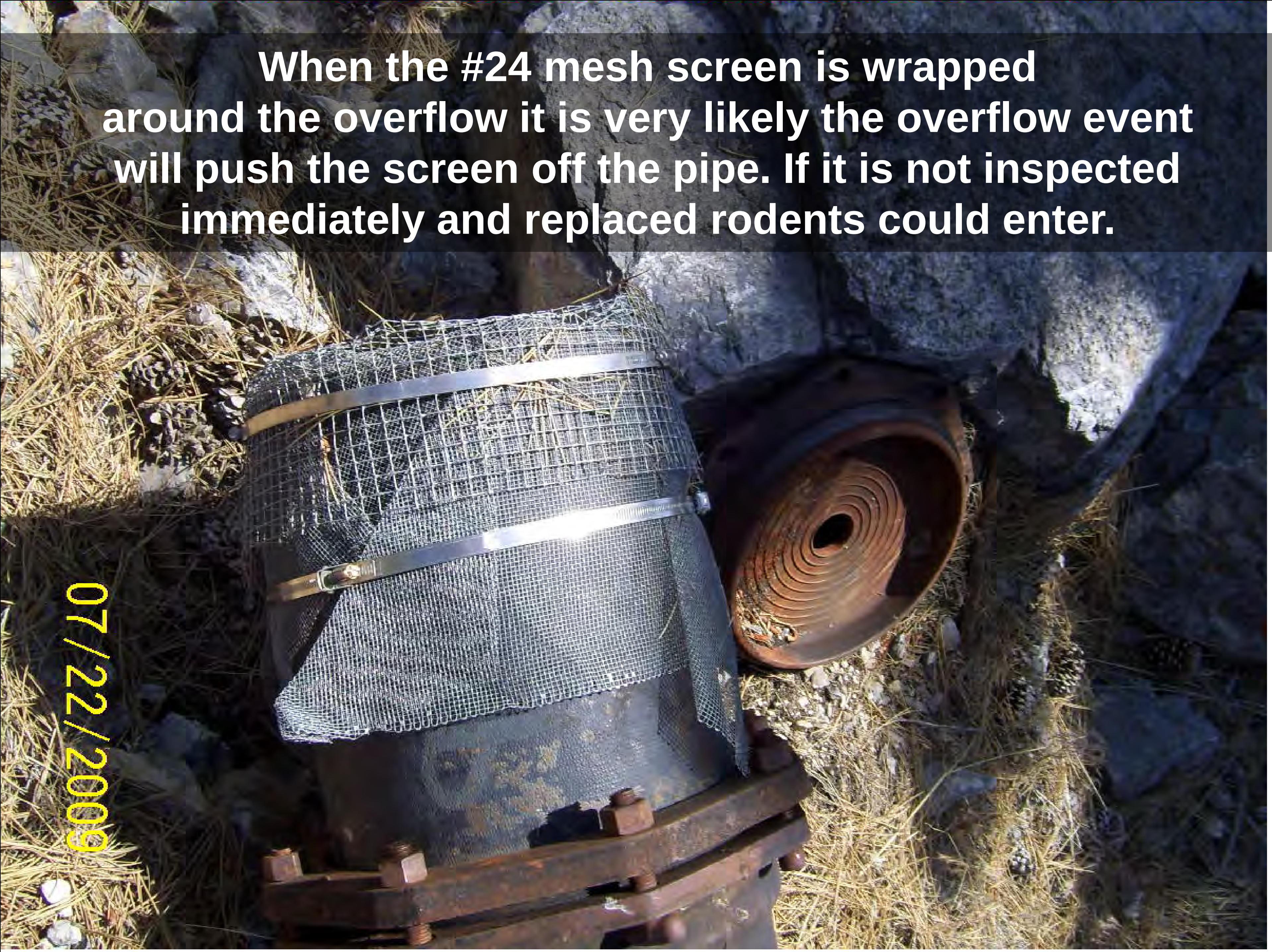
Also see, Section 10.4.8 Components

SANITARY SURVEY TRAINING COURSE


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.



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

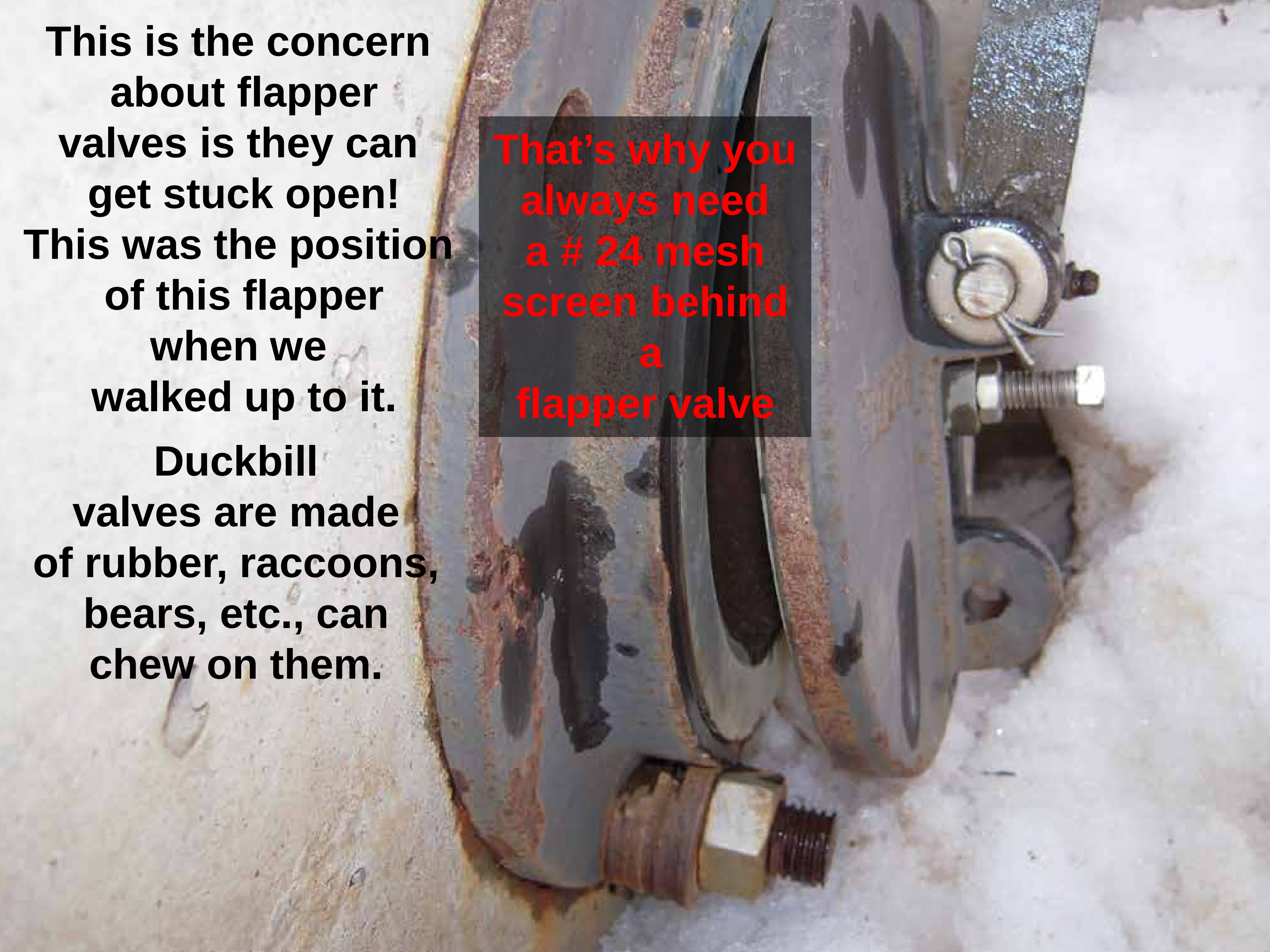
{Section 10.4.10, #15 Overflows, a (2nd paragraph)}

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. <u>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.</u>

Also see, Section 10.4.8 Components

SANITARY SURVEY TRAINING COURSE

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

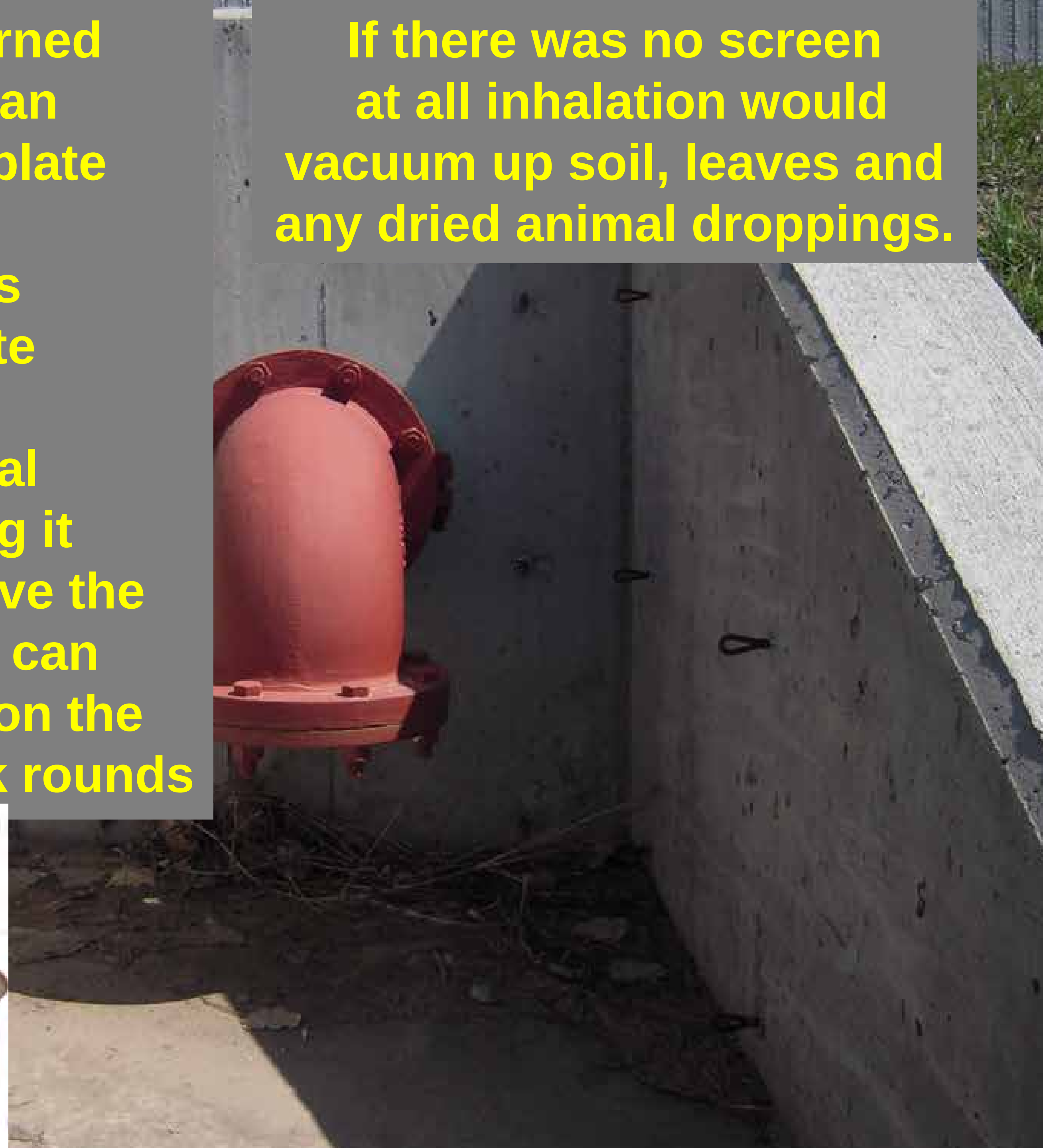
This flapper valve is hiding a very damaged # 24 screen.
This would be caught if daily to twice a week inspections were performed.

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.

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

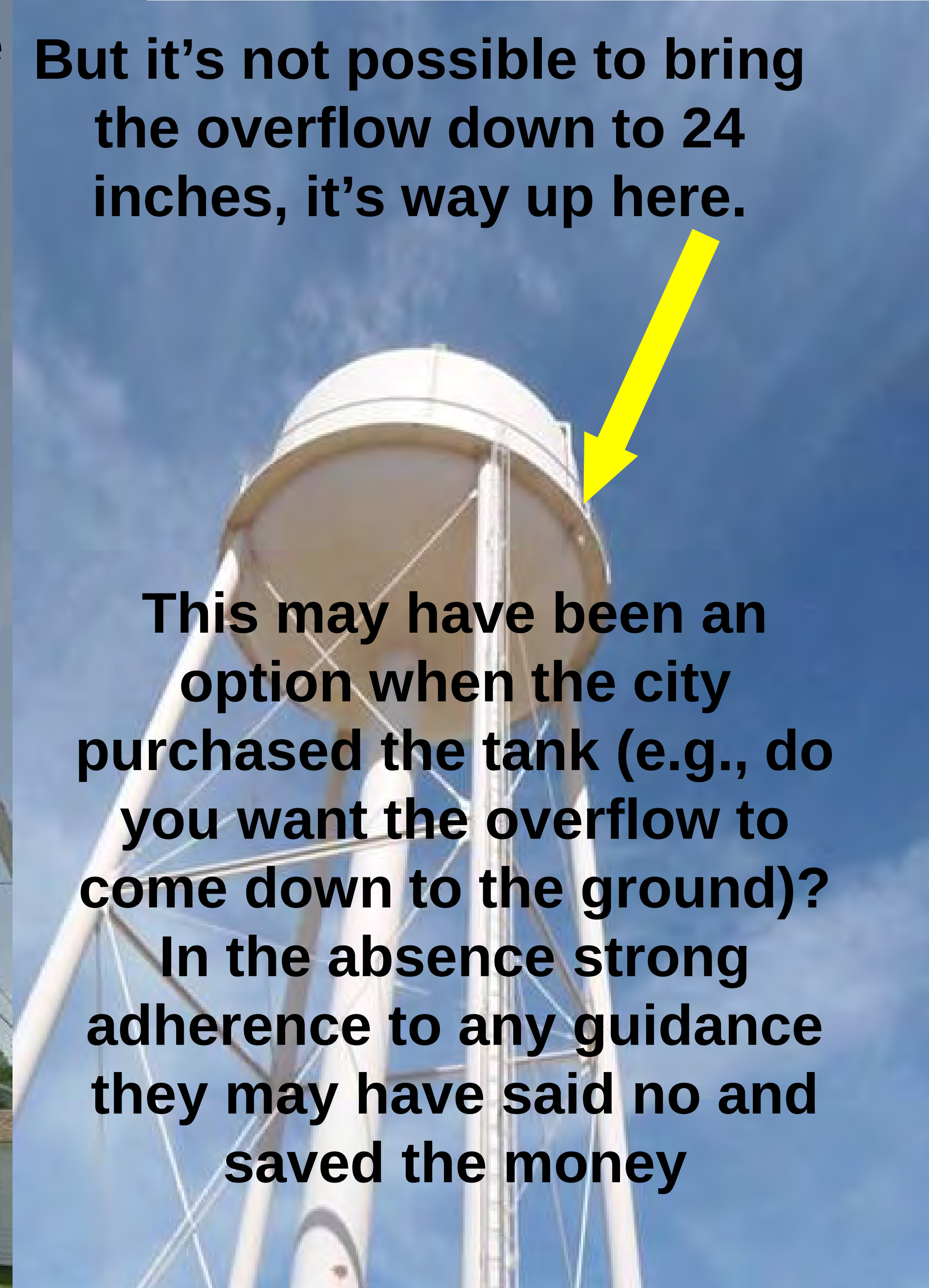
Another practical
reason for having it
12 to 24 inches above the
ground is so you can
inspect the screen on the
daily to twice a week rounds

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




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

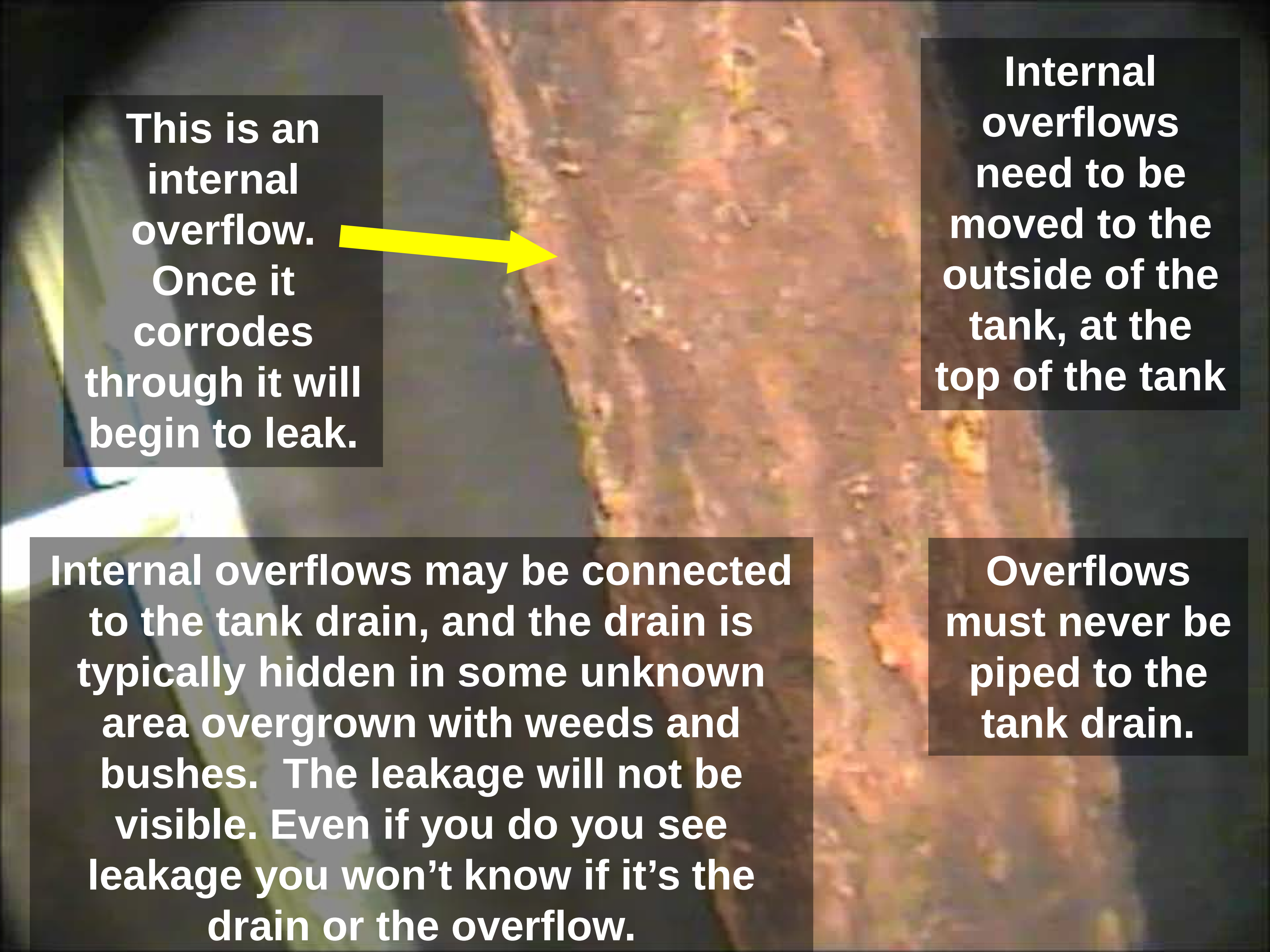
{Section 10.4.10, #15 Overflows, b (1st paragraph)} Overflows, like vents, breathe air in and out of the tank and can inhale contaminants (leaves, soil, dried feces, feathers, etc.) into the finished water. Therefore, the screen must be at least 24 inches (but not less than 12 inches) above the splash 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

A Learner's Guide

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


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.

A Learner's Guide

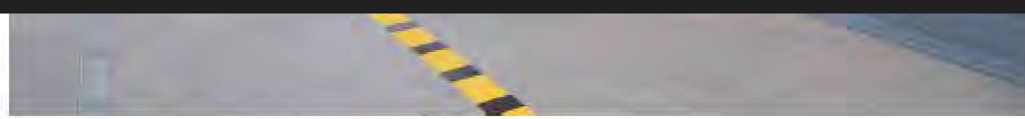
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE

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.

How to Conduct a Sanitary Survey of Drinking Water Systems

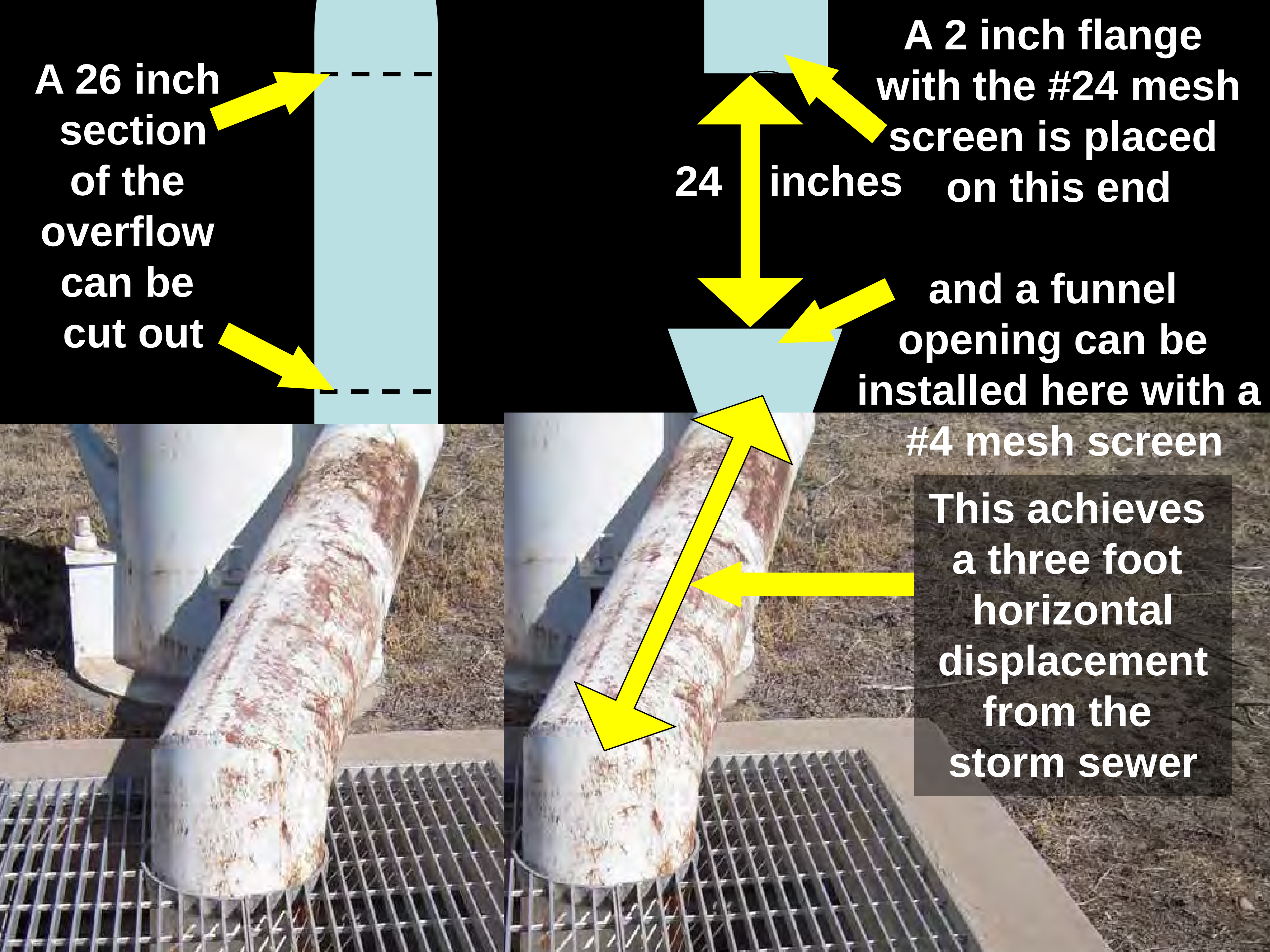
{Section 10.4.10, #15 Overflows, b (2nd paragraph)} If the overflow discharges above a storm sewer, operators need to displace the outlet horizontally by at least 3 feet or have a duckbill valve to avoid breathing air from the storm sewer. The overflow must discharge over a splash plate or engineered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

Also see, Section 10.4.8 Components



A Learner's Guide

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

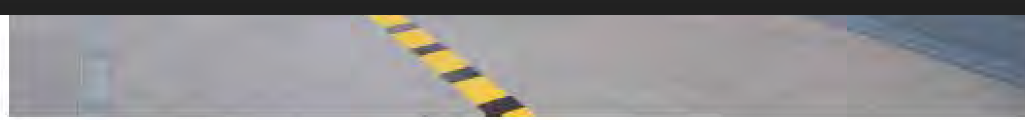

A 26 inch section of the overflow can be cut out
24 inches
A 2 inch flange with the #24 mesh screen is placed on this end
and a funnel opening can be installed here with a #4 mesh screen
This achieves a three foot horizontal displacement from the storm sewer

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

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. <u>The overflow must discharge over a splash plate or engineered outlet (concrete or riprap) that will not submerge the overflow when spilling.</u>

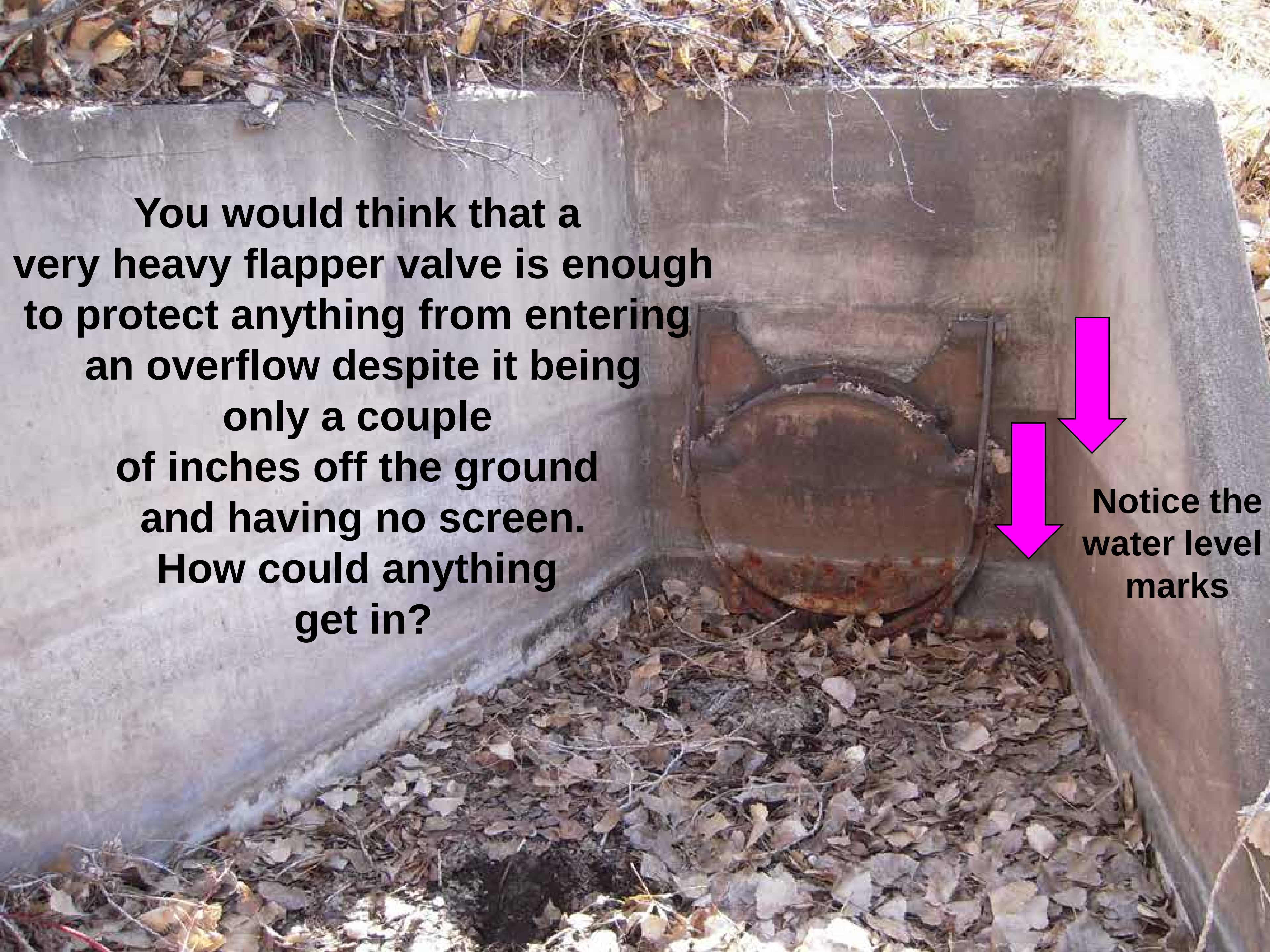
Also see, Section 10.4.8 Components



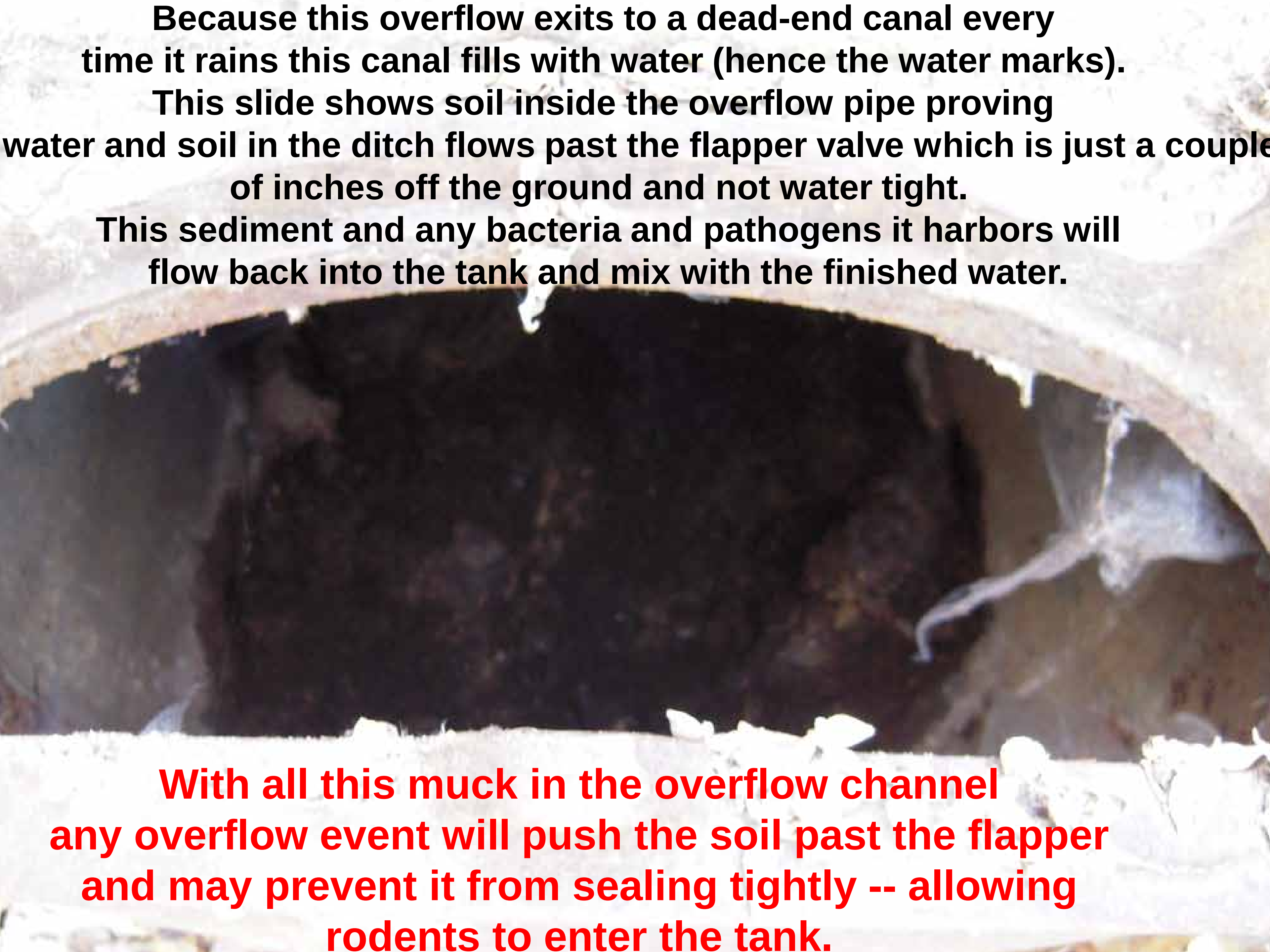
A Learner's Guide

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

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

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

A Learner's Guide

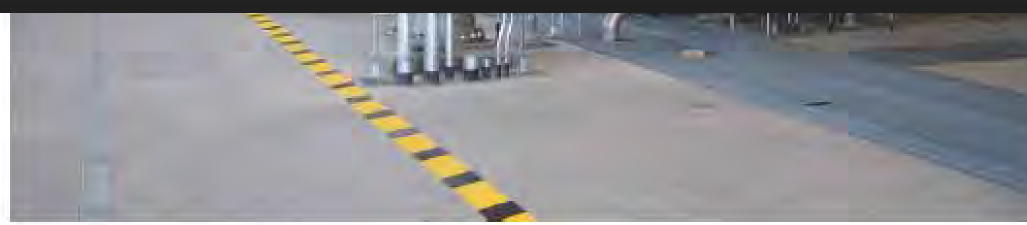
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE

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 accidently 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

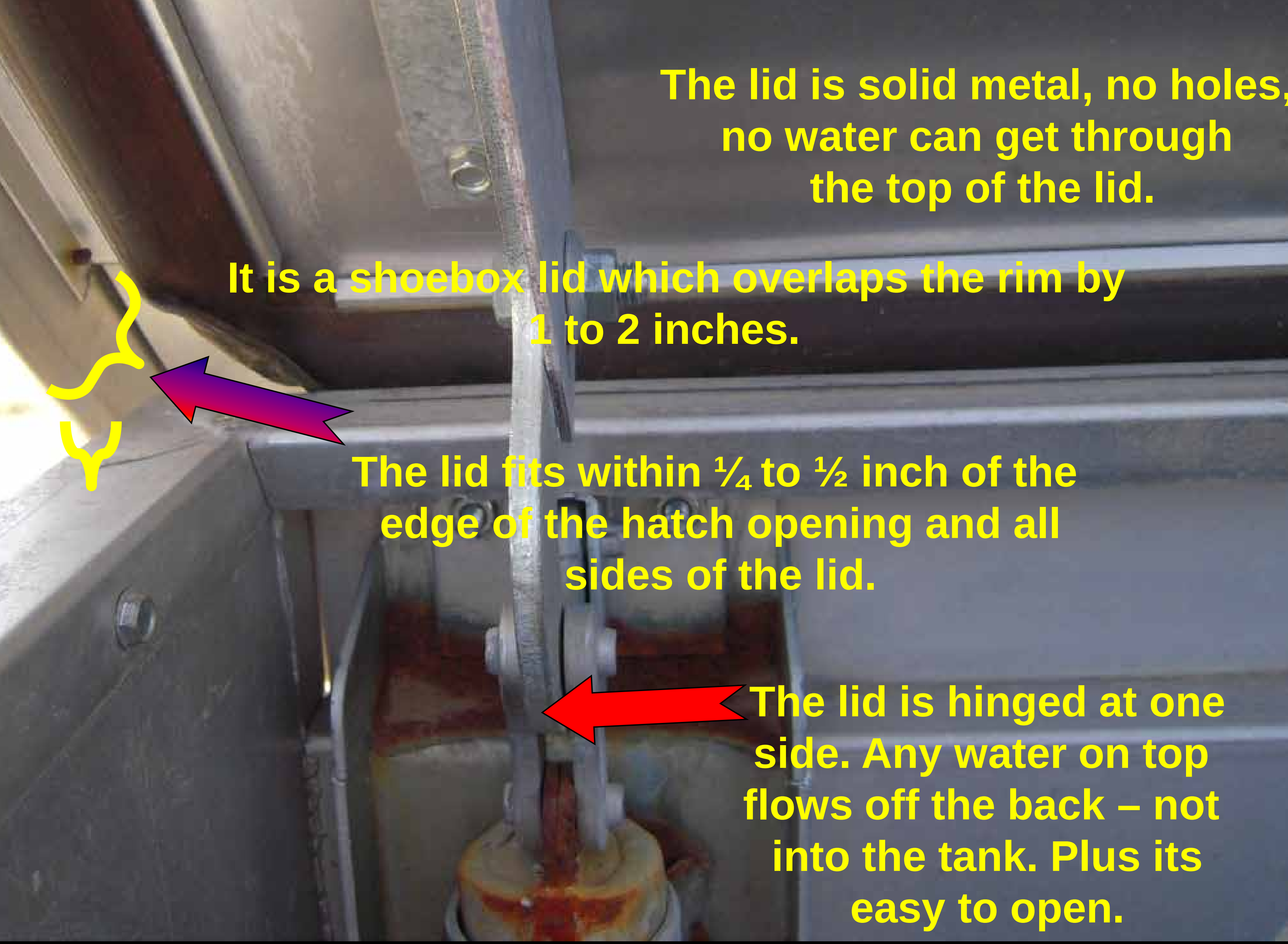
{Section 10.4.10, #16 Hatches (2nd paragraph)} …Is the lid solid and water tight, as well as hinged at one side. Is the lid a shoebox design that overlaps the rim by one or two inches? Does the lid fit over the hatch like the top of a shoebox, with no more than a ¼ to ½ of an inch space between the hatch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

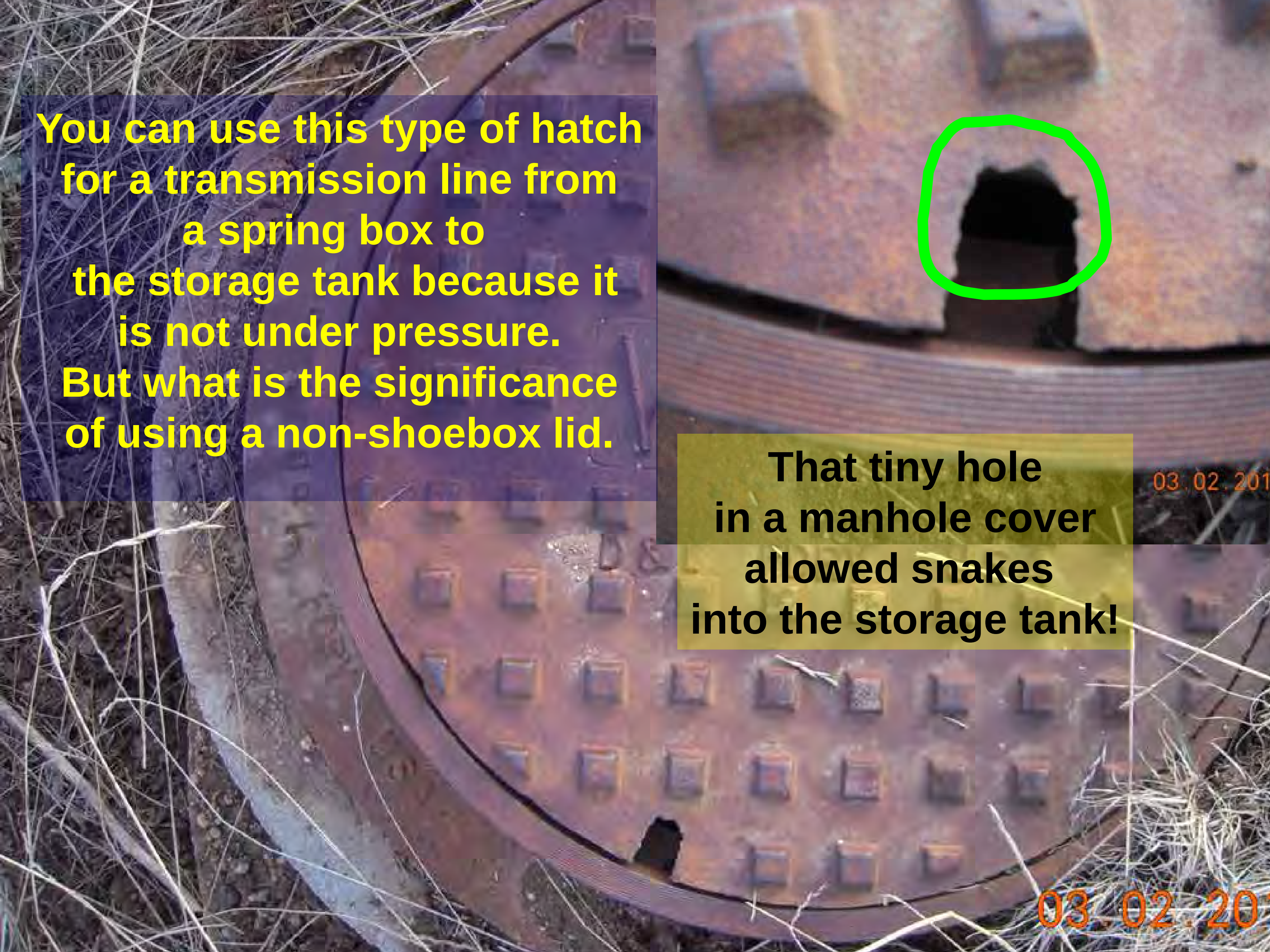
Also see, Section 10.4.8 Components



A Learner's Guide

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


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 ¼ to ½ 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!

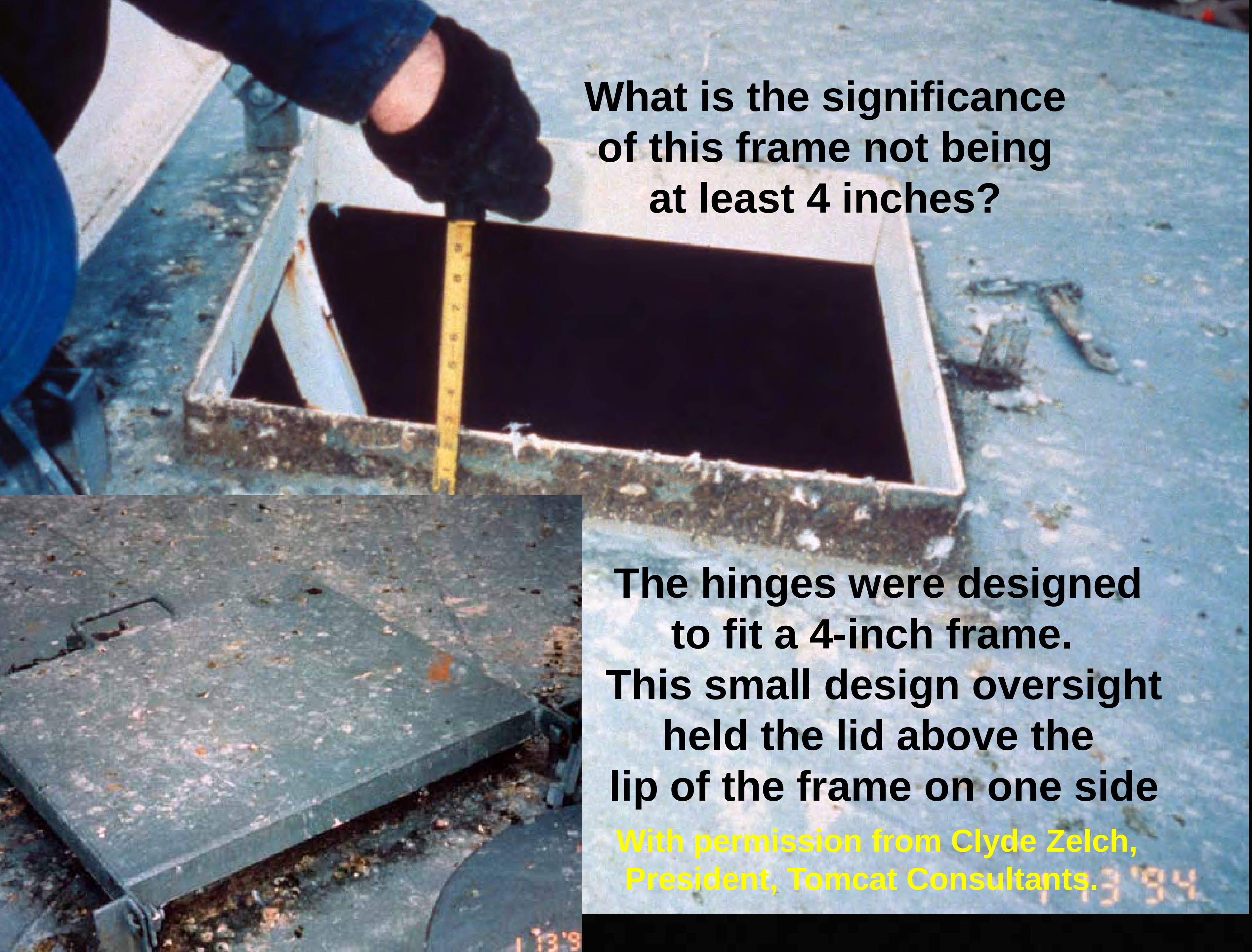
How to Conduct a Sanitary Survey of Drinking Water Systems

{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.

A Learner's Guide

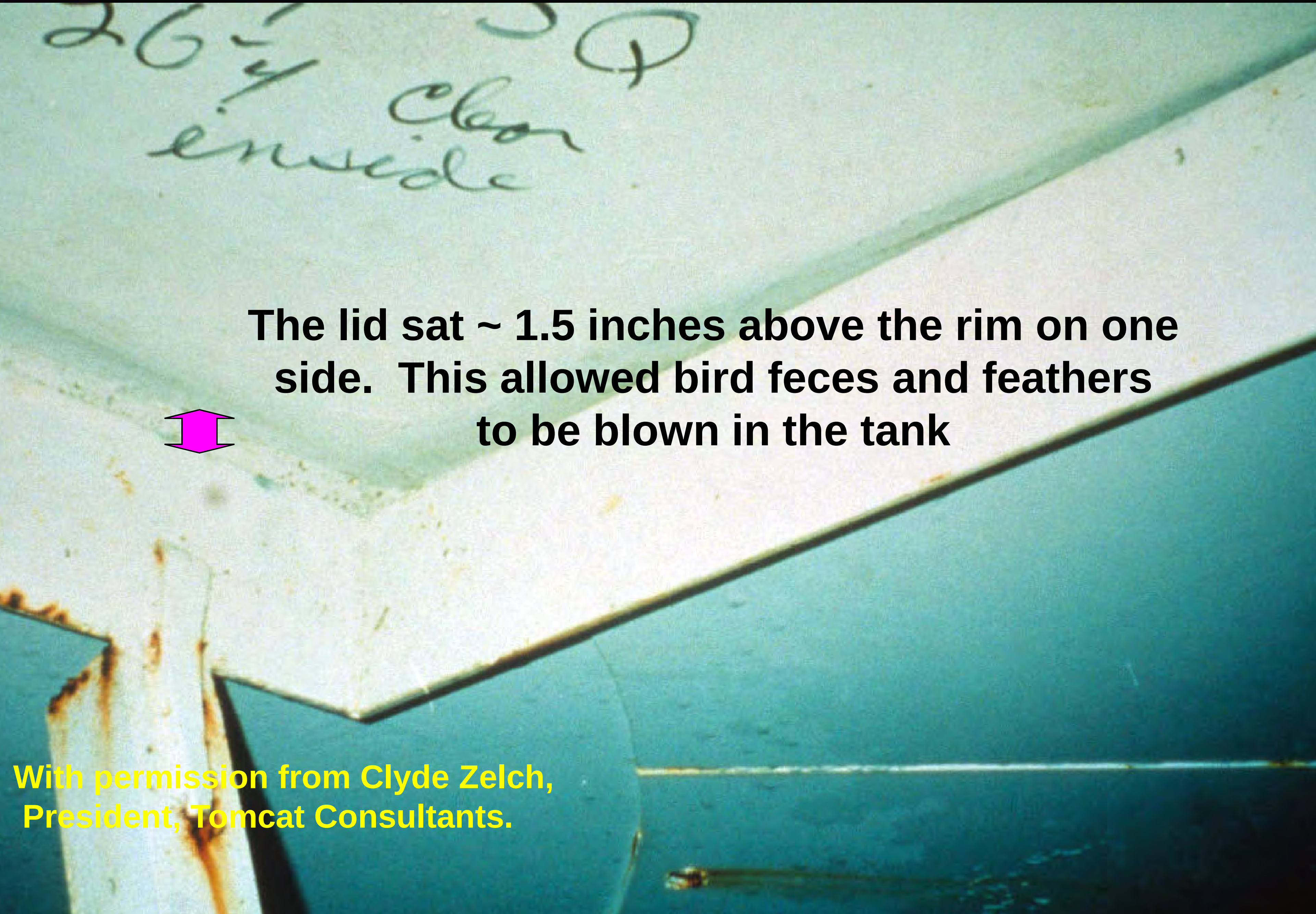
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE



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

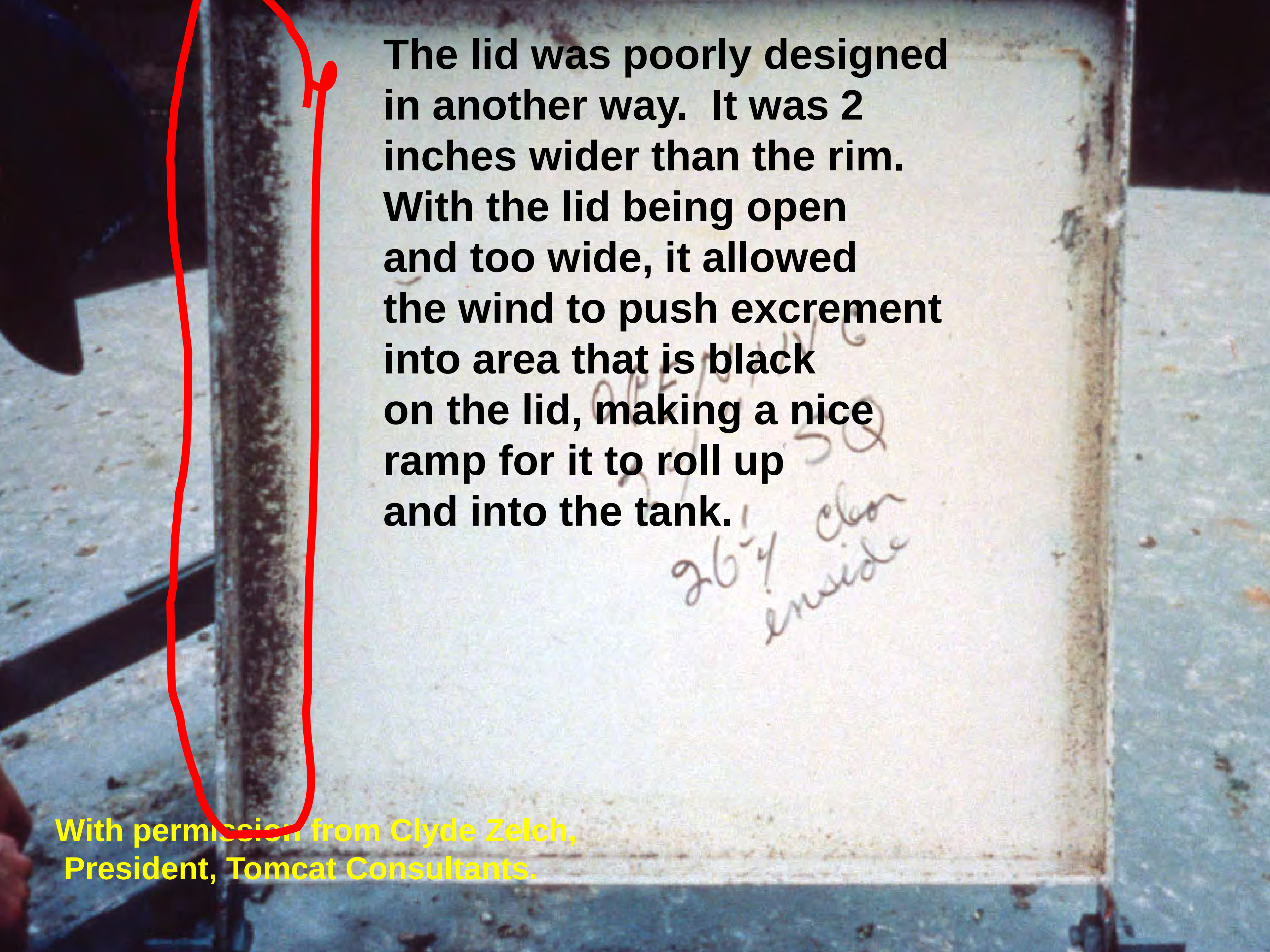
The hinges were designed to fit a 4-inch frame. This small design oversight held the lid above the lip of the frame on one side

With permission from Clyde Zelch, President, Tomcat Consultants.



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.

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.

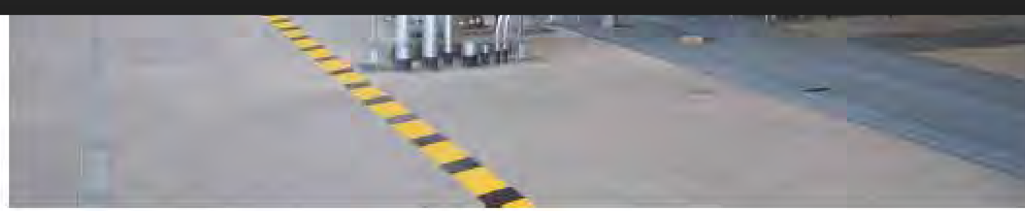
With permission from Clyde Zelch, President, Tomcat Consultants.

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

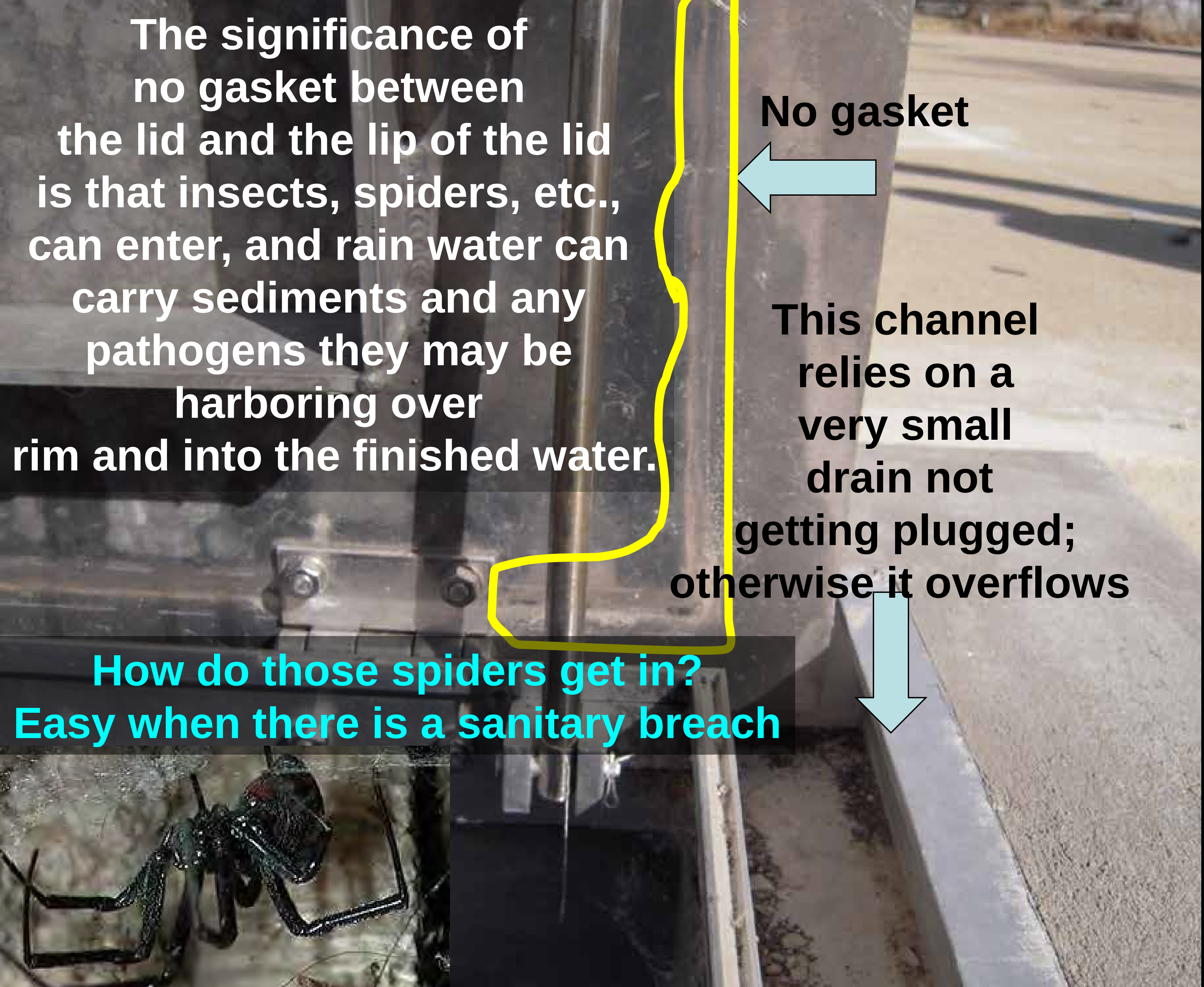
{Section 10.4.10, #16 Hatches (4th paragraph)} Is there a gasket between the rim and the lid and does the latch pull the lid tight against the gasket? When shut, push down on the lid to see if it moves. Movement indicates it is not tight against the gasket creating a pathway for insects, bird droppings,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

Also see, Section 10.4.8 Components

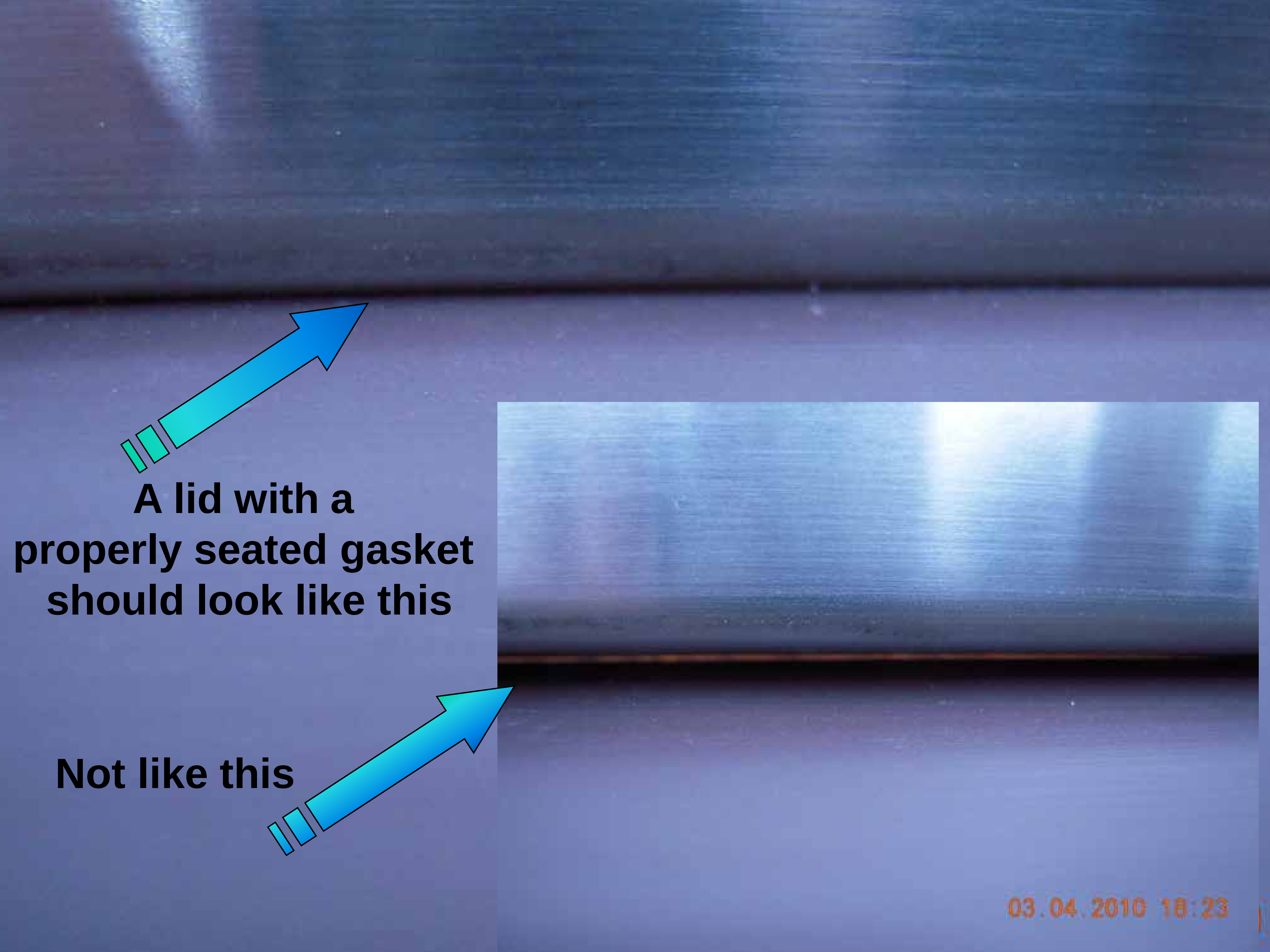


A Learner's Guide

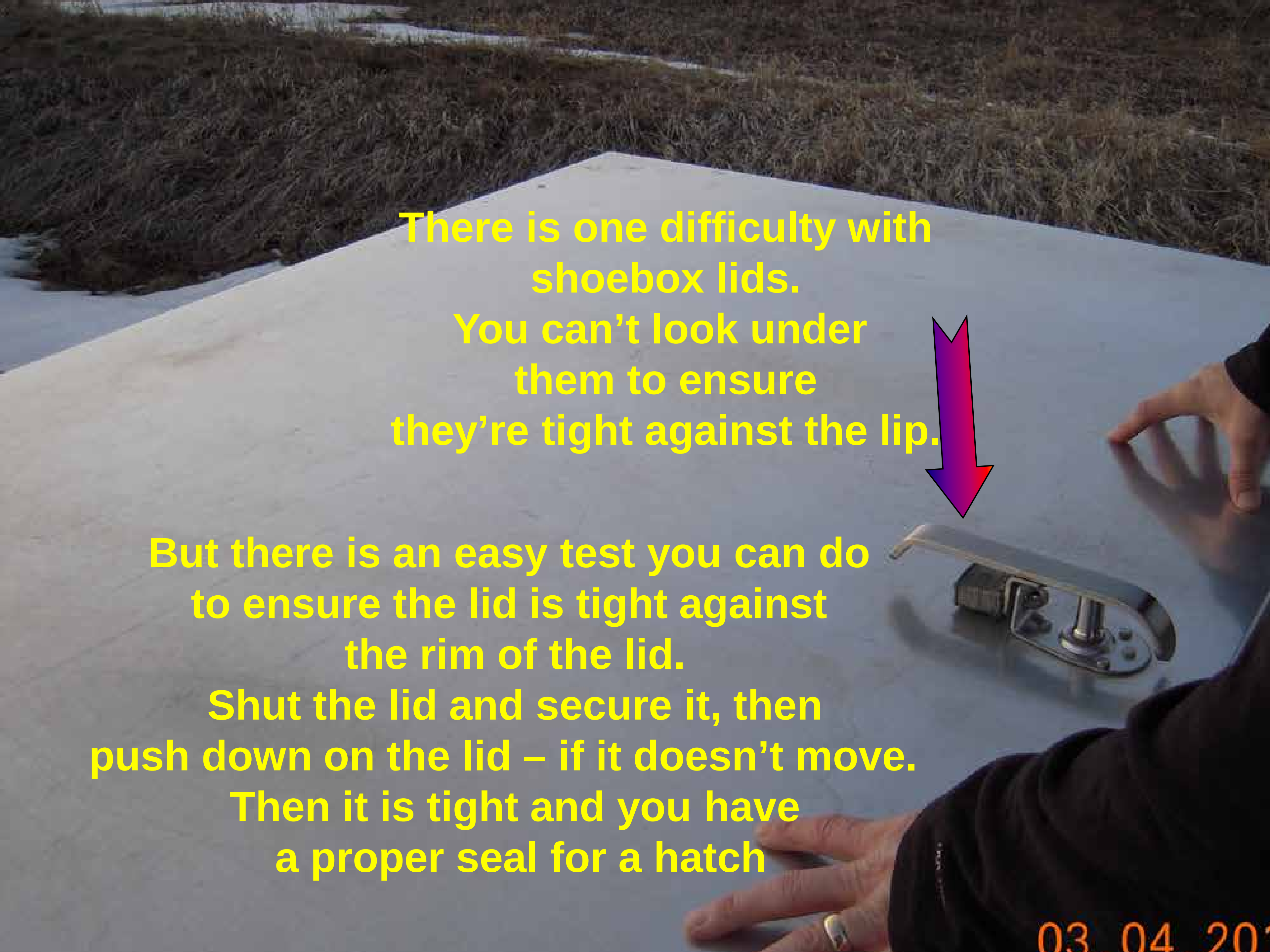
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE


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 ½-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
03.04.2010 18:23

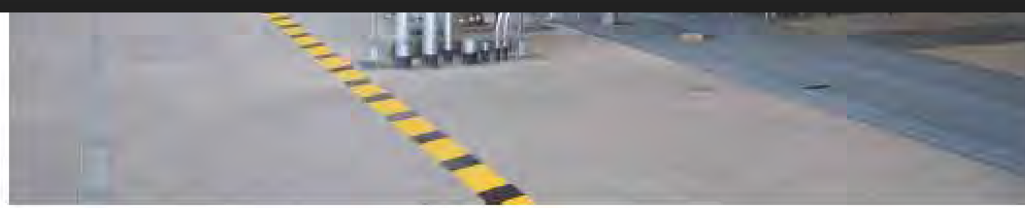
With a hatch that is tight against
the gasket and an inverted
U for the vents, the inside of your
tank should look like this. No light at all.
No light is very important it shows there are no holes and
it eliminates the possibility of algae growth.


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

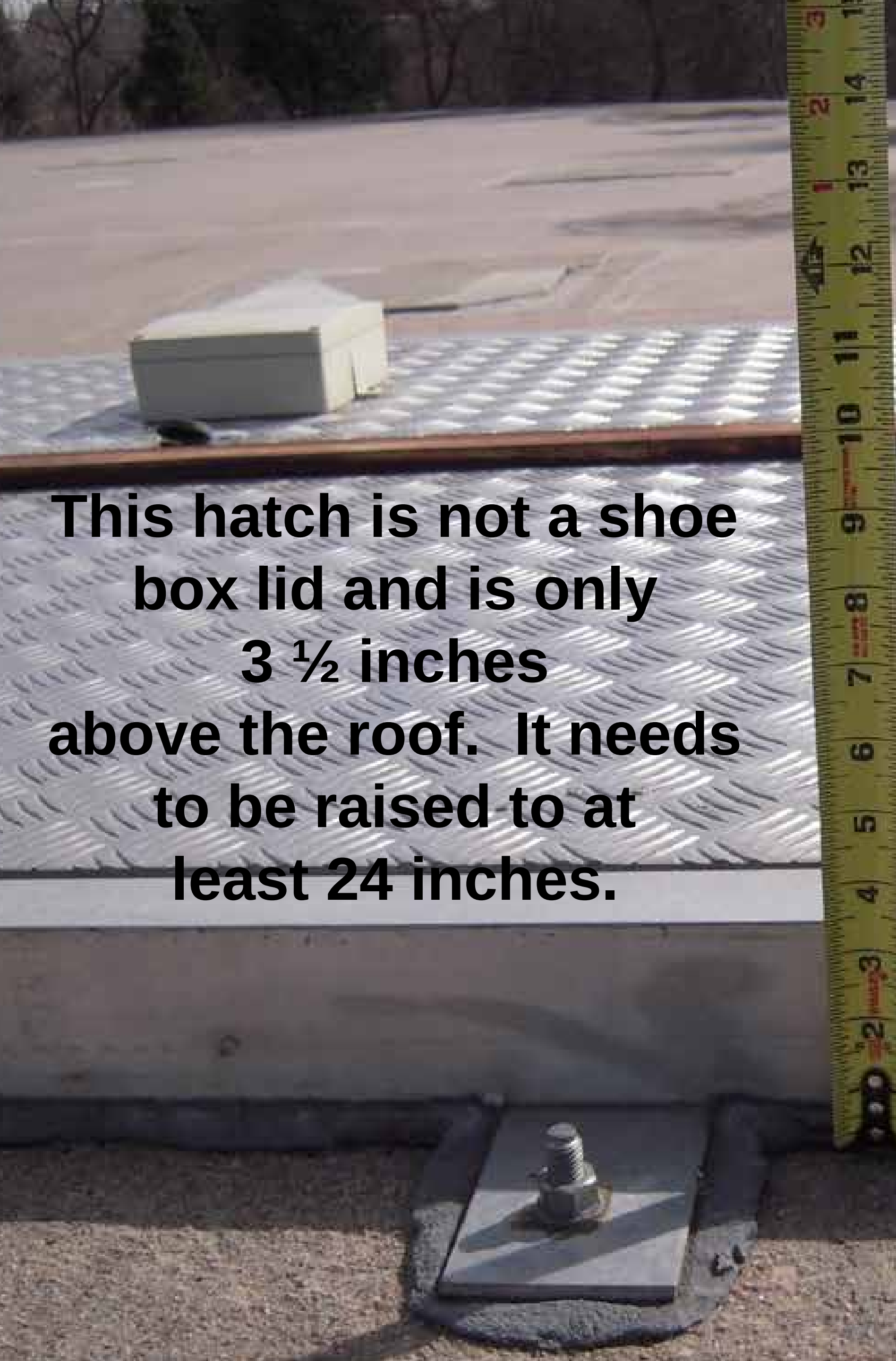
{Section 10.4.10, #16 Hatches (5th paragraph)} Hatches flush with the roof need to be raised to the minimum heights discussed above to protect against rain and snow washing sediment, bird droppings, mouse pellets (a single mouse pellet can have thousands of Salmonella in it), etc., into the tank.

Also see, Section 10.4.8 Components



A Learner's Guide

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



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.

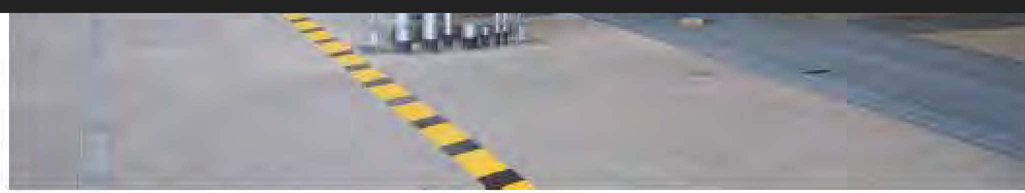
Some companies have pre-made hatches and extensions that can be bolted to the concrete frame to raise a hatch.

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 constructions 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



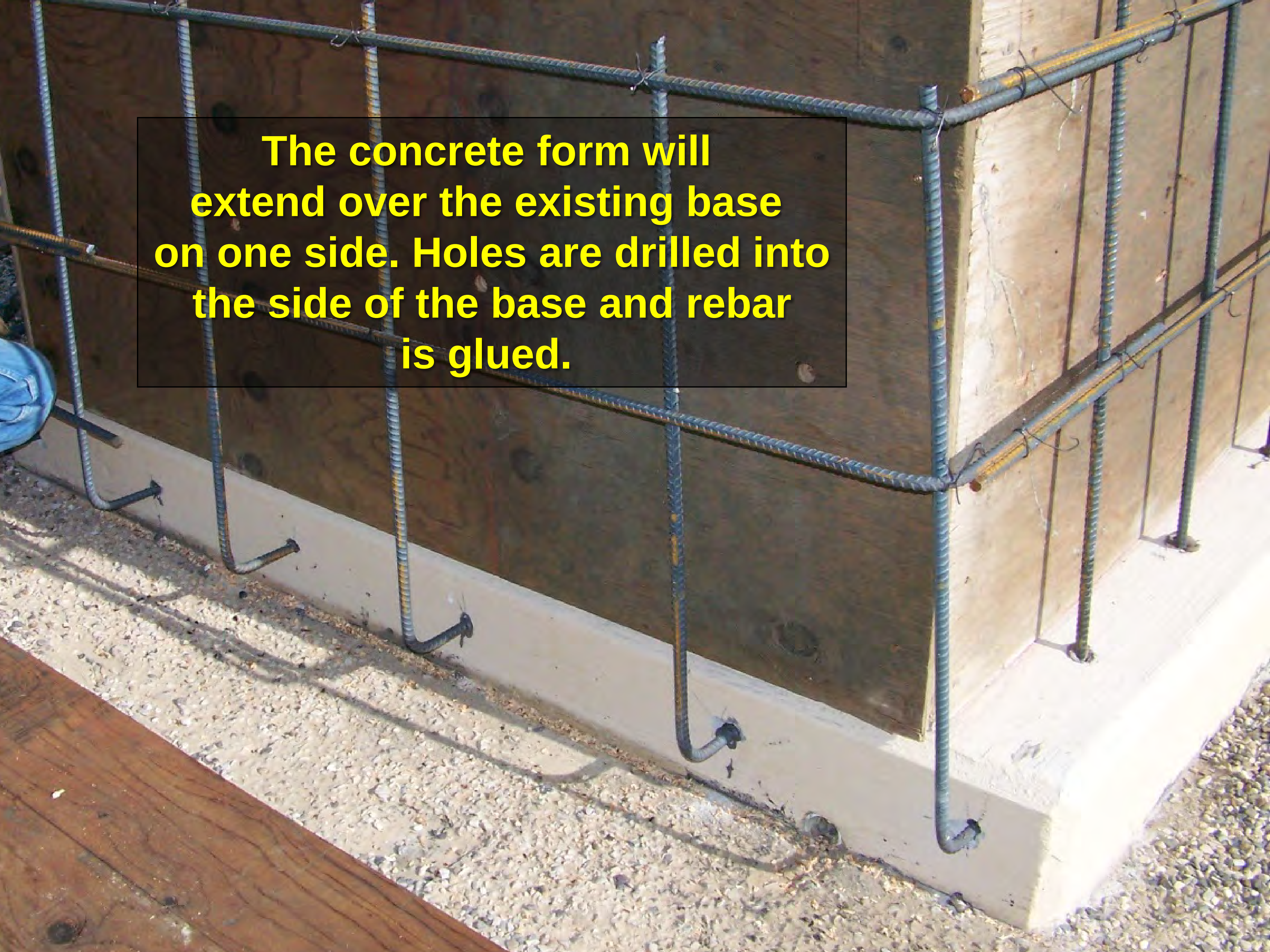
A Learner's Guide

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


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.

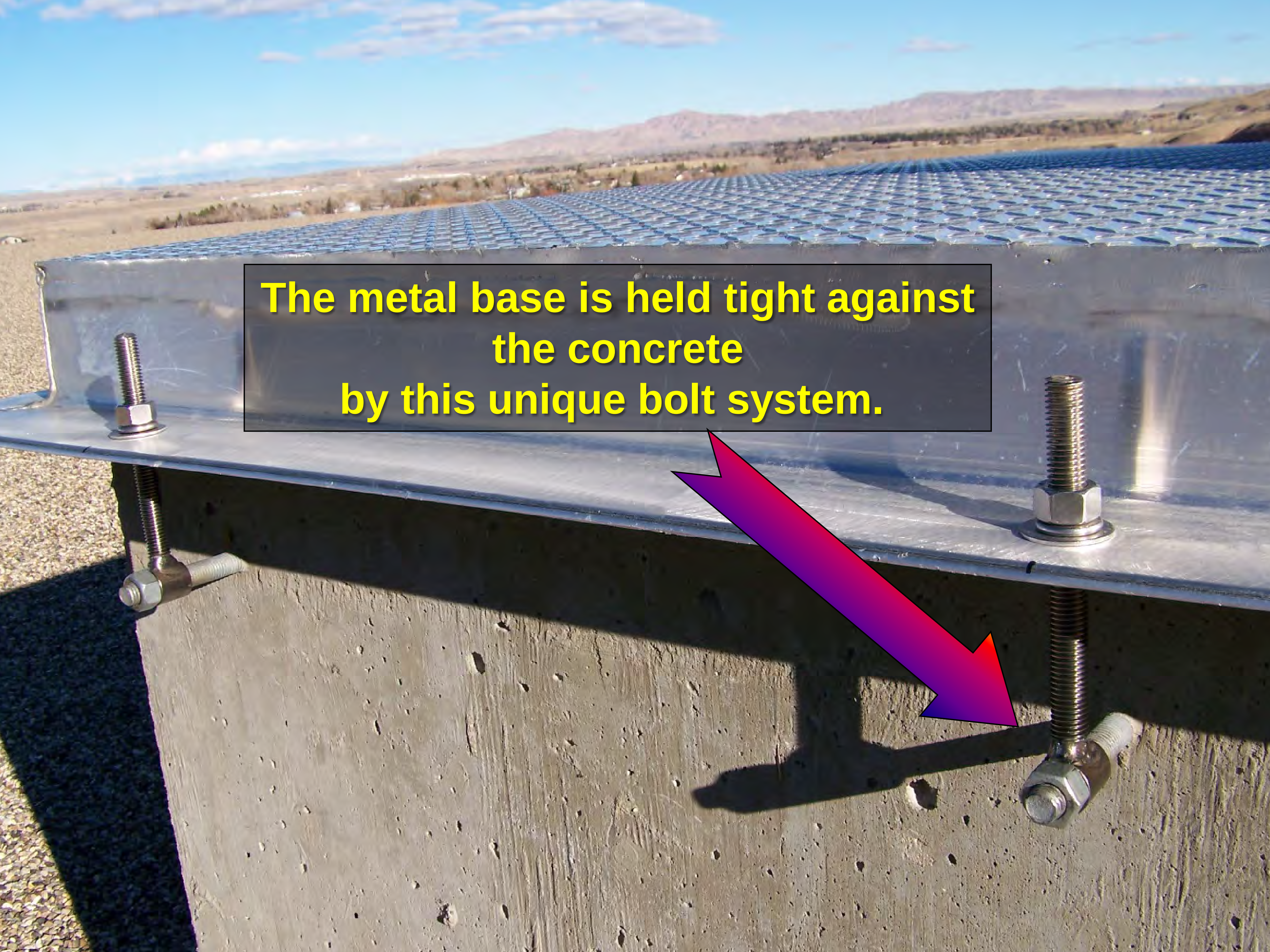

Bolts are added to hold the hatch to the concrete walls.

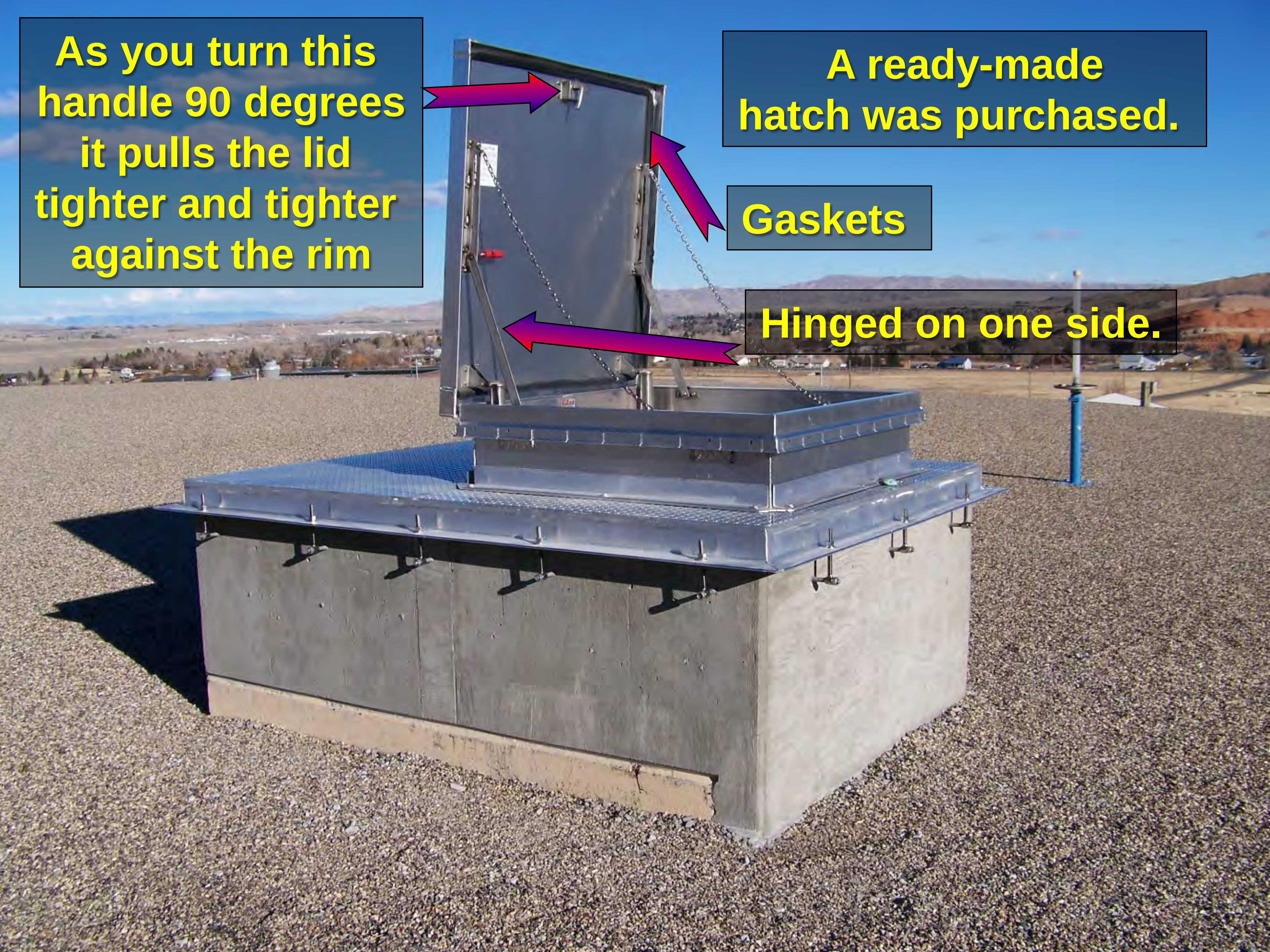

Concrete walls have been poured.

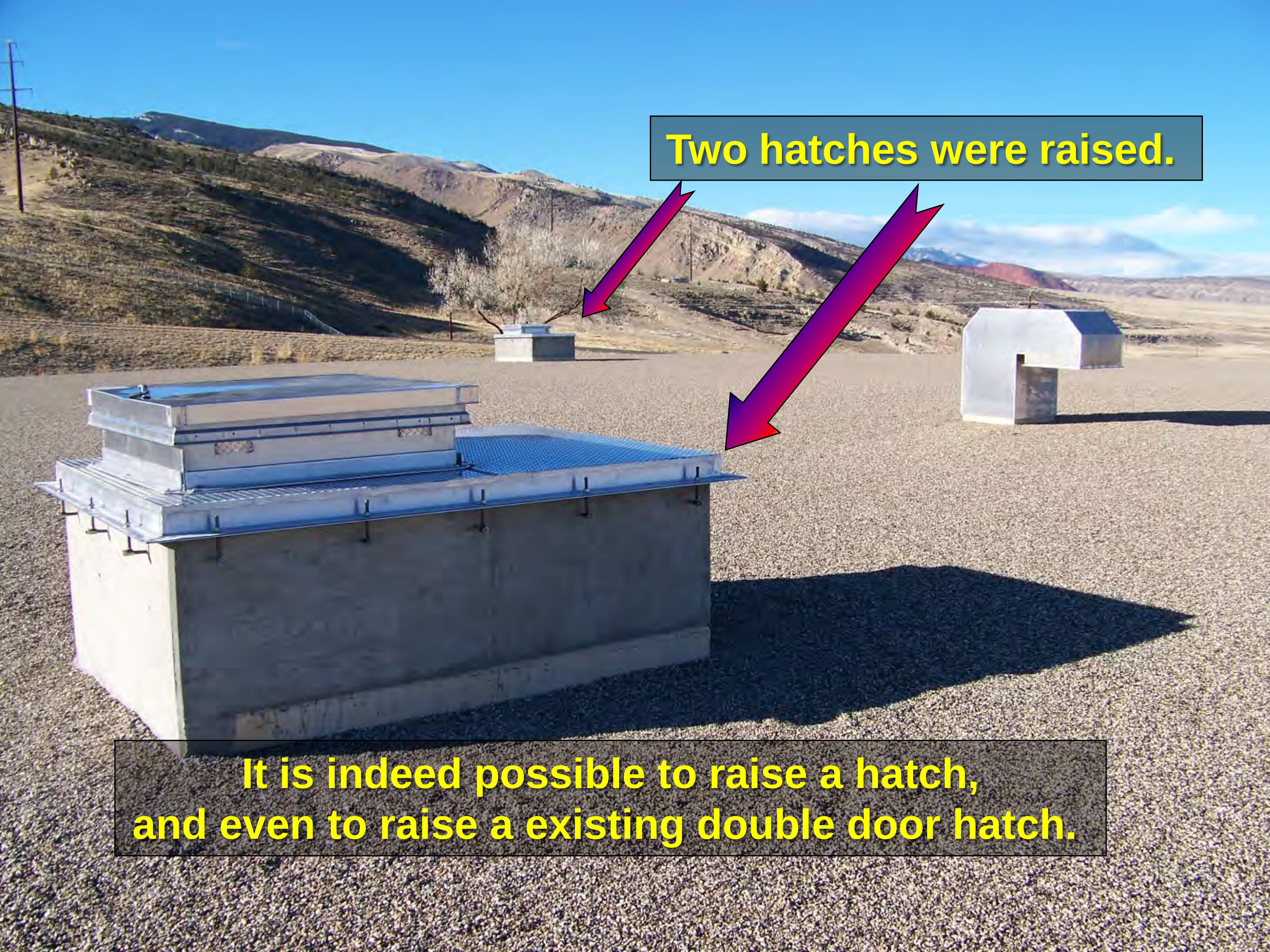
The stainless steel hatch fabricated by a local company.

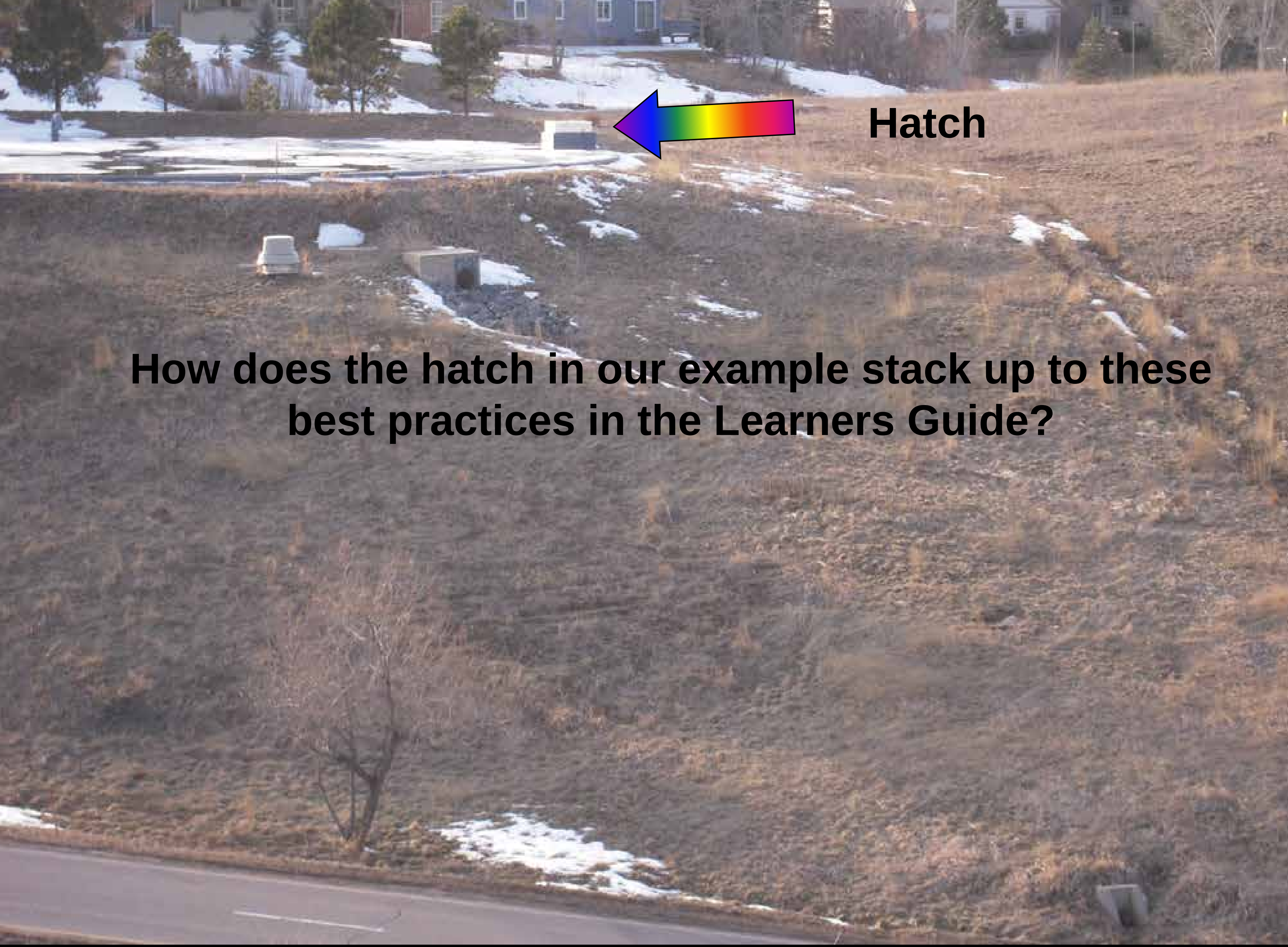

Rubber gaskets are added
to ensure the concrete to metal
and metal to metal connections
are tight and secure.

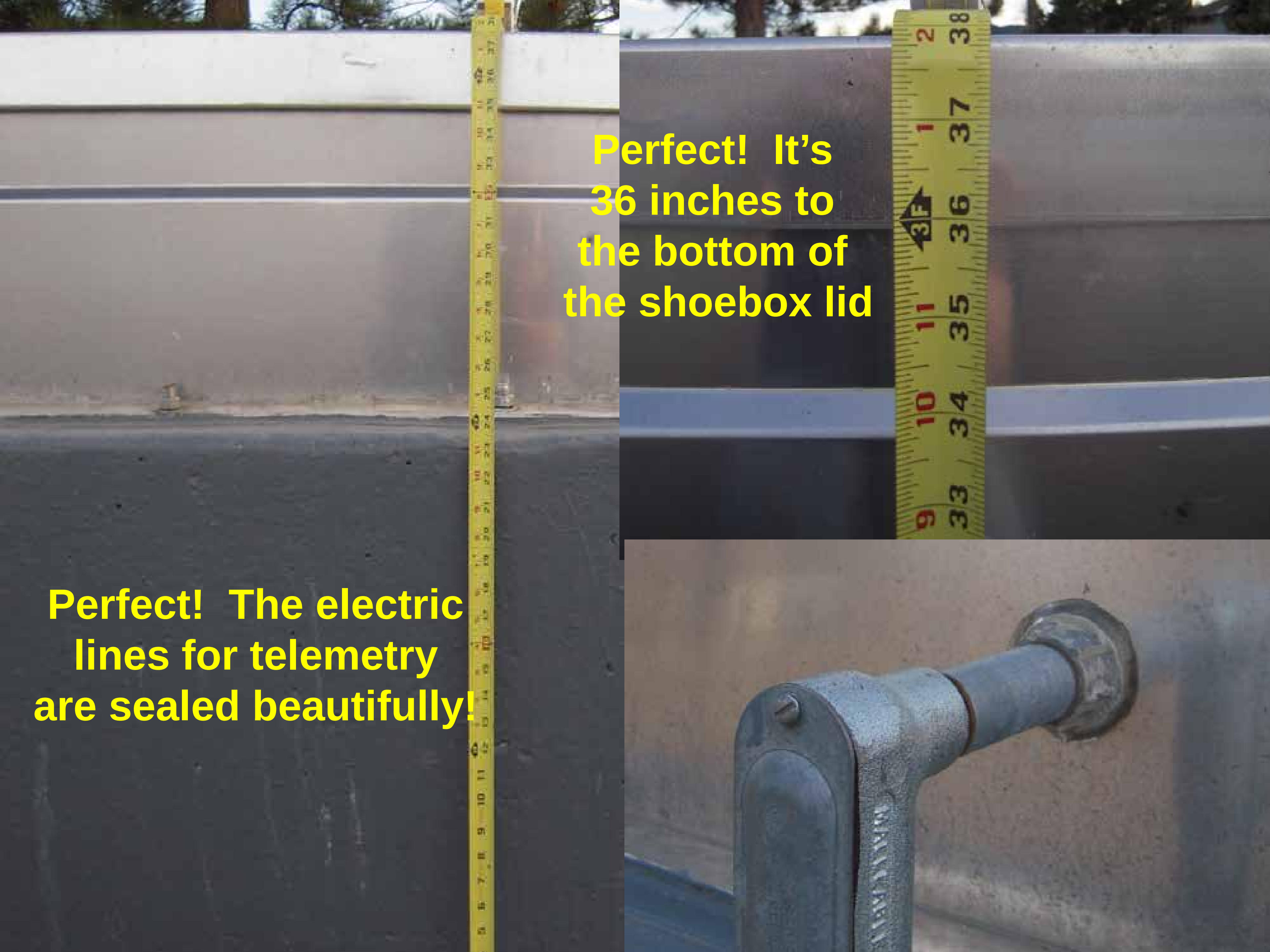

The fabricated base is
set on the concrete form. A shoebox
lid has been created for the
entire double door area with a
normal hatch placed on top.


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.

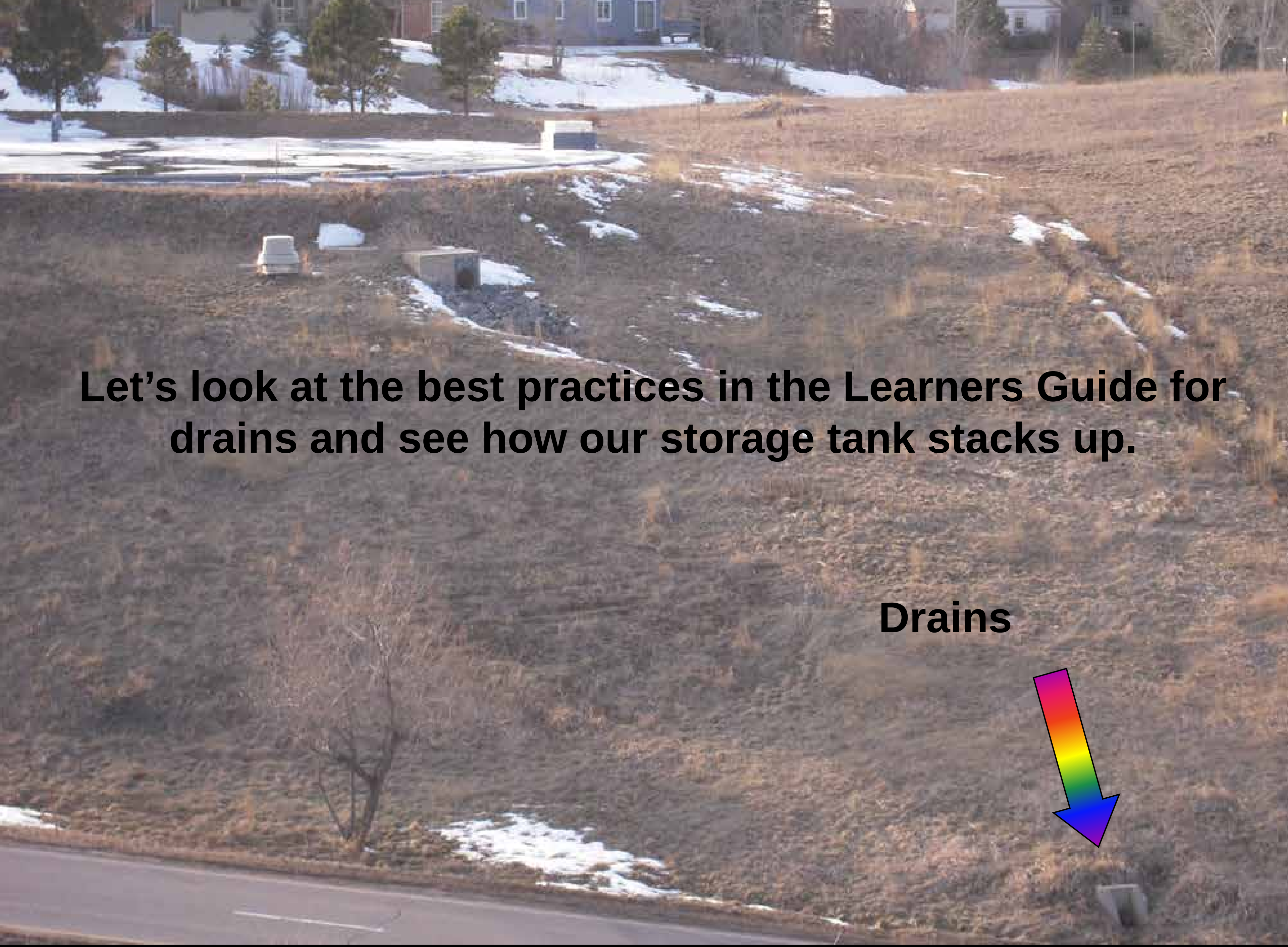

Hatch
How does the hatch in our example stack up to these best practices in the Learners Guide?


Perfect! It's
36 inches to
the bottom of
the shoebox lid
Perfect! The electric
lines for telemetry
are sealed beautifully!


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


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

Hatch


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 a 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?

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 <u>needs to be removable</u>. 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

A Learner's Guide

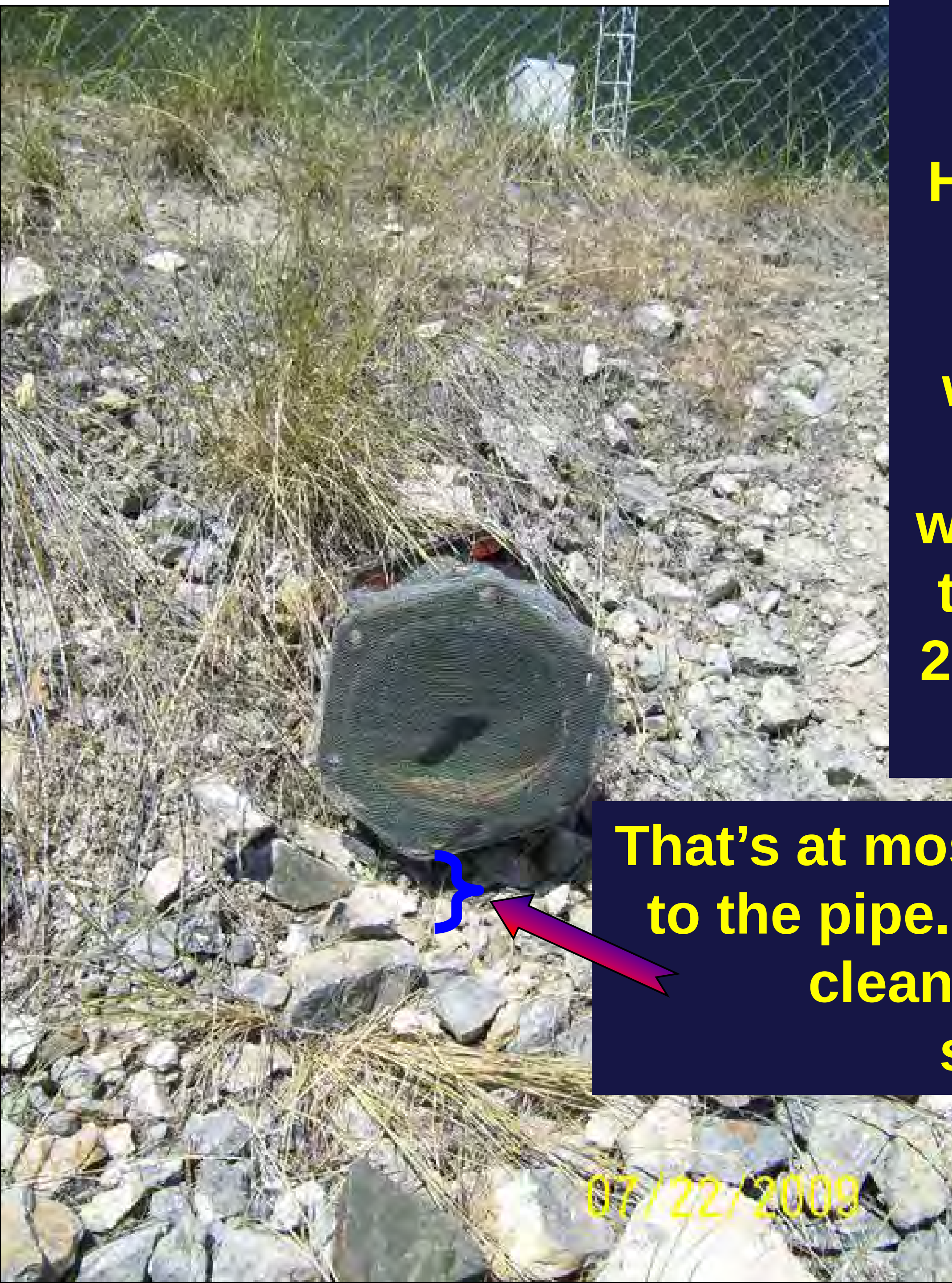
DESIGNED TO ASSIST IN THE DELIVERY OF A SANITARY SURVEY TRAINING COURSE

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

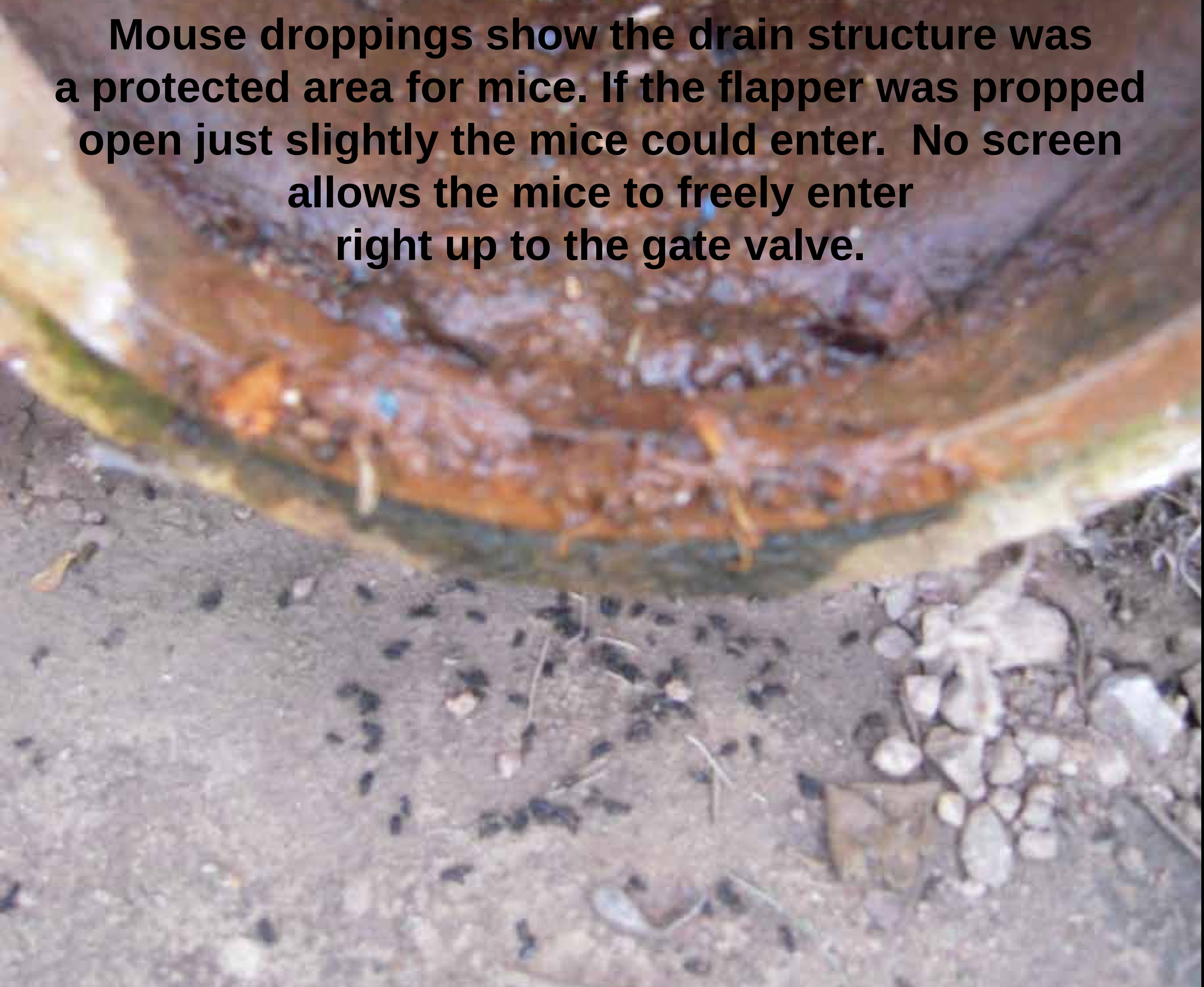


Animals have sharp claws and teeth. Having the screen so close to the ground gives the rodents leverage to really work at tearing the screen apart. Water attracts life, wildlife will work hard to get to it. Only stainless steel # 24 mesh, not fabric screens should be used.

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

This drain 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!

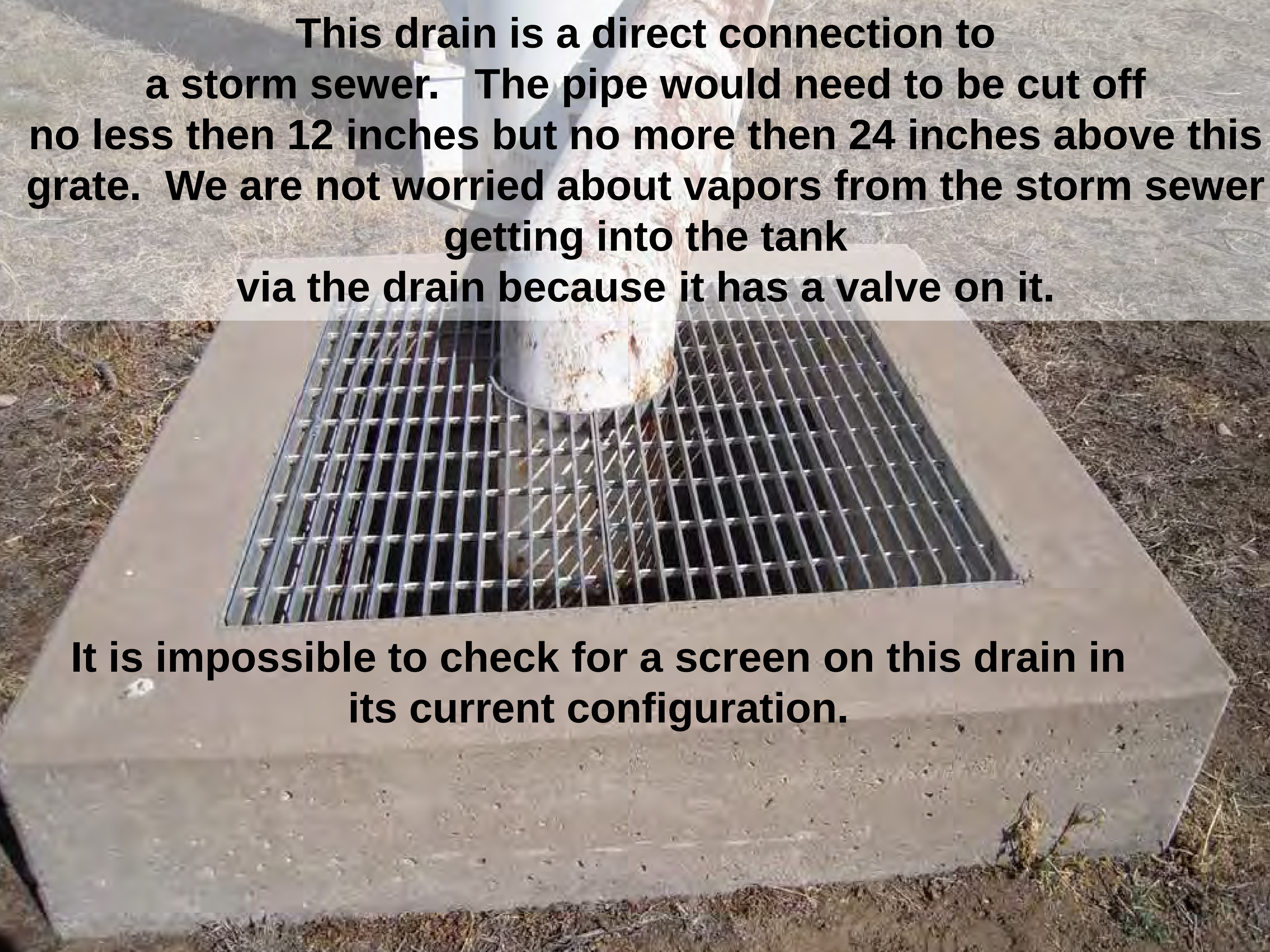
Submerged drains should be redesigned such that they are not submerged during a typical rain event and that water does not pool at the drain. Stagnant water is host to a broad array of microorganisms and is unsanitary. Any unsanitary condition at any tank component needs to eliminated to reduce the risk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

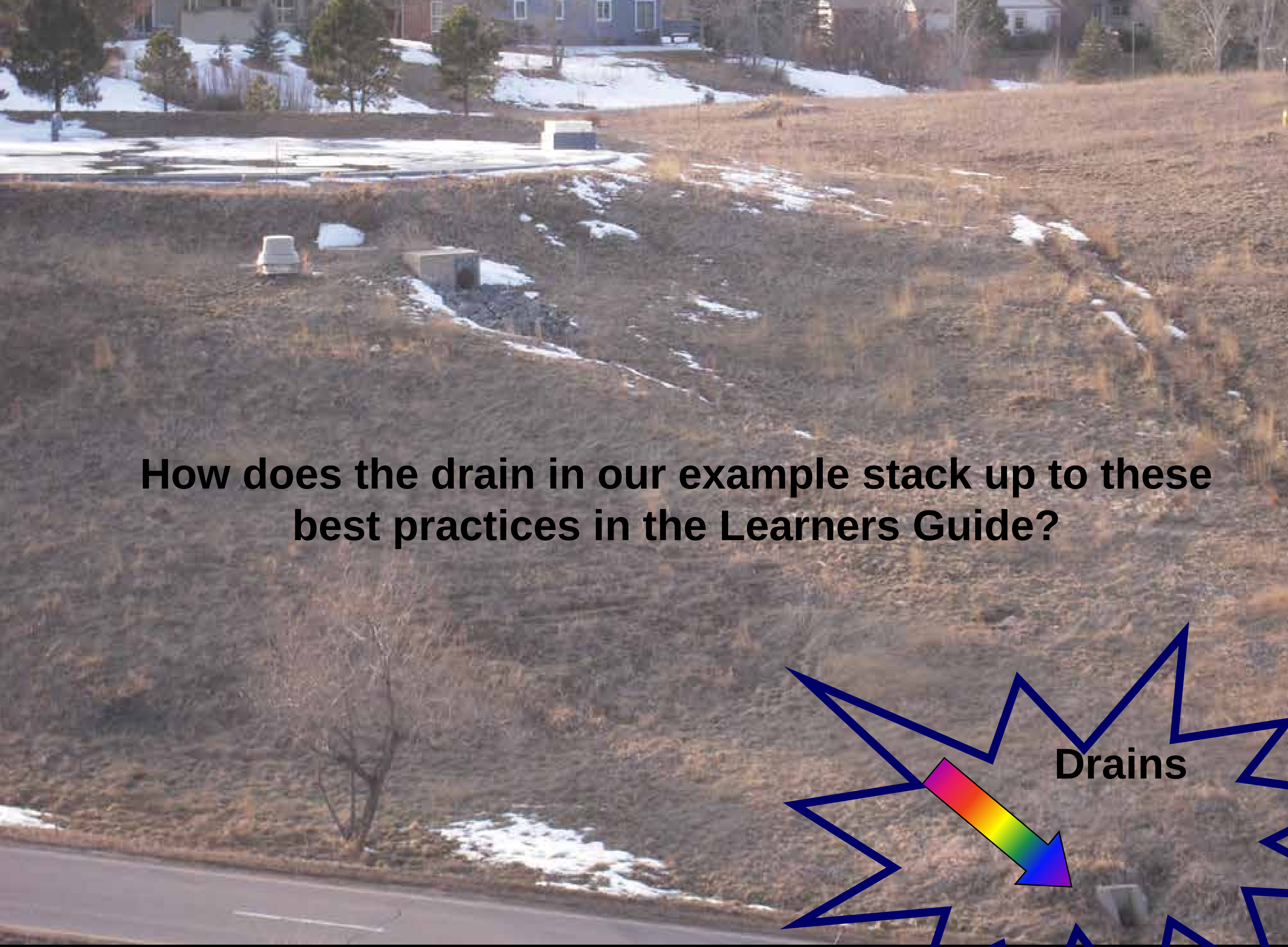

Mouse droppings show the drain structure was
a protected area for mice. If the flapper was propped
open just slightly the mice could enter. No screen
allows the mice to freely enter
right up to the gate valve.

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.

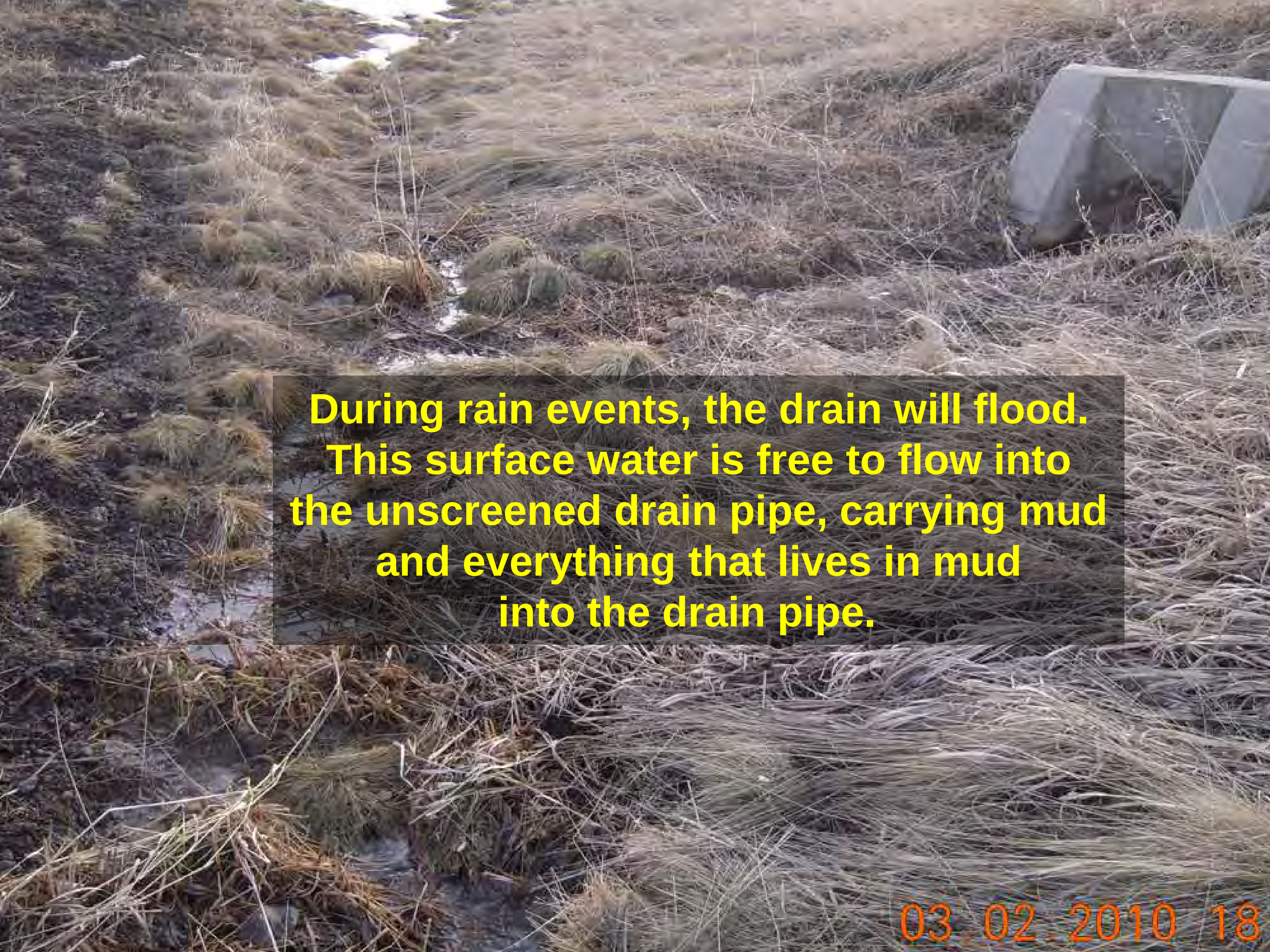
In 12 hours a single bacteria can reproduce and create 10 million copies of itself. The animals can bring bacteria and pathogens right to the gate valve. The gate valve is no obstacle to the 2nd smallest living thing on earth. They can grow their way right into the tank. Drain valves will usually leak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

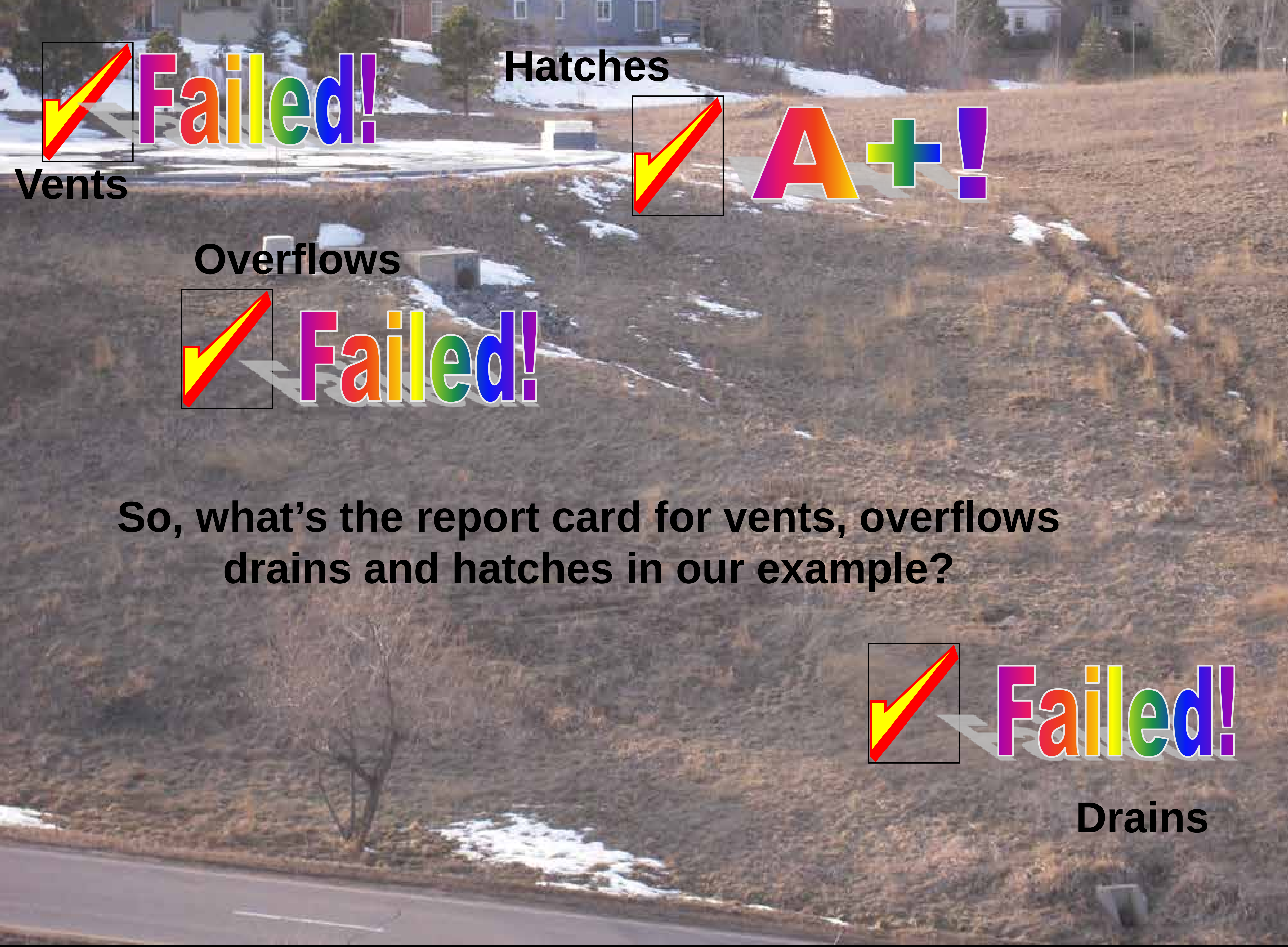

This drain is a direct connection to
a storm sewer. The pipe would need to be cut off
no less then 12 inches but no more then 24 inches above this
grate. We are not worried about vapors from the storm sewer
getting into the tank
via the drain because it has a valve on it.
It is impossible to check for 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?
Drains

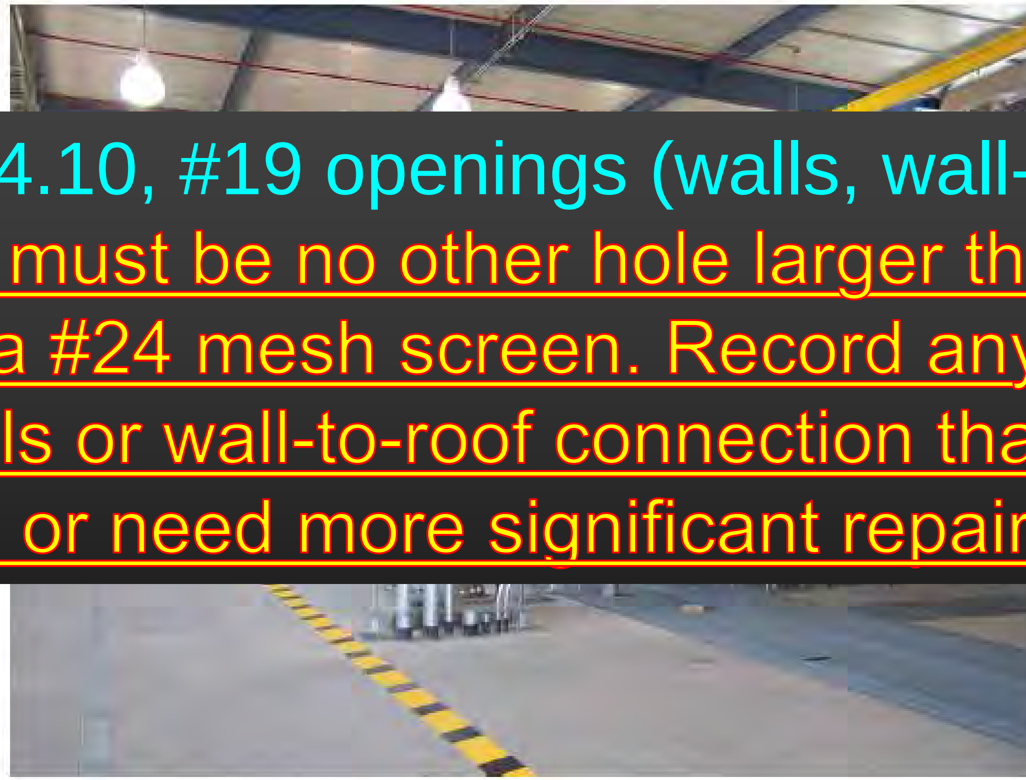
It has a nice engineered splash plate but the drain is 3 inches from the ground, 21 inches shy of 24 inches.
It has no screen.


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!
Vents
Hatches
A+!
Overflows
Failed!
So, what’s the report card for vents, overflows drains and hatches in our example?
Failed!
Drains

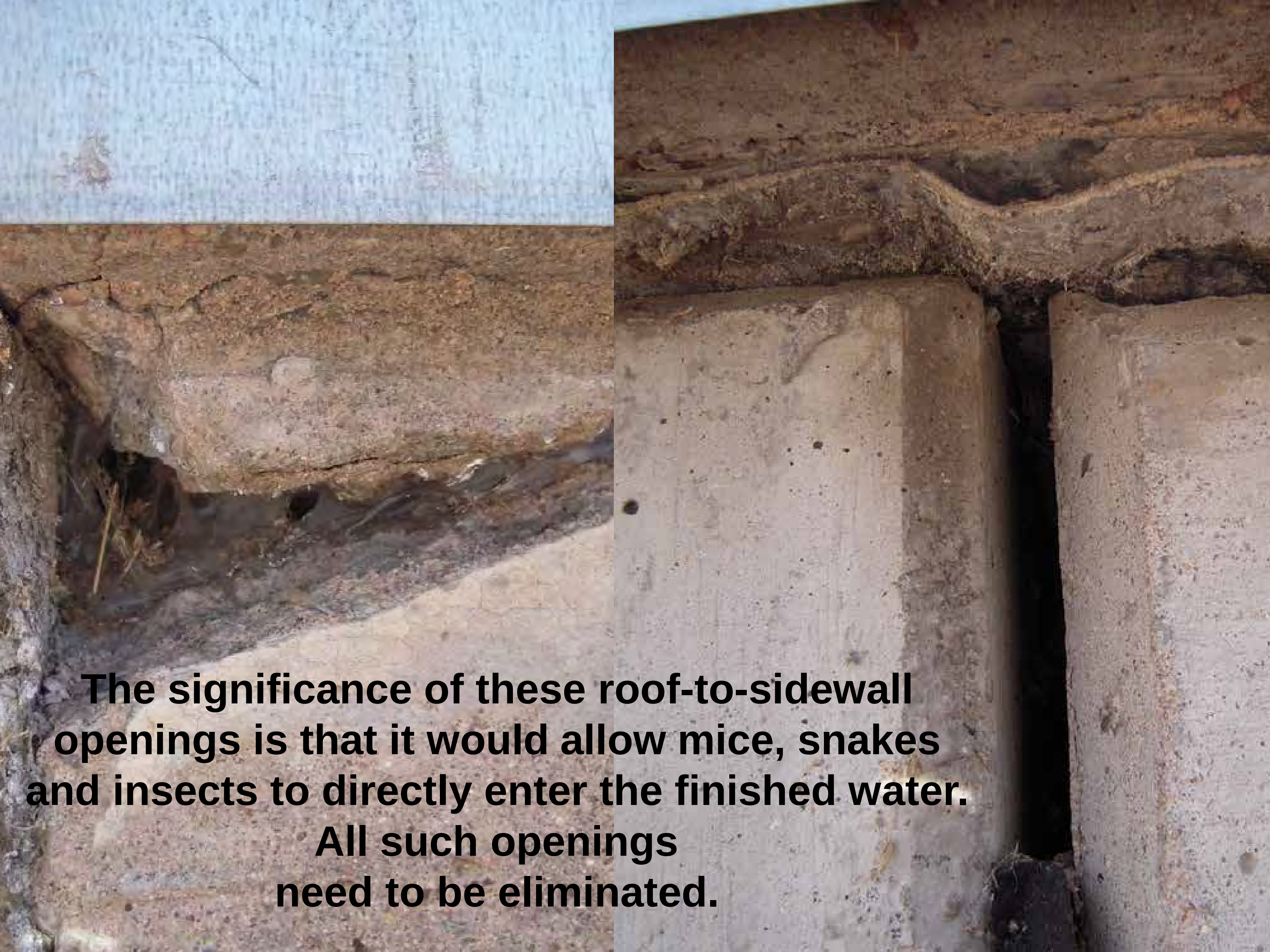
How to Conduct a Sanitary Survey of Drinking Water Systems



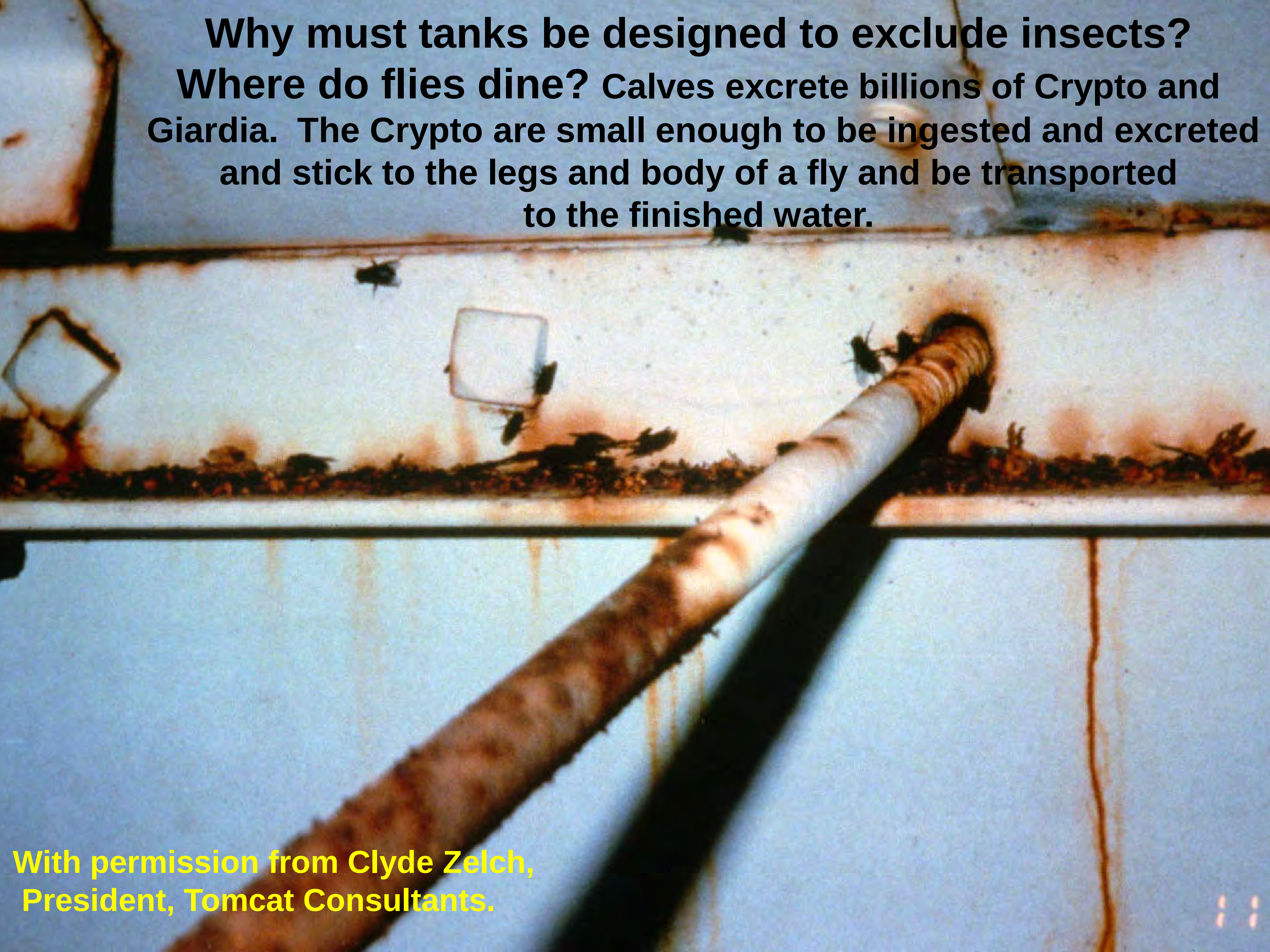
{Section 10.4.10, #19 openings (walls, wall-to-roof or roof)} There must be no other hole larger than that afforded by a #24 mesh screen. Record any openings in the roof, walls or wall-to-roof connection that operators need to seal or need more significant repair.

A Learner's Guide

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


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.

These tanks are notorious for roof-to-sidewall openings; they freely allow, insects and any diseases they may harbor, 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.

Cattle manure is a recognized source of C. Parvum oocysts and is a favorite breeding place, food source and descending spot for house flies.

C. Parvum is prevalent in preweaned cattle. Infection can yield oocyts exceeding 10^{10} per day. That is ten billion! 10,000,000,000 oocysts.

For the fly, under the species, Diptera, there are 120,000 species. When they land on Cryptosporidium infected calf feces, oocyts adhere to their legs, wings, body and mouth parts (exoskeleton) and are ingested.

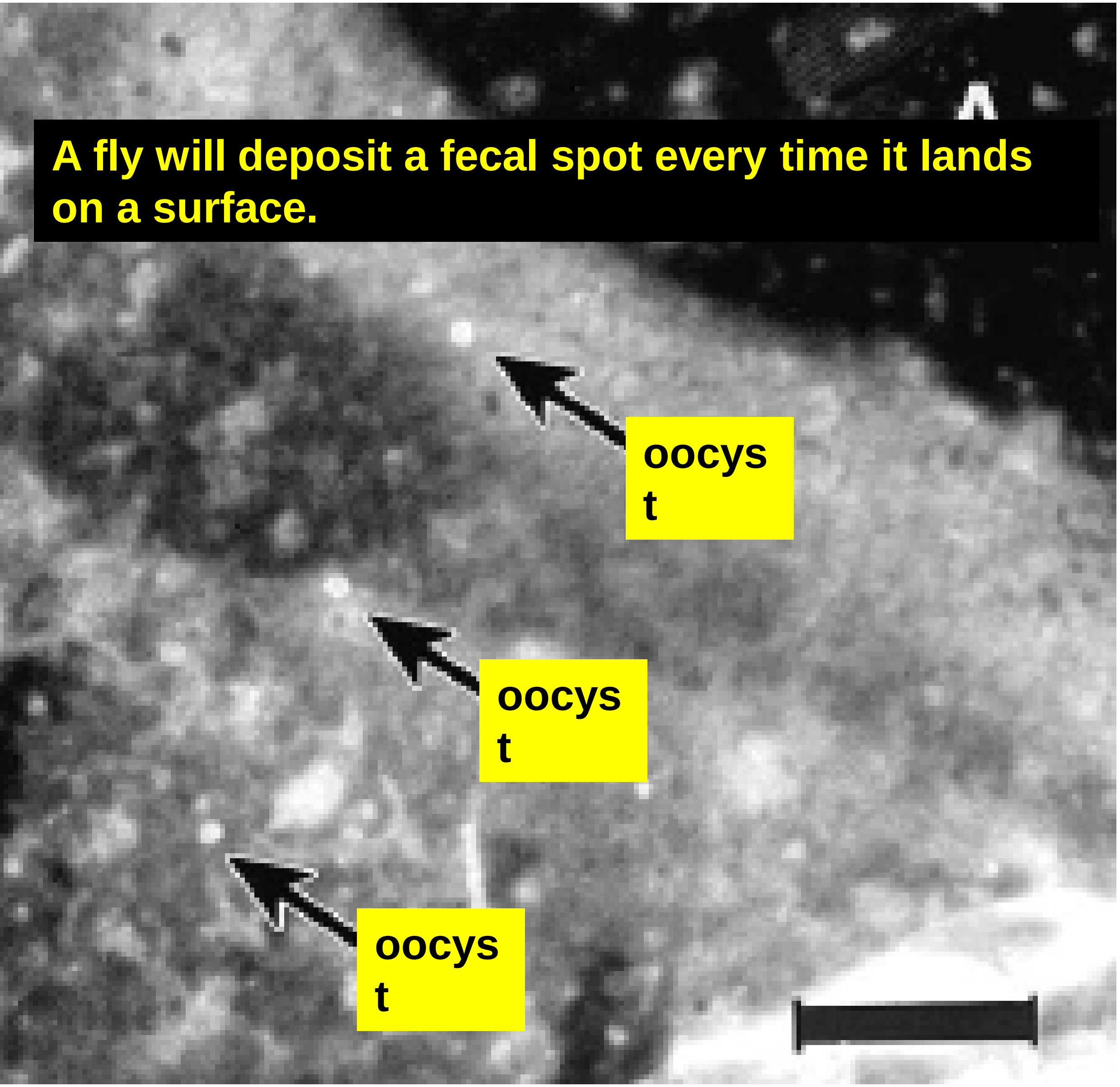
Transmission of oocysts occurs through fecal deposition, mechanical dislodgement from the exoskeleton, and through regurgitation of ingested particles.

HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM*

by THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER *American Journal of Tropical Medicine Hygiene* 61(3), 1999, pp. 500–504

House flies are recognized as transport hosts for a variety viral, bacterial and protozoal pathogens of public health significance.

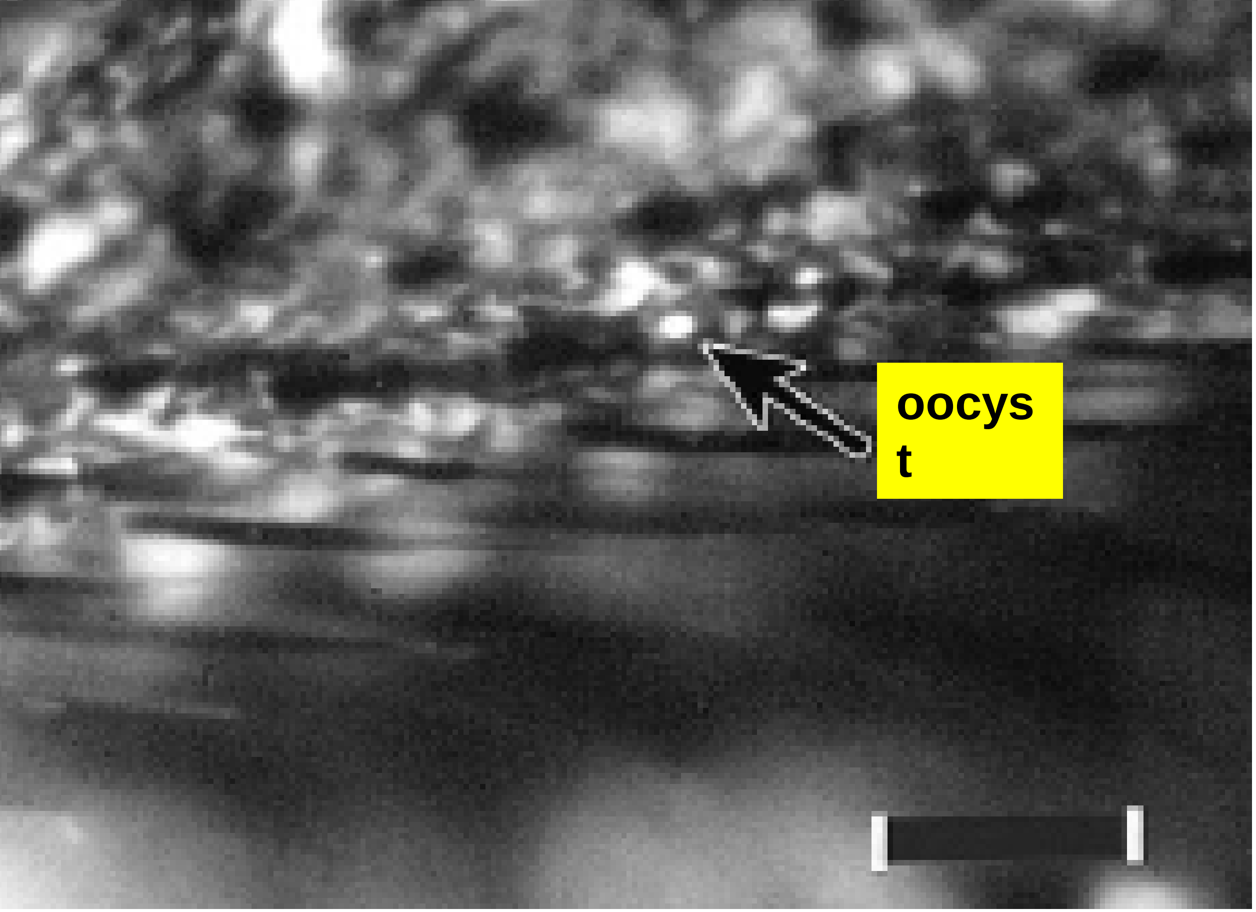
In this study, adult and larval stages of house flies breeding on and having access to C. Parvum-contaminated substrates were found to mechanically carry the oocysts in their digestive tracts and on their external surfaces.



HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM* *by*
THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER American Journal of Tropical Medicine Hygiene 61(3), 1999, pp. 500–504

A: Fly fecal spot

***C. Parvum* oocysts (arrows) were detected by immunofluorescent antibodies in the fecal spots of flies exposed to bovine diarrheal feces containing oocysts.**



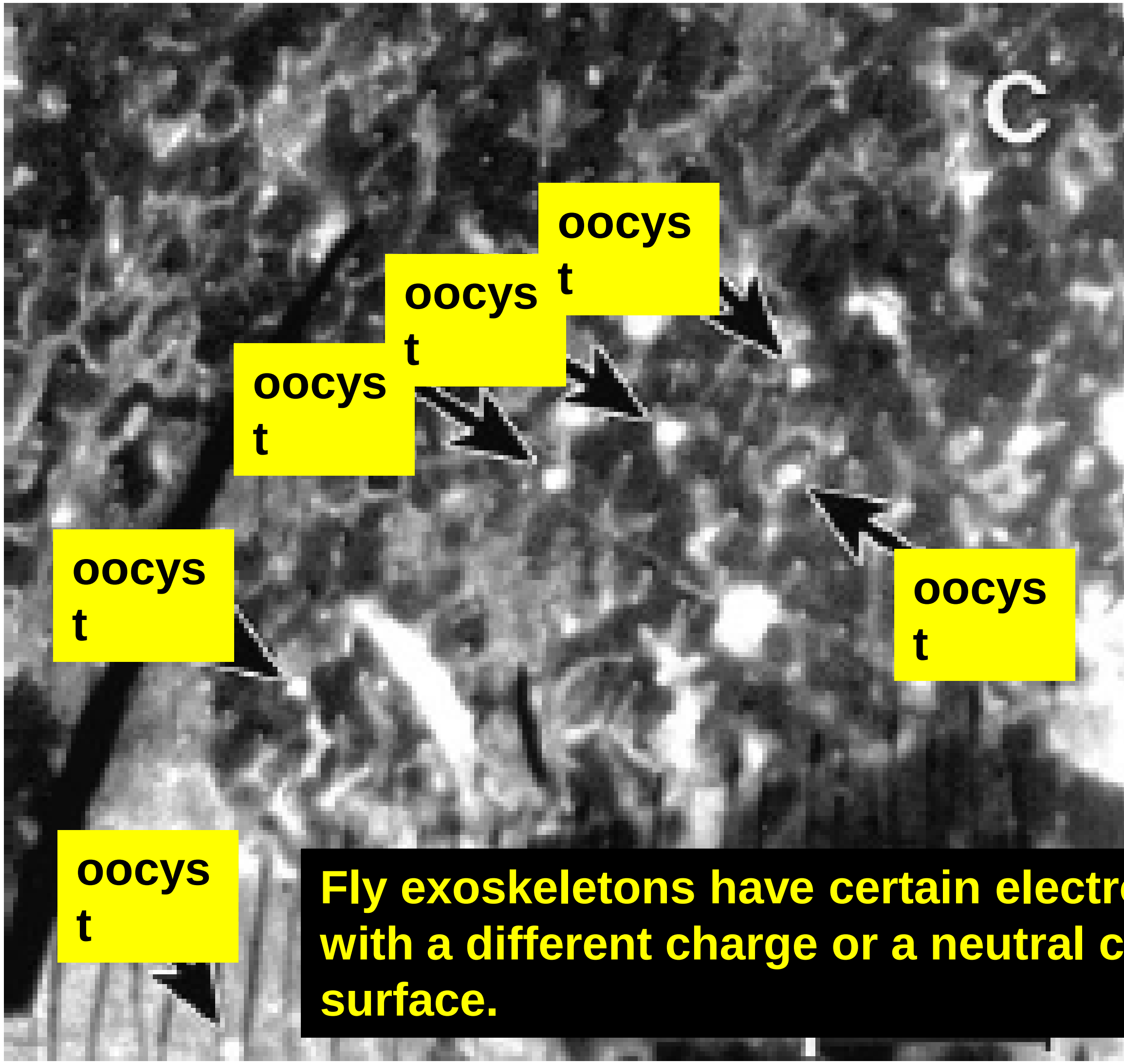
HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM* *by*

THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER American Journal of Tropical Medicine Hygiene 61(3), 1999, pp. 500–504

B: Leg (tibia)

***C. Parvum* oocysts (arrows) were detected by immunofluorescent antibodies on the hairs on the leg (exoskeleton) of a house fly.**

The fine hairs on the fly's feet are coated with a sticky substance enhancing the adhesion of viruses, bacteria and protozoans which then can be directly transported to the next visited surface and dislodged.



HOUSE FLIES (*MUSCA DOMESTICA*) AS TRANSPORT HOSTS OF *CRYPTOSPORIDIUM PARVUM* *by*

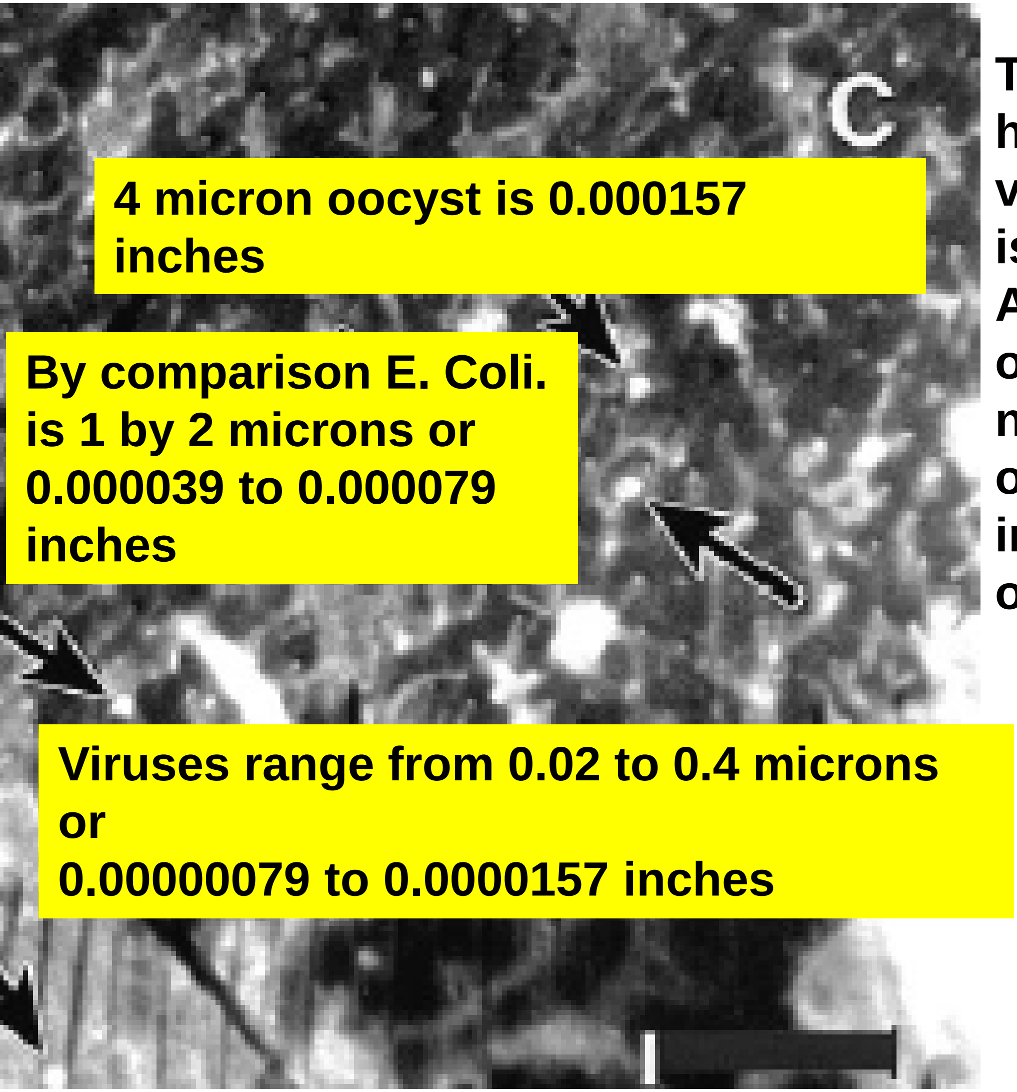
THADDEUS K. GRACZYK, MICHAEL R. CRANFIELD, RONALD FAYER, AND HEATHER BIXLER

American Journal of Tropical Medicine Hygiene 61(3), 1999, pp. 500–504

C: Posterior margin of the wing

C. Parvum **oocysts were detected by immunofluorescent antibodies on the wing bristles of a fly (exoskeleton)**

Fly exoskeletons have certain electrostatic charges, any particles with a different charge or a neutral charge will adhere to the fly surface.

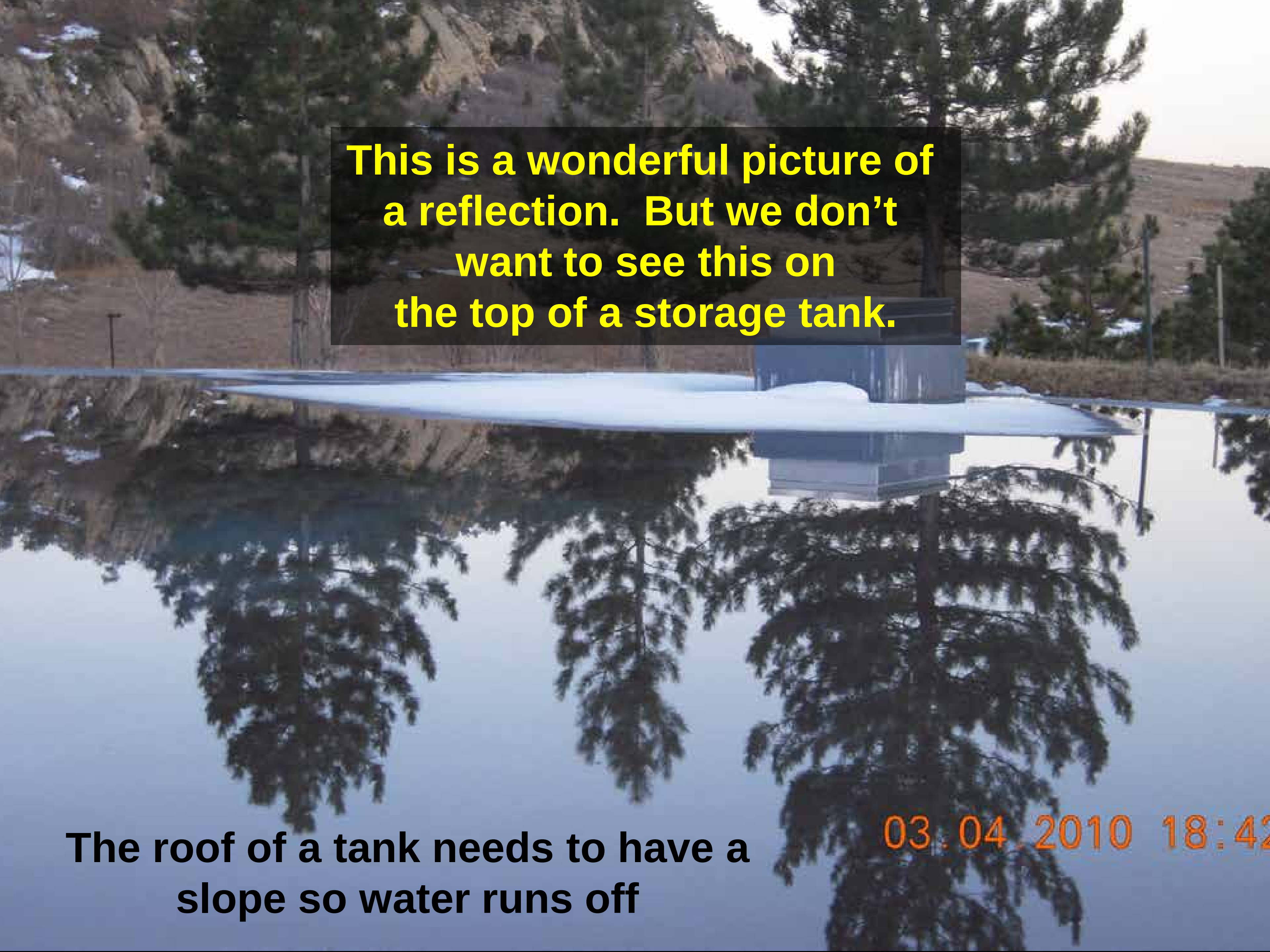


This research has demonstrated that house flies are efficient mechanical vectors of C. Parvum - a protozoan that is known to cause disease in humans. A 3-day exposure of flies to feces with oocyts resulted in deposition for the next 8 days of an average of 100 oocysts/cm^2 through feces alone and, in addition, carried more than 200 oocyts on its exoskeleton.

The flight range for a fly is as far as 20 miles.

This study eluted 267, 131, 32, 19 and 14 oocysts off of flies exoskeleton on days 3, 5, 7, 9, and 11, from feces that had only 2×10^5 or 200,000 oocyst/ml. That means by the 11th day, 243 oocysts had dislodged from the exoskeleton.

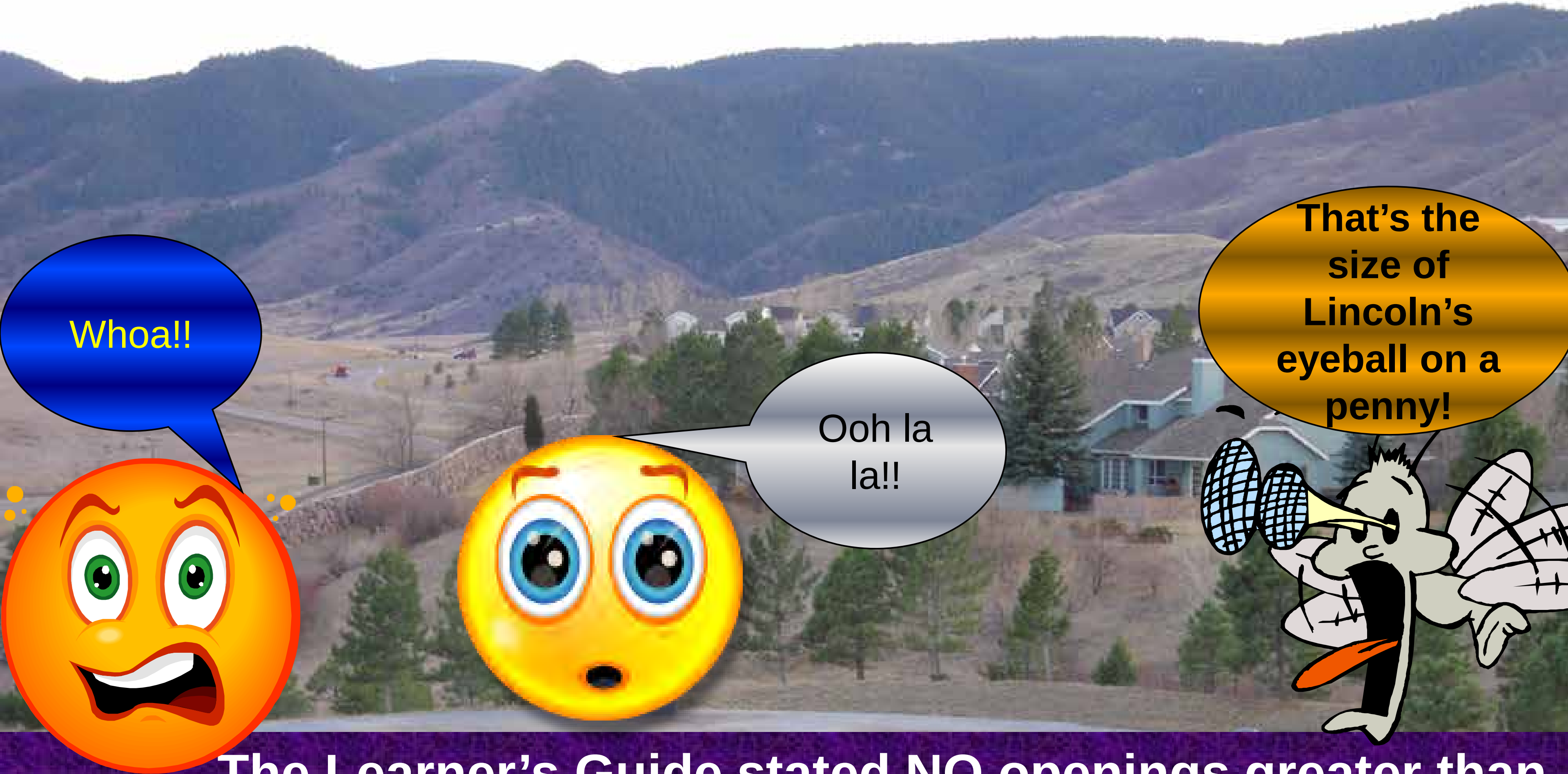
How many more oocysts can be transported when there are 10^{10} – five times the number in the study?



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

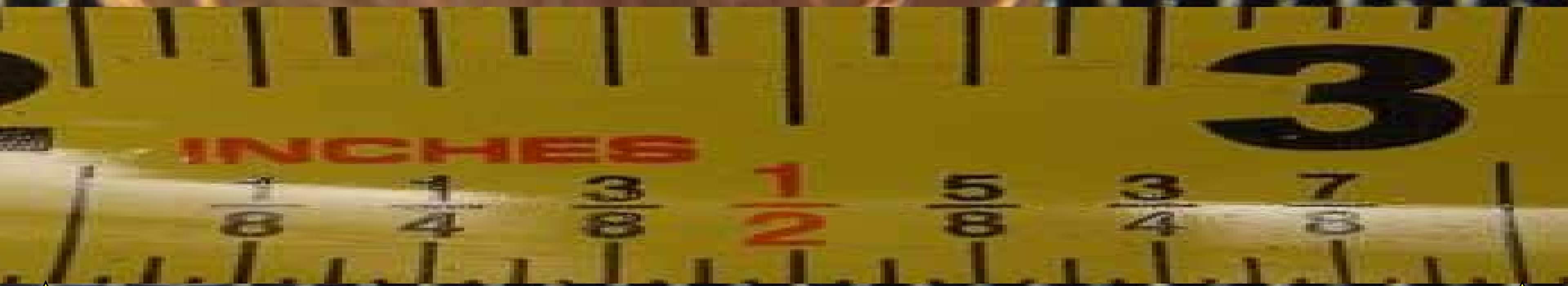

Perfect seal!



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.



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.

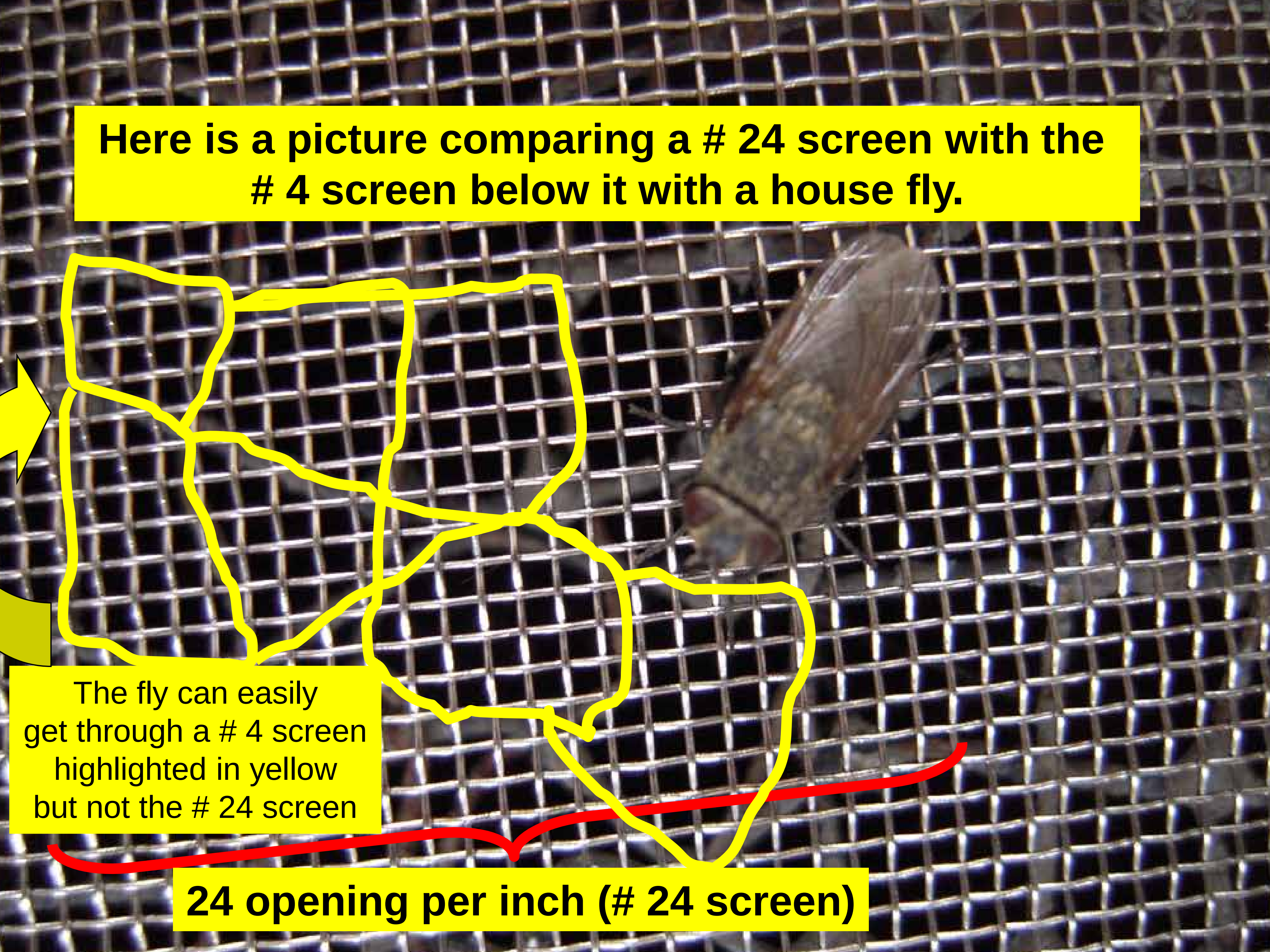
A #24 mesh screen will not allow the water in your tank to become a breeding ground for mosquitos.

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.

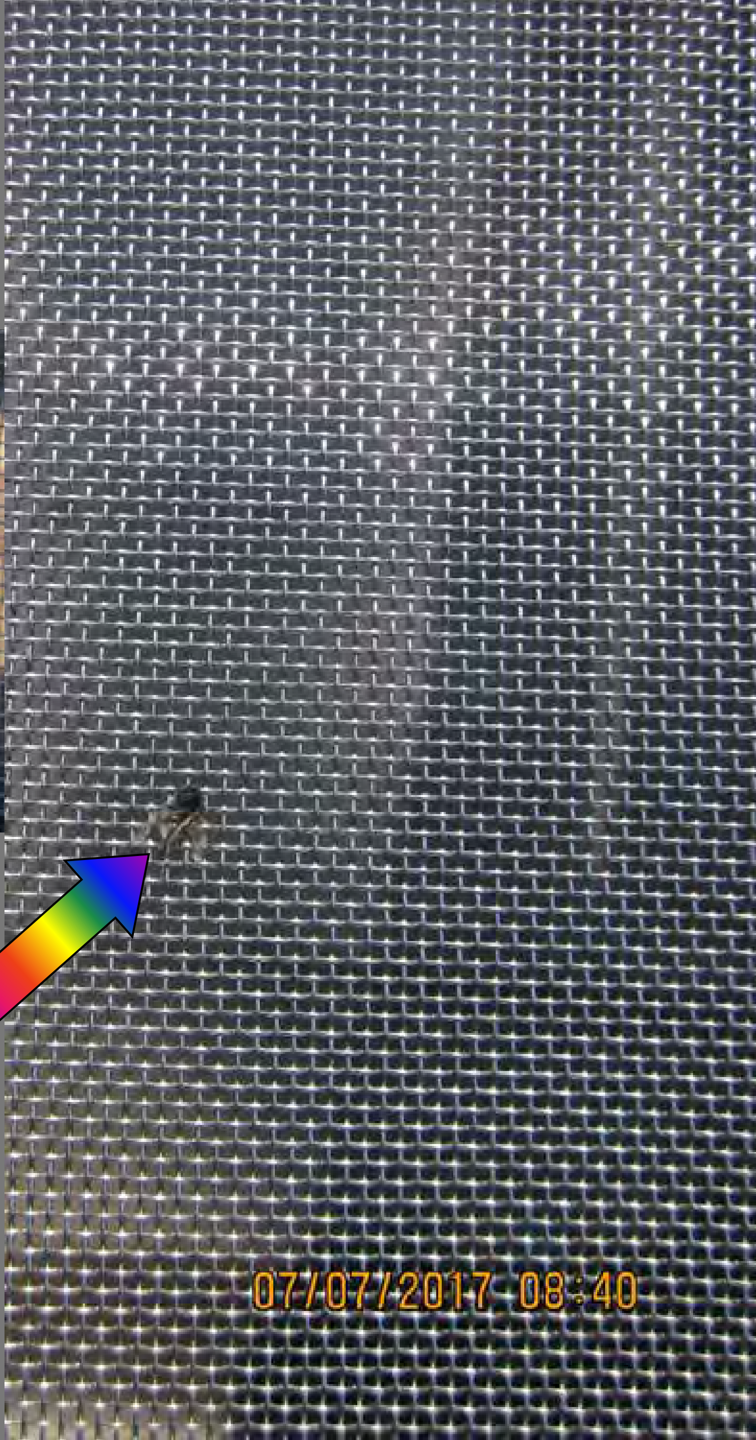
Diseases from mosquitoes: malaria, yellow fever, dengue, filariasis and encephalitis West Nile virus (WNV), Zika virus.

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)

This is a mosquito on #16 mesh screen. The mosquito can easily contort its body to fit through a #16 mesh screen.

This is a mosquito on #24 mesh mesh screen. The mosquito can not contort its body to fit through a #24 mesh screen. Insects are not attracted to clean water but where sediment has built up. They sense a nutrient rich water source and are attracted to that source.



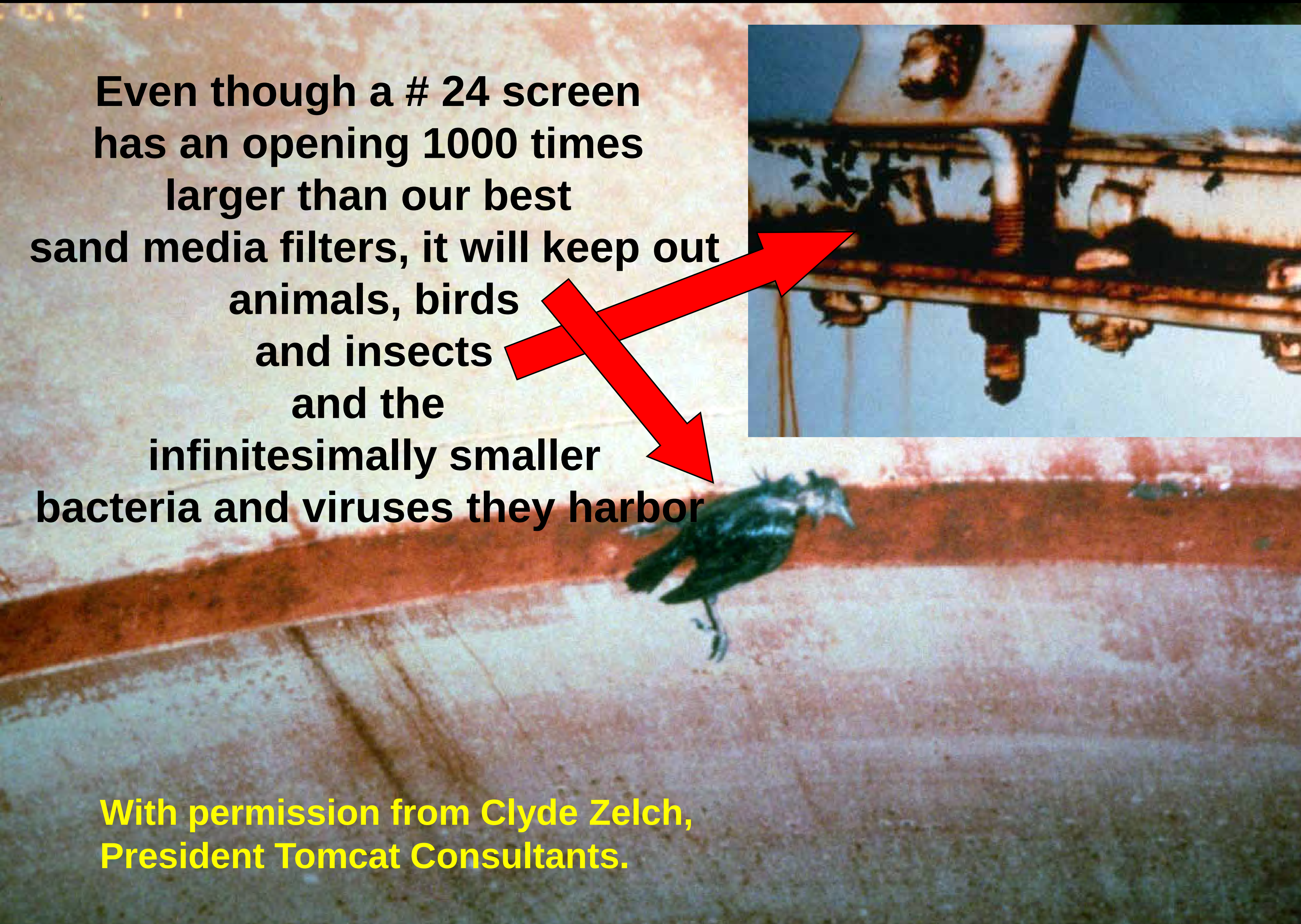

So, we should be checking for and fill
any opening greater than a # 24 screen!
Sound ridiculous?
Not when you compare it to what
size opening the water has already come through
in a well-operated filter or aquifer

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.

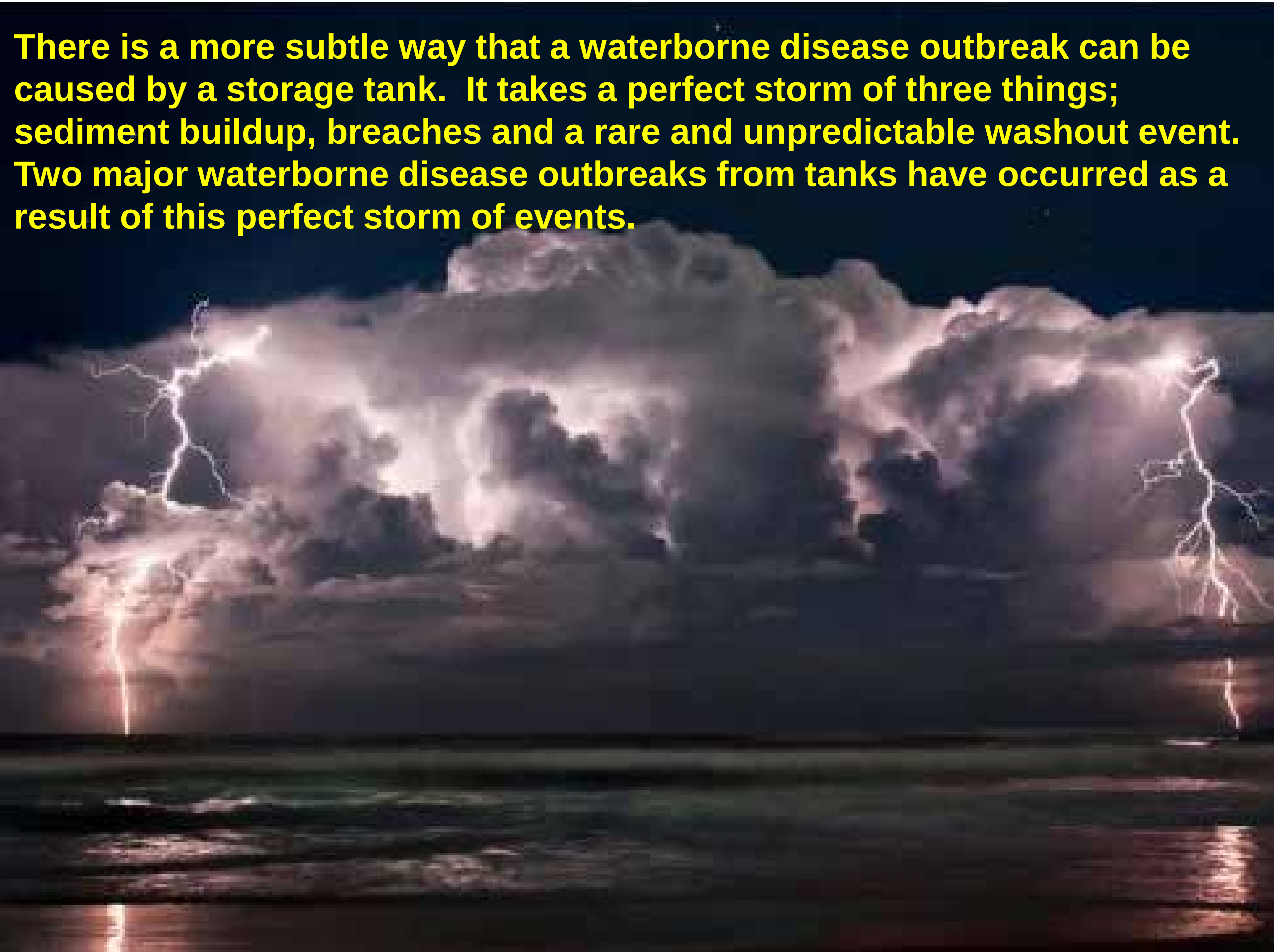
Let’s see what a 1000-fold increase looks like.
If we have a car going through a 10 foot by 10 foot opening,
what would a 1000-fold increase look like?

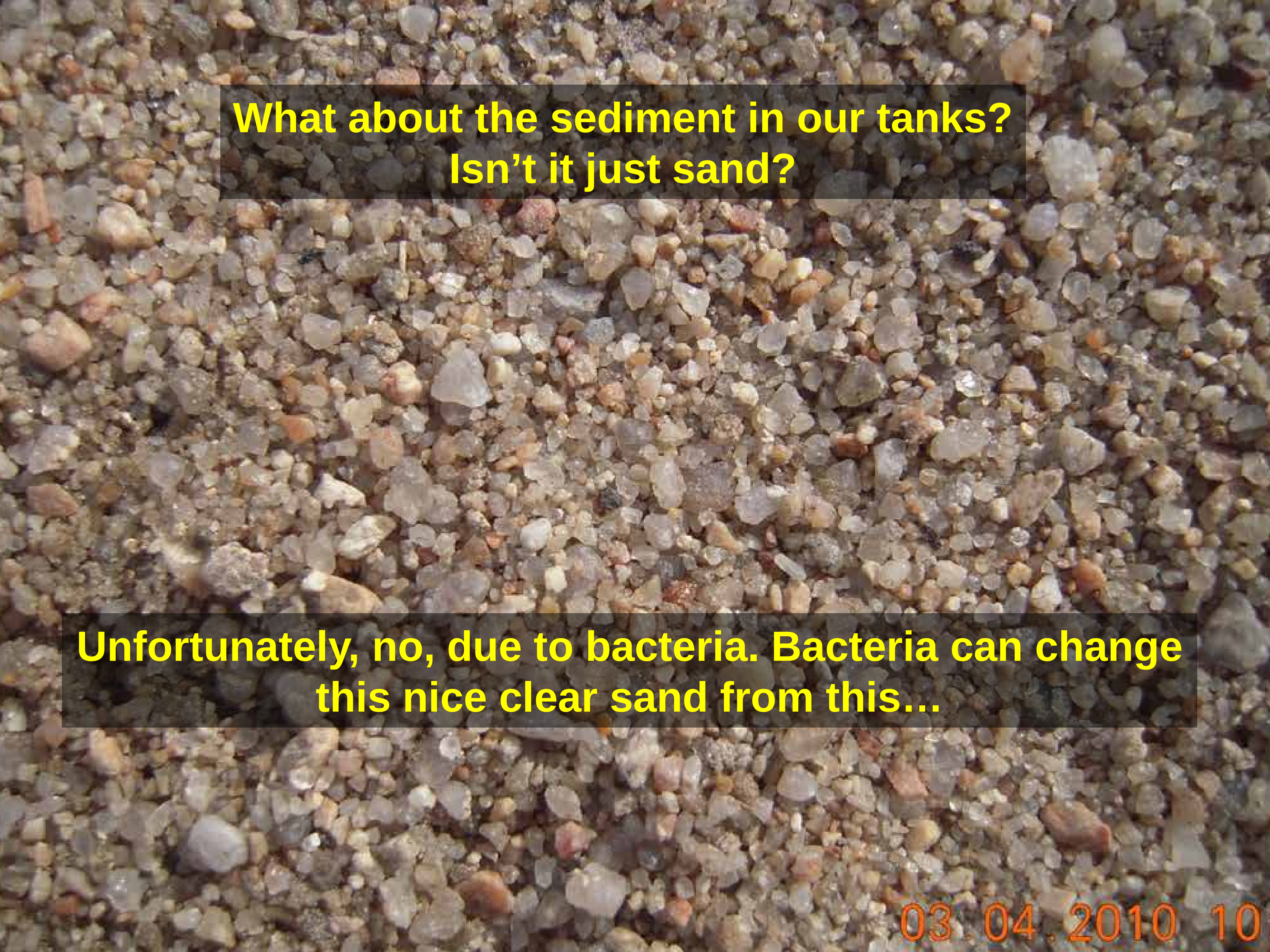
So, in comparison to filtration, the opening of a # 24 screen is quite a compromise to the sanitary integrity of the finished water. We should try our best to find and eliminate any openings larger than afforded by a # 24 screen. Caulking works well to fill small holes.

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

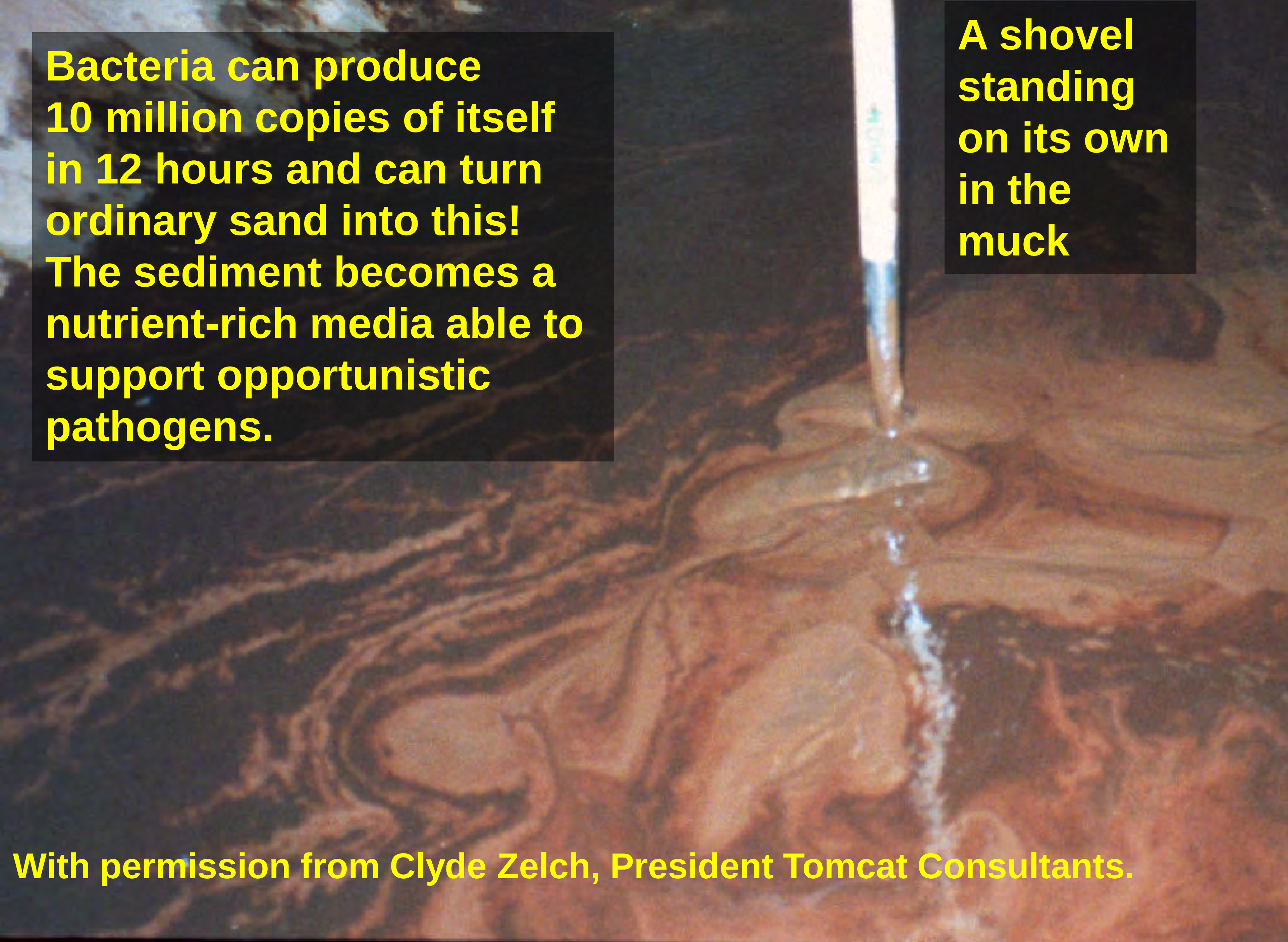

Even though a # 24 screen
has an opening 1000 times
larger than our best
sand media filters, it will keep out
animals, birds
and insects
and the
infinitesimally smaller
bacteria and viruses they harbor
With permission from Clyde Zelch,
President Tomcat Consultants.

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.

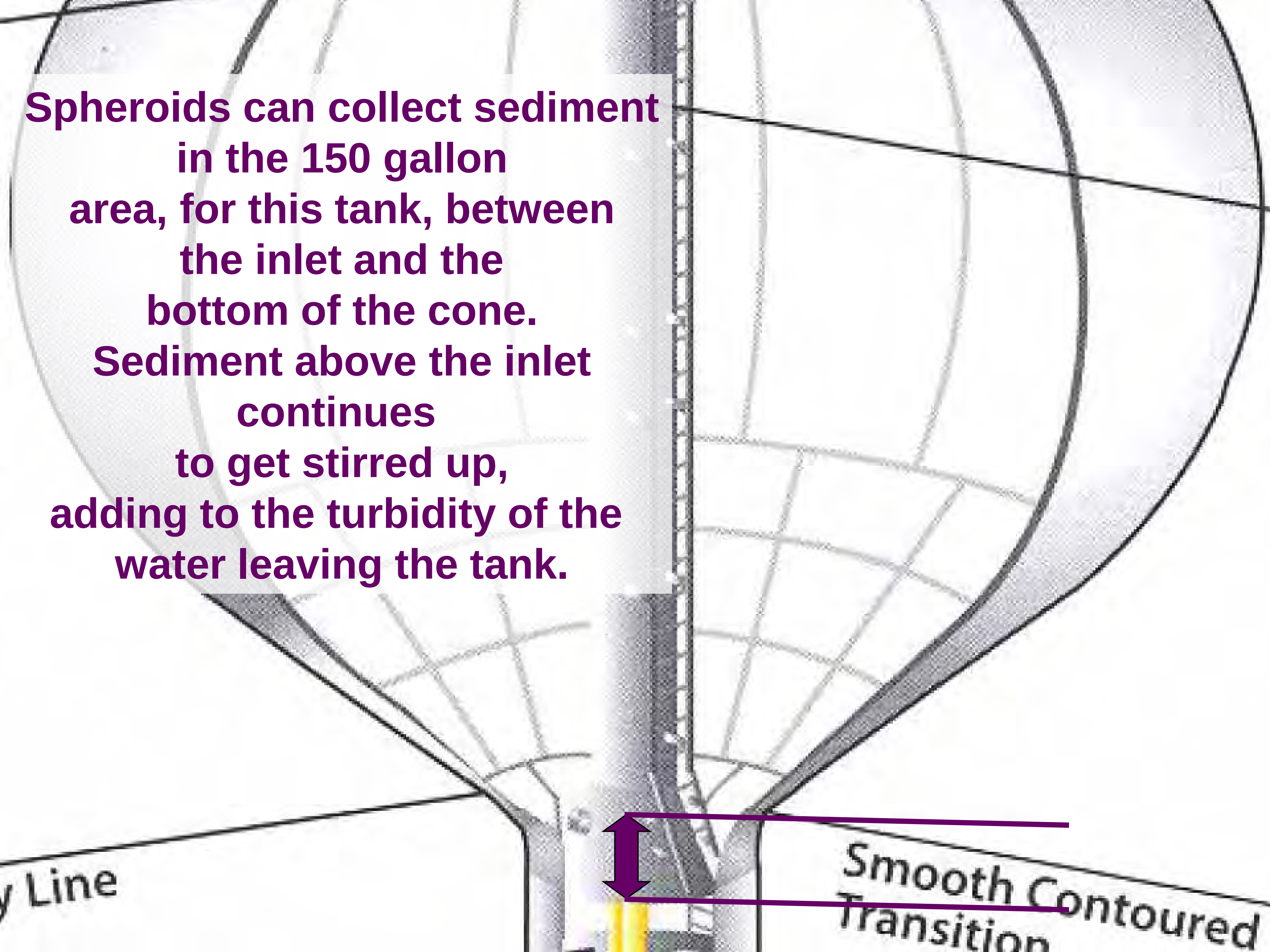



What about the sediment in our tanks?
Isn't it just sand?
Unfortunately, no, due to bacteria. Bacteria can change
this nice clear sand from this…
03 04 2010 10

…to this. Bacteria effectively turn the sand into 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 opportunistic
pathogens.
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.




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

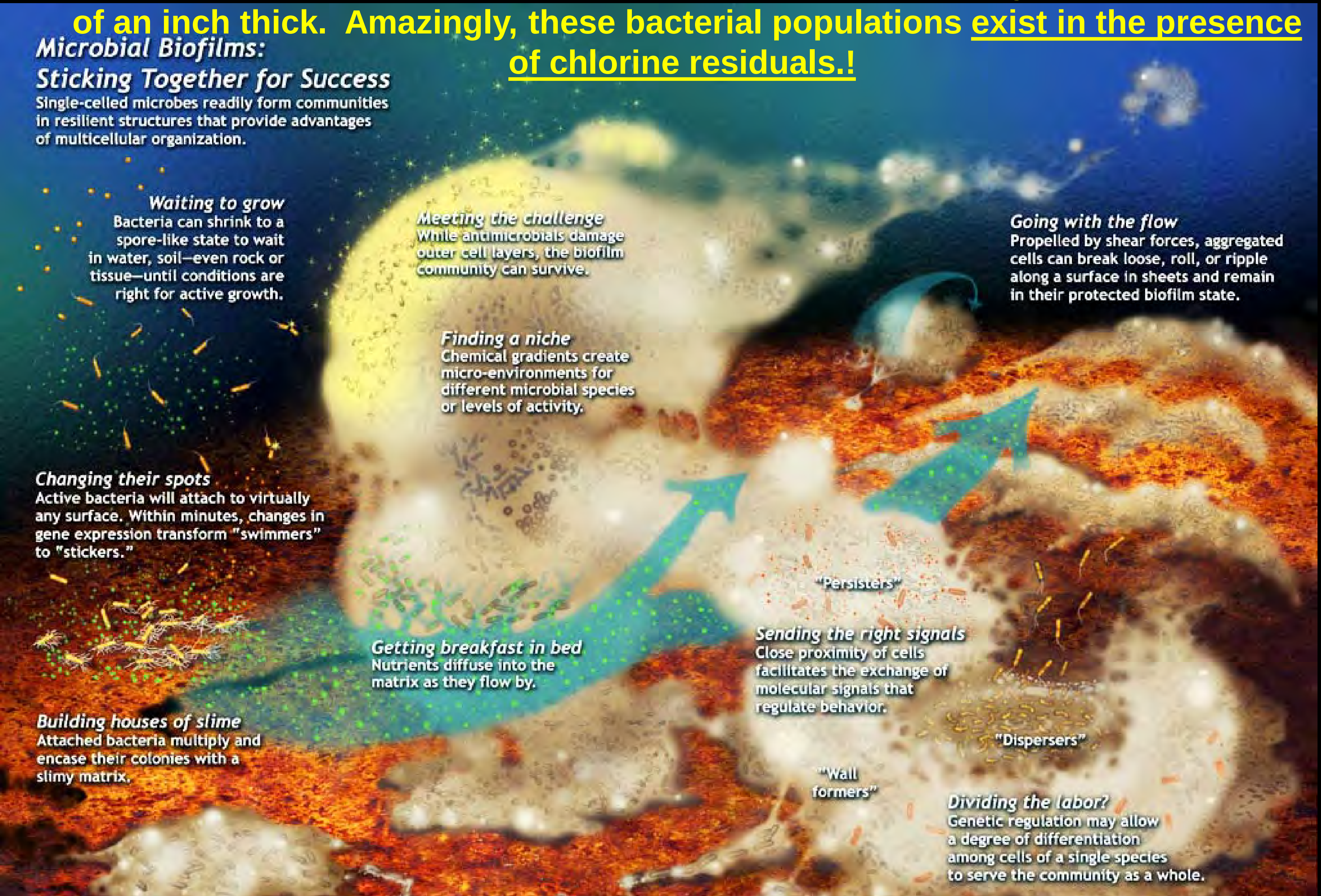
Brookfield, Wisconsin, had 3 spheroids.

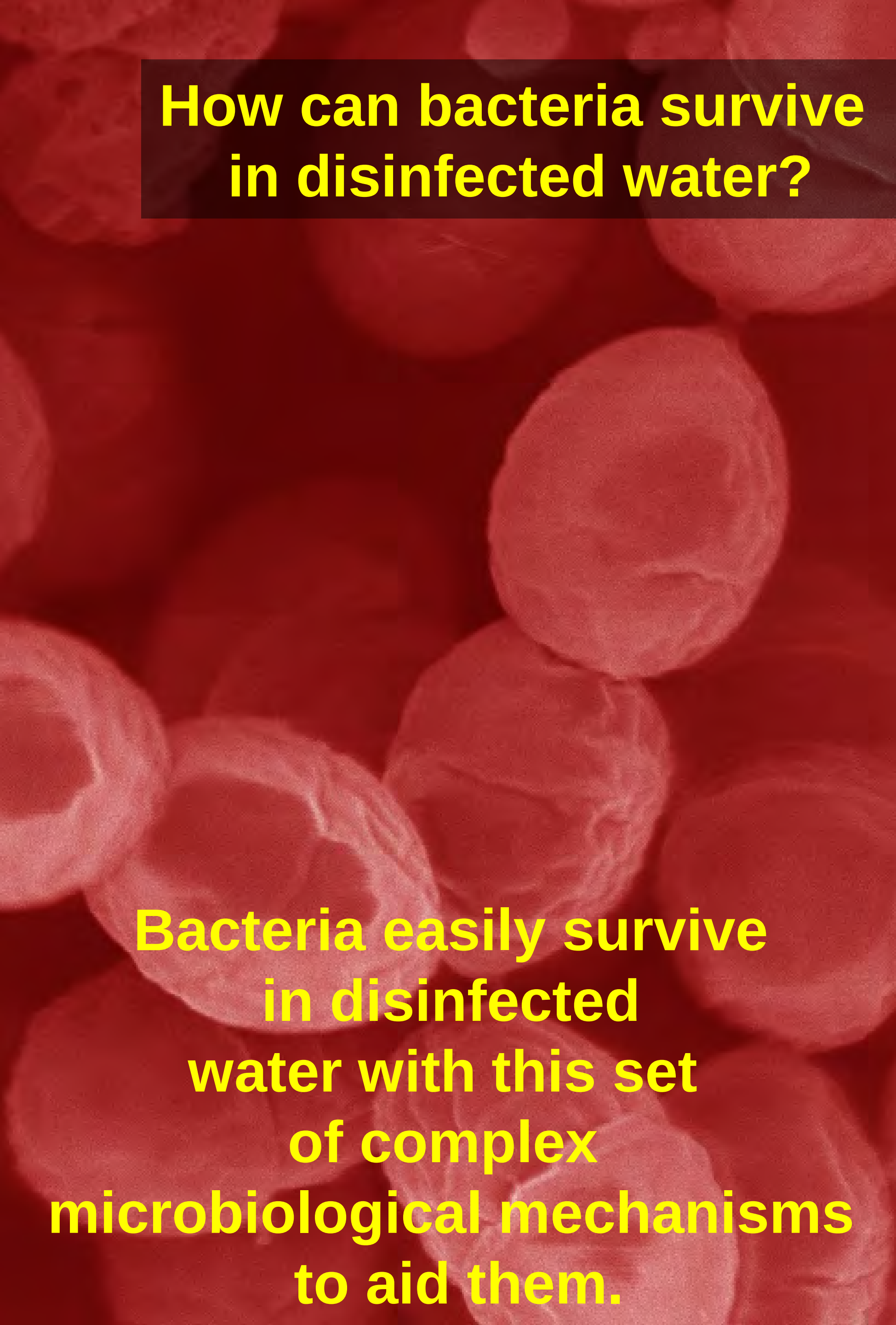
Two tanks were last cleaned 7 years ago. The result:
4 to 12 inches of sediment

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.!





How can bacteria survive in disinfected water?

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.

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

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

than bacteria (densities up to 10^4

Amphipods

What other things live in the sediment

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

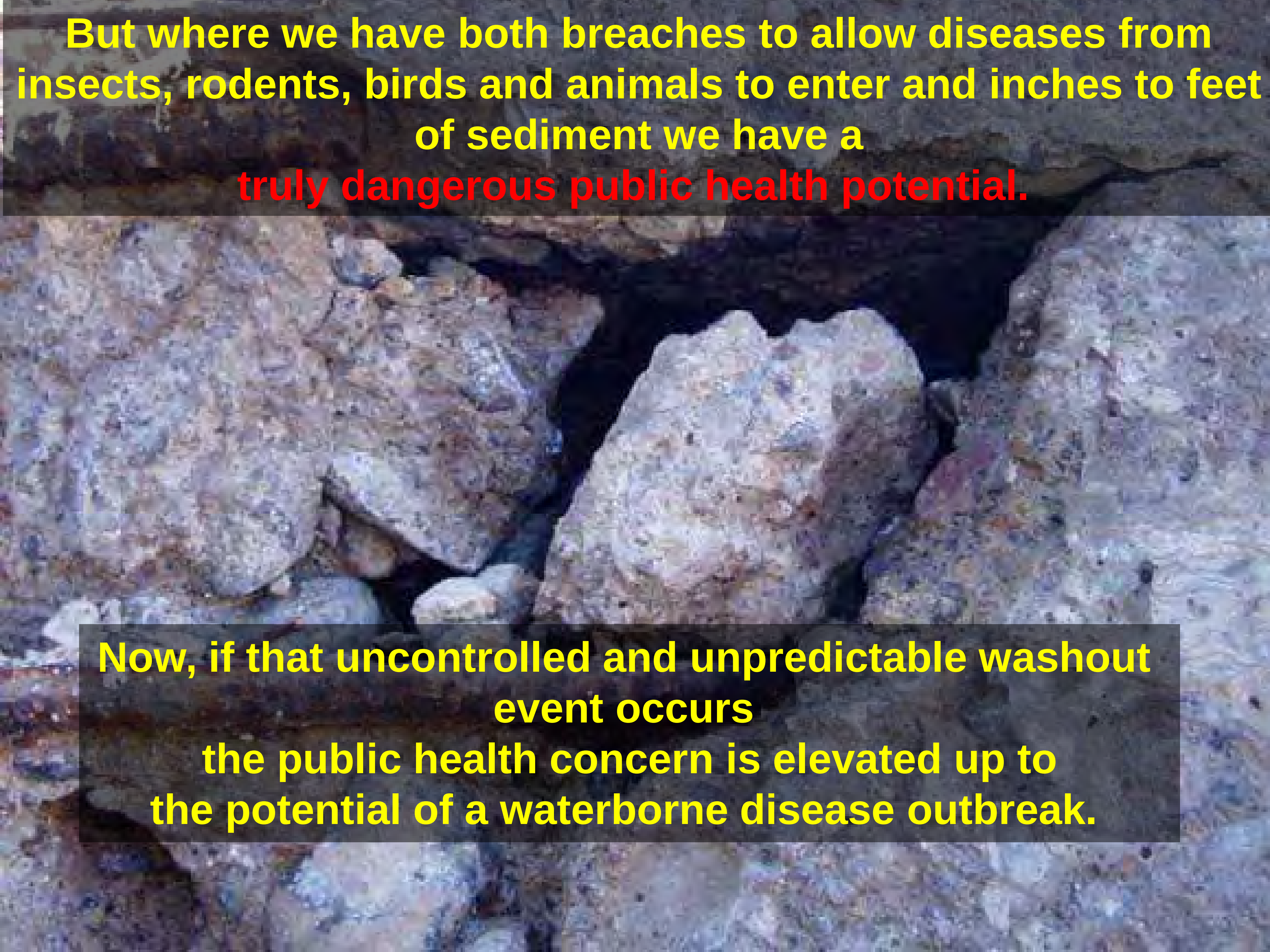
Most pathogens do not live long outside of the intestinal tract. However, in a microbial and nutrient-rich environment, like the sediment in tanks, they can survive for a greater length of time.

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

EPA research on tank sediments, and some of the first ever conducted, showed the presence of the following opportunistic pathogens in descending order of prevalence: Mycobacterium, Legionella, Pseudomonas aeruginosa and Acanthamoeba. In tanks with breaches other pathogens can be transported to the sediment like: E.coli 0157, Campylobacter, Salmonella, Cryptosporidium, Giardia Lamblia and viral pathogens. EPA's research shows there are important <u>public health reasons</u> for removing sediment from tanks.

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 floor and walls and into the distribution system.

Alamosa faces water lawsui

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 of dollars simply defending itself. The law firm that brought suit against Milwaukee had developed one of the most extensive libraries in the country.

This 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.

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.