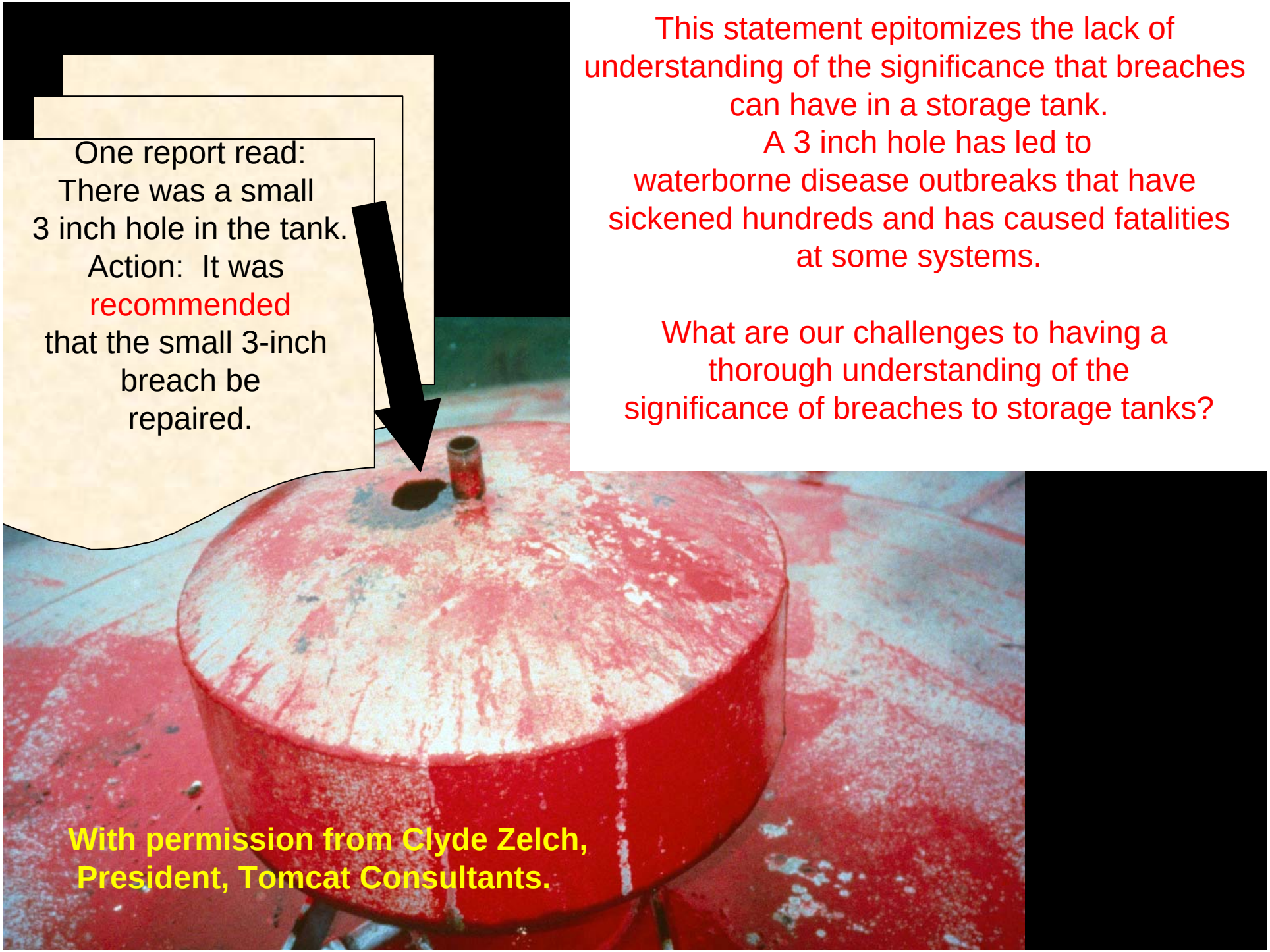
Understanding the Significance of Breaches to to Finished Drinking Water Storage Tanks

Bob Clement, Environmental Engineer, EPA Region 8, April 28, 2010

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

Anonymous

The purpose of this presentation is to bring together a wealth of knowledge from the very general to the highly technical and from many different fields of science, to help us understand the significance of breaches to vents, drains, overflows, and other locations on finished water storage tanks.

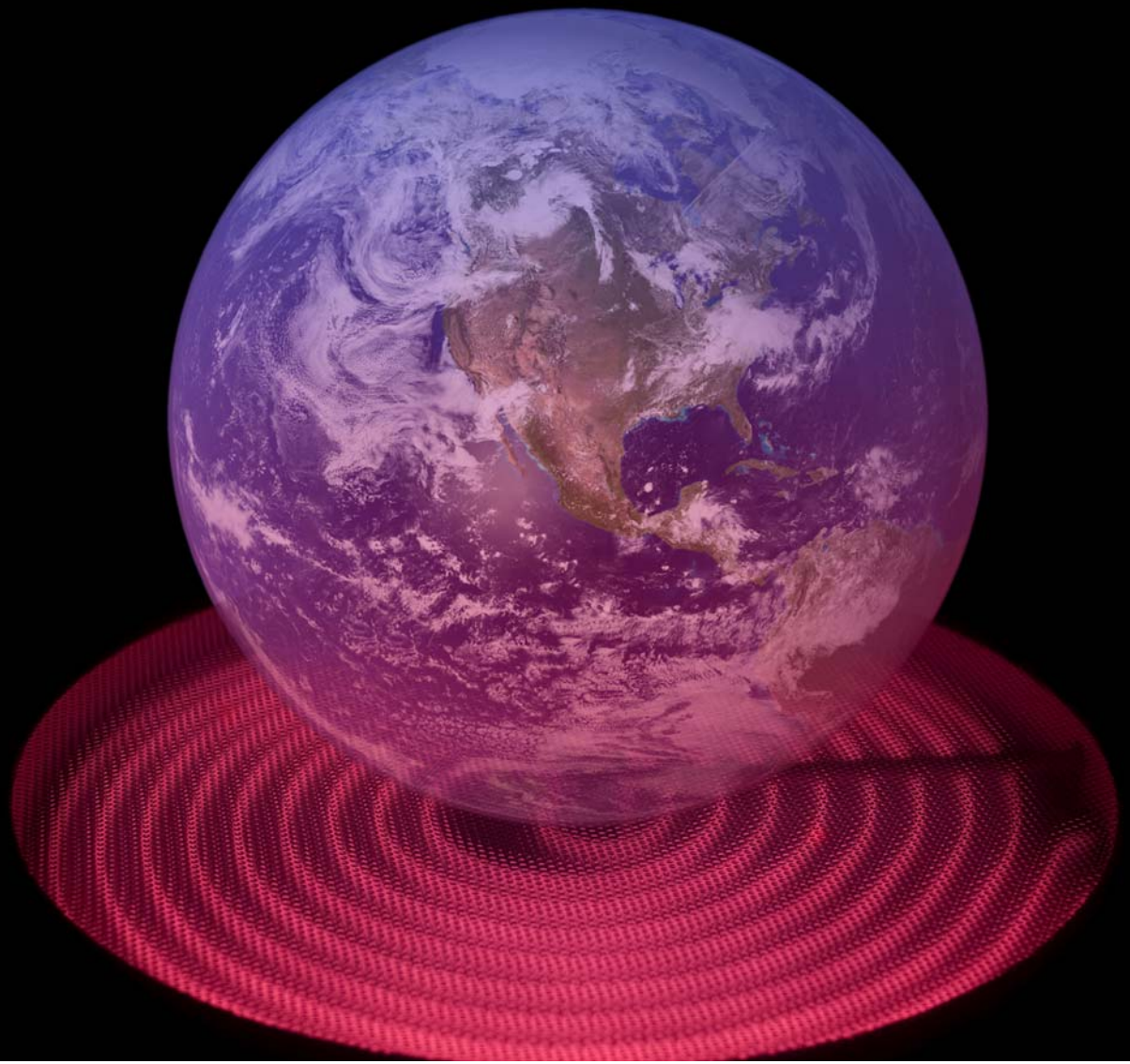


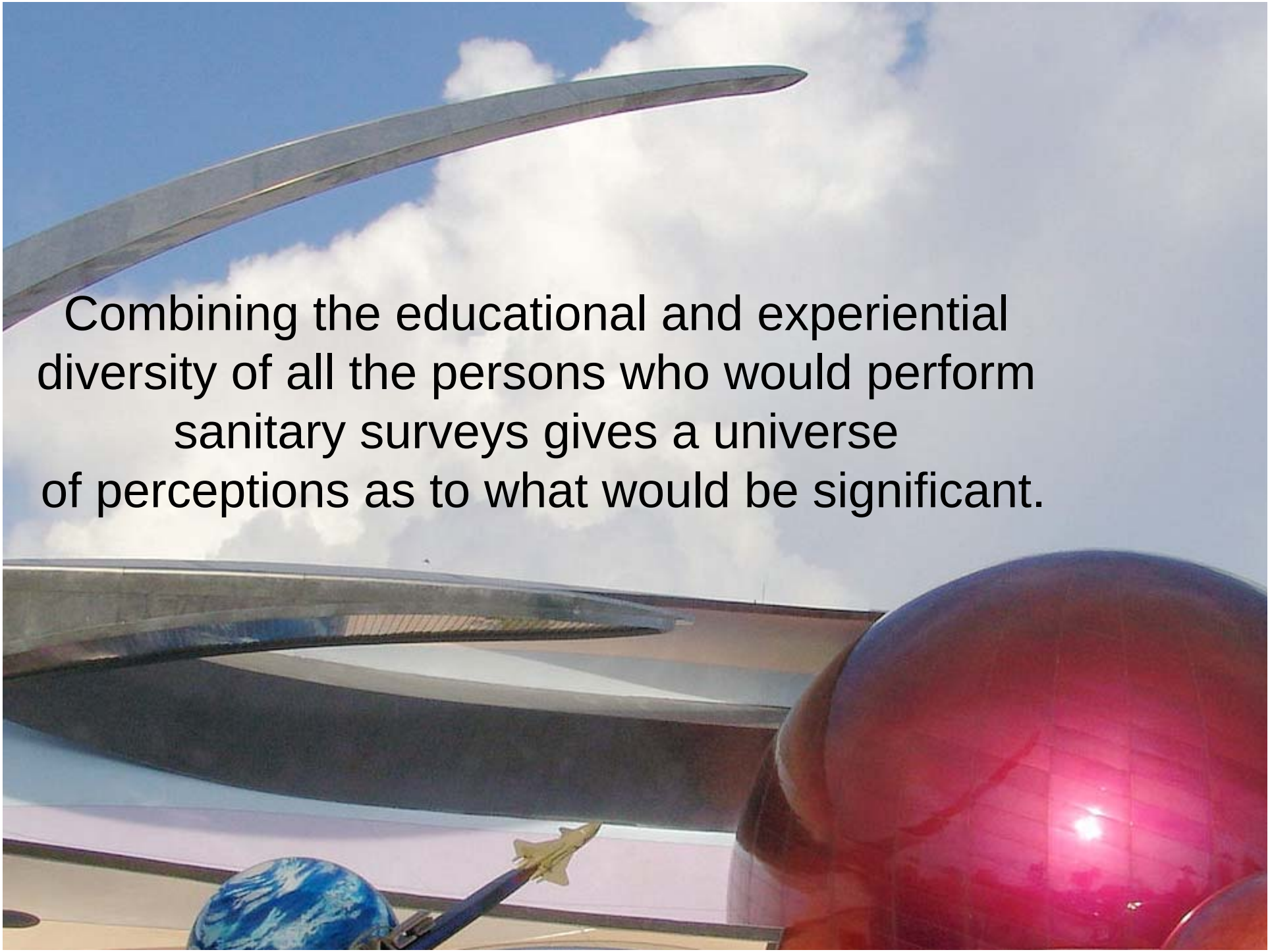
This statement epitomizes the lack of understanding of the significance that breaches can have in a storage tank.
A 3 inch hole has led to waterborne disease outbreaks that have sickened hundreds and has caused fatalities at some systems.

What are our challenges to having a thorough understanding of the significance of breaches to storage tanks?

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. Inquires about it, but investigates no further.

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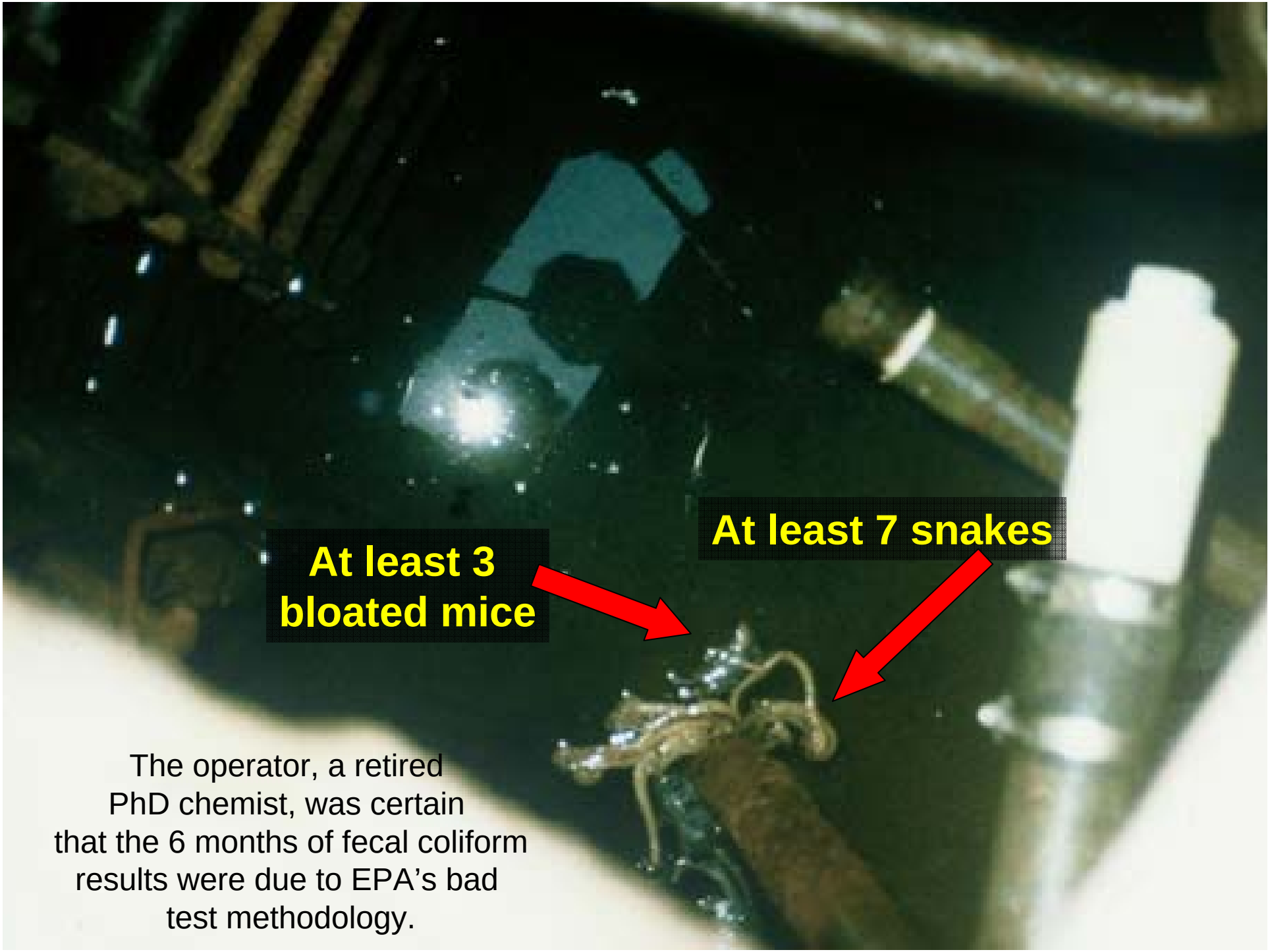
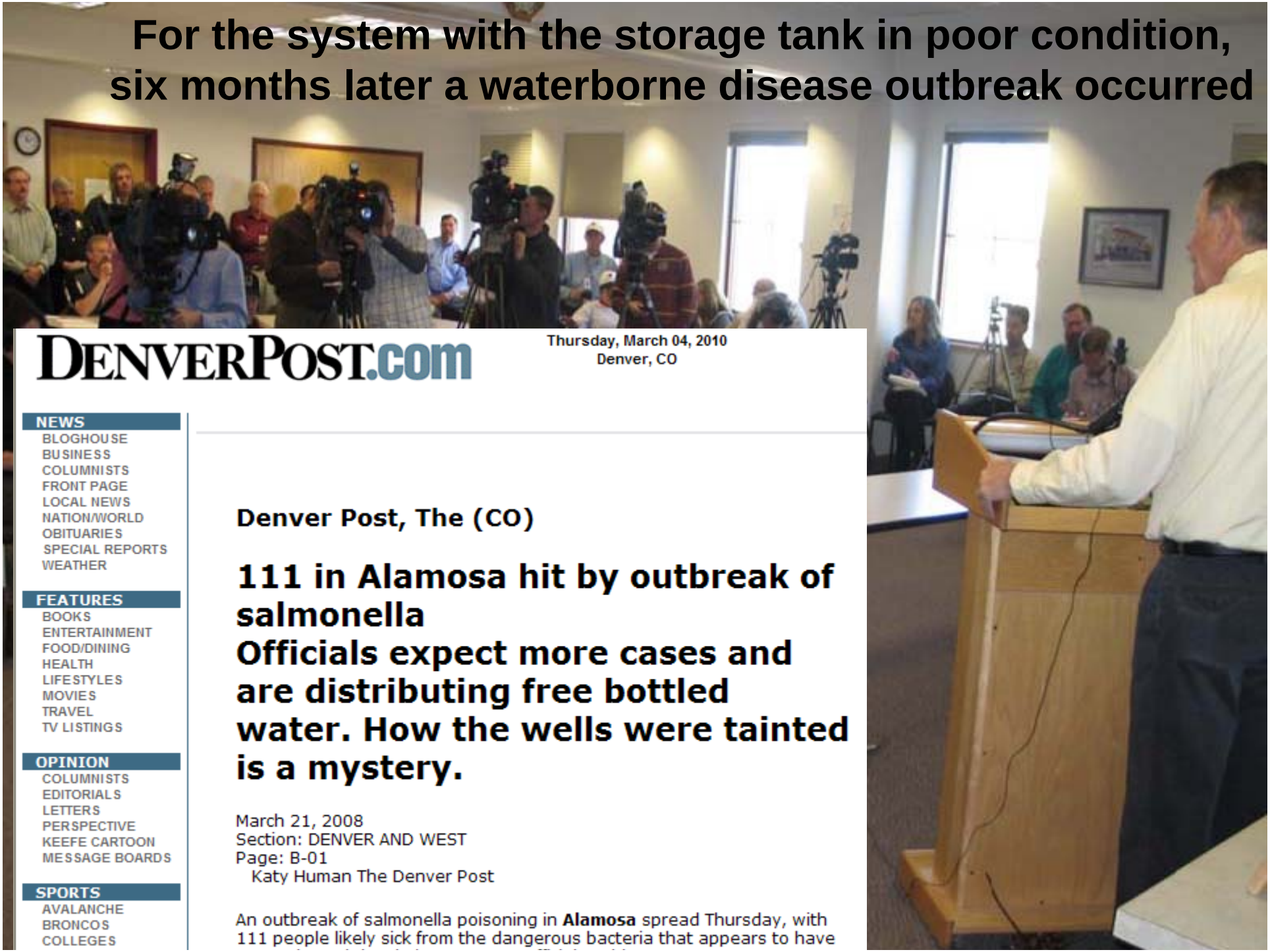


The operator, a retired PhD chemist, was certain that the 6 months of fecal coliform results were due to EPA's bad test methodology.

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



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Denver Post, The (CO)

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

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

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

To understand the complete picture of the complexities and all that was involved in the waterborne disease outbreak at Alamosa please see the Final report prepared by Colorado Department of Public Health and Environment

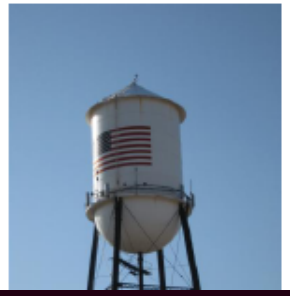
WATERBORNE
SALMONELLA OUTBREAK
IN ALAMOSA, COLORADO
MARCH AND APRIL 2008

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 they are inconsistent.

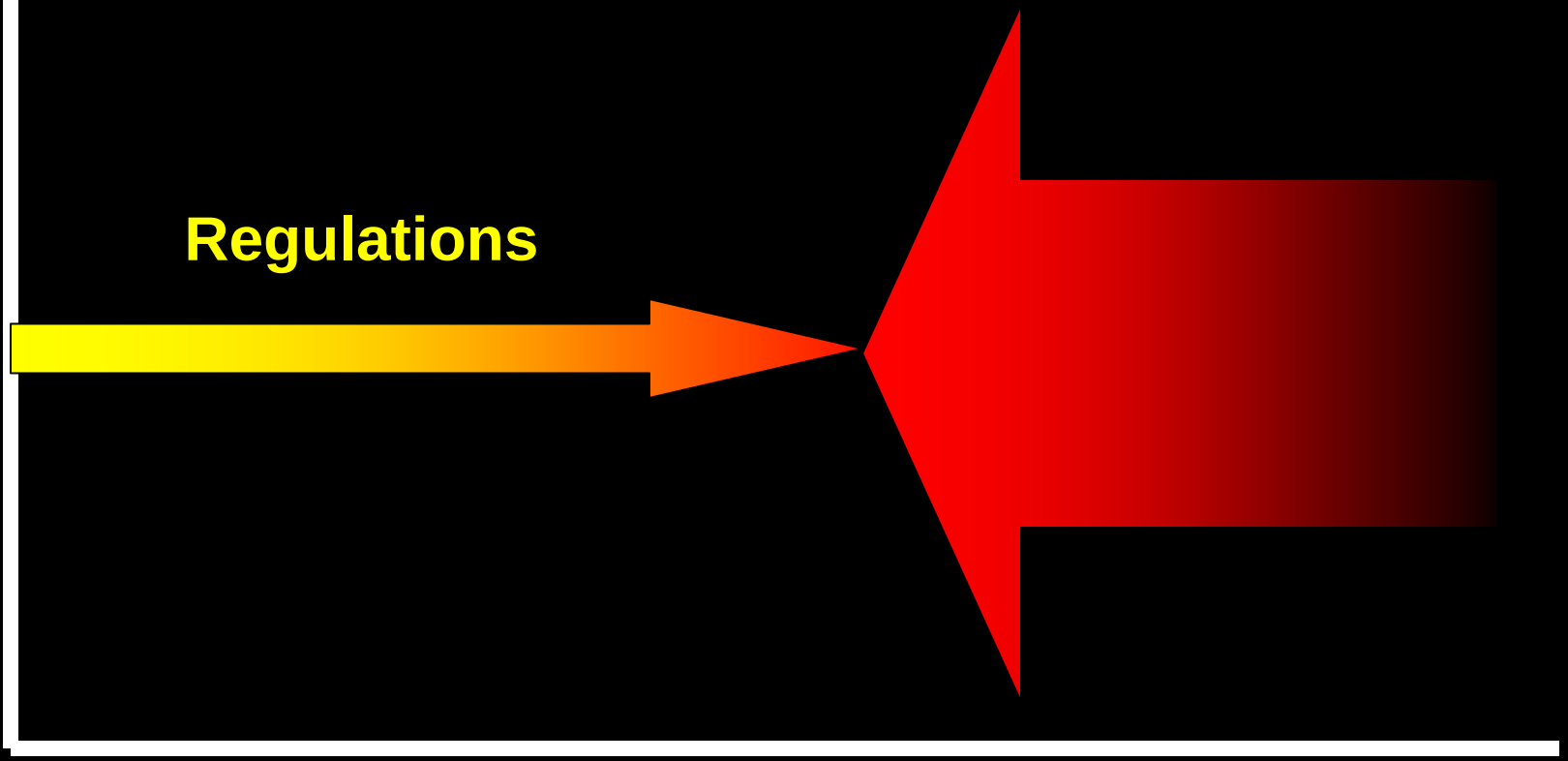
In general,
regulations are able to achieve more
consistent implementation across the 50 states.

Guidance and recommendations

Regulations

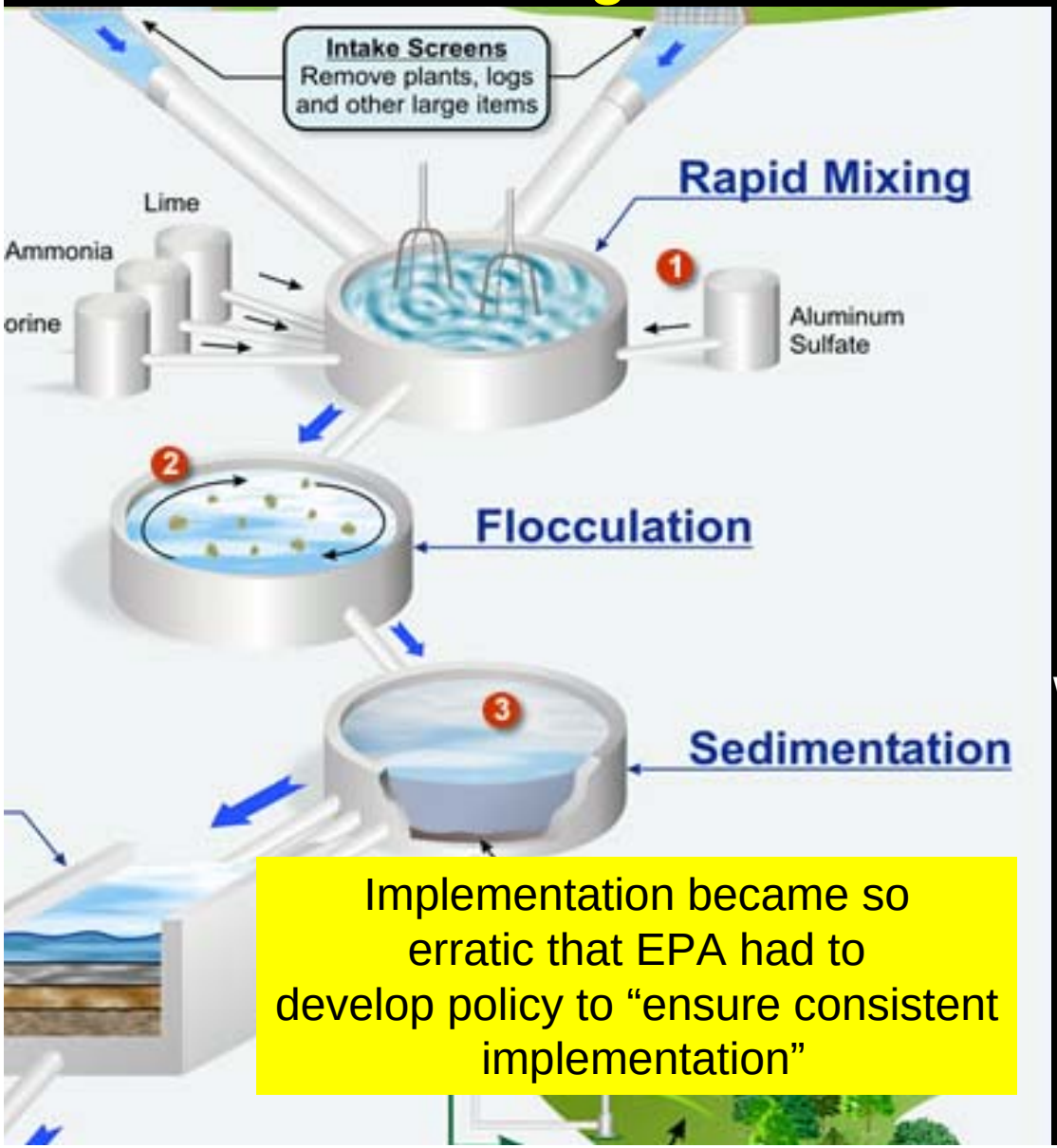
Increasing consistency in implementation

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



Increasing consistency in implementation

Take, for example, what the total organic carbon removal requirements in the Stage 1 DBP Rule did to our rock-solid understanding of what conventional treatment is.



Implementation became so erratic that EPA had to develop policy to "ensure consistent implementation"

TOC removal applied only to conventional systems, all of a sudden…

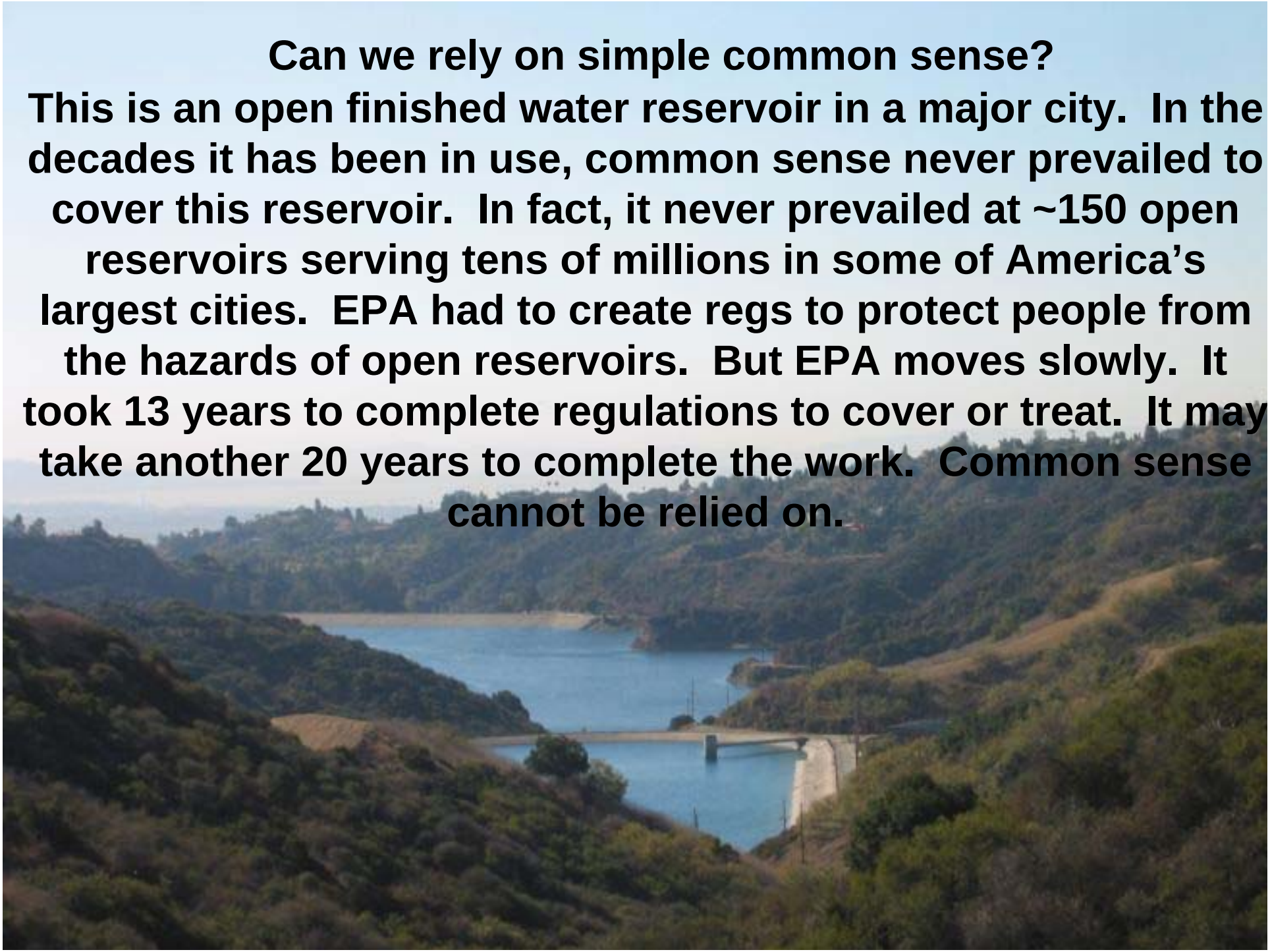
Systems with any other type of settling outside of traditional engineered gravity settling basins were classified as direct filtration

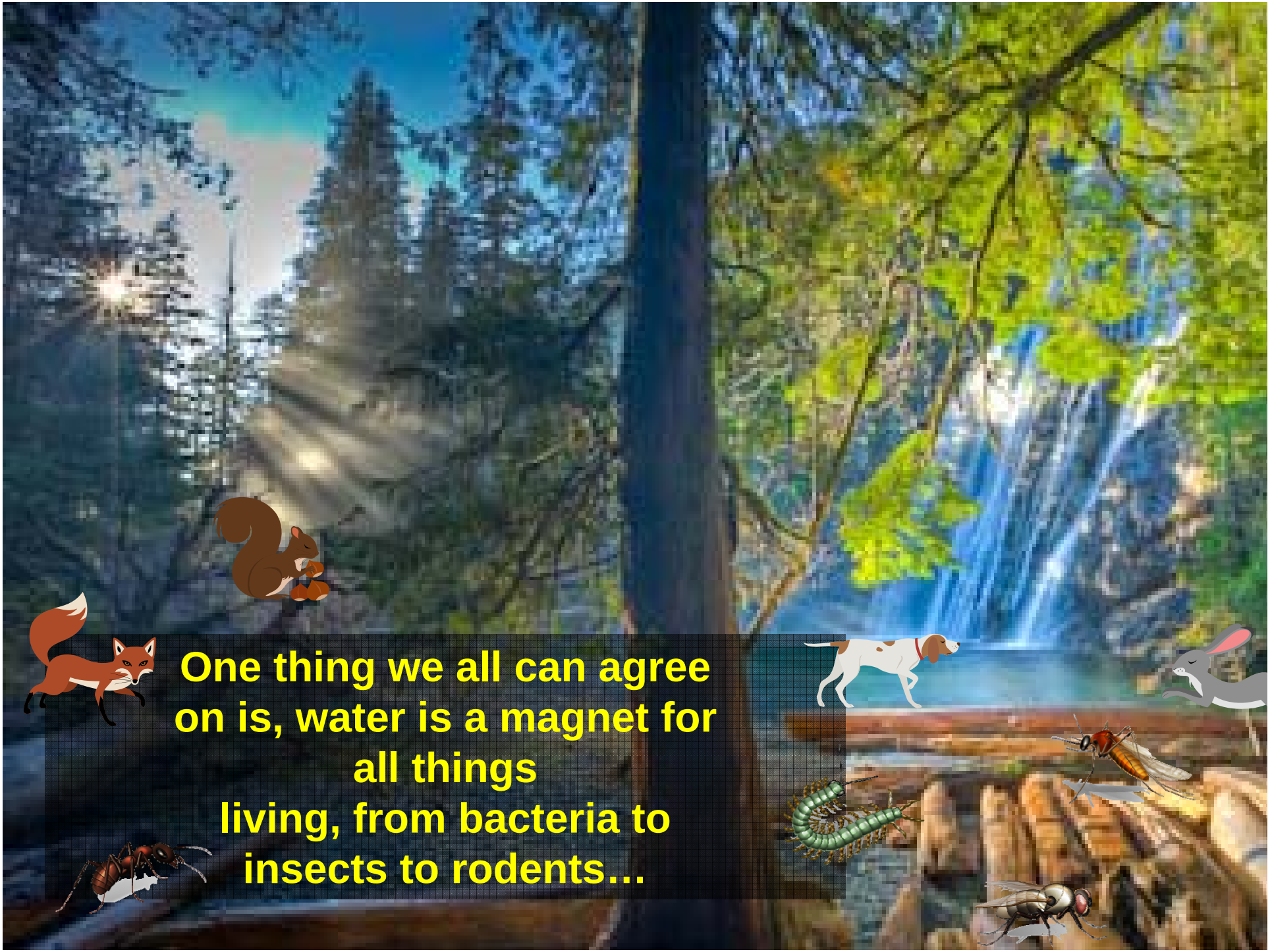
Packaged rapid sand filtration plants with settling were classified as alternative filtration

If this level of inconsistency in implementation can occur with regulations, it is easy to see what challenges we face with just recommendations and guidance for tanks.

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.




One thing we all can agree
on is, water is a magnet for
all things
living, from bacteria to
insects to rodents…

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.

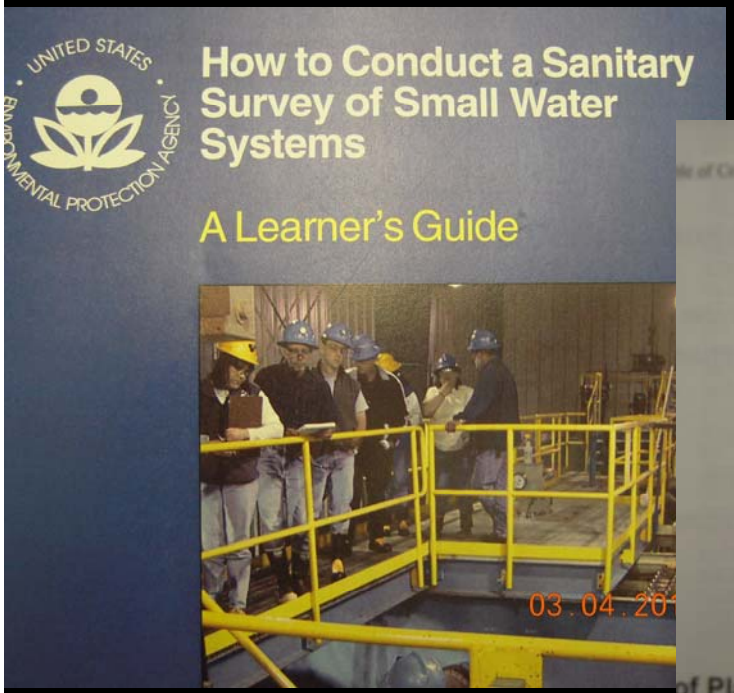
Storage tanks are one of the most vulnerable parts of a distribution system for three reasons:

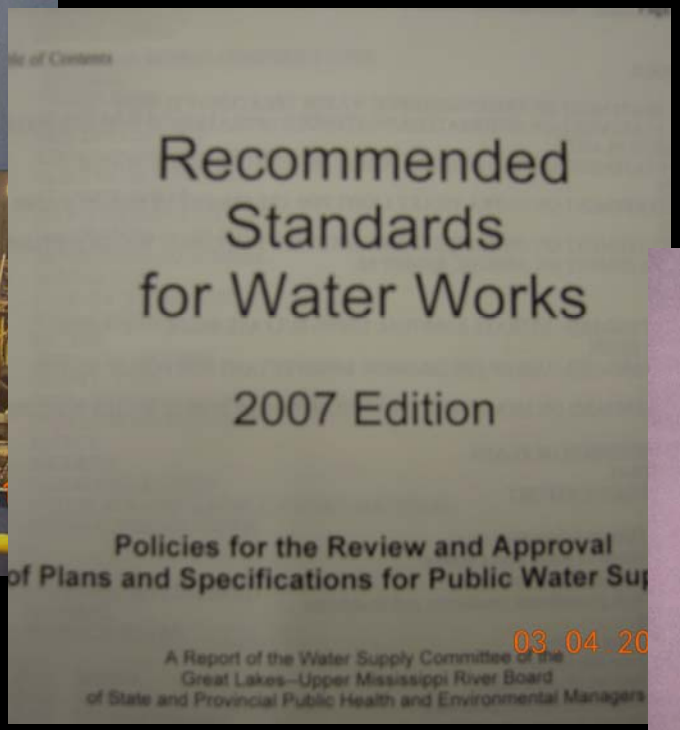
1) The finished water is in contact with the atmosphere through vents, overflows, hatches, and other unplanned openings, and;

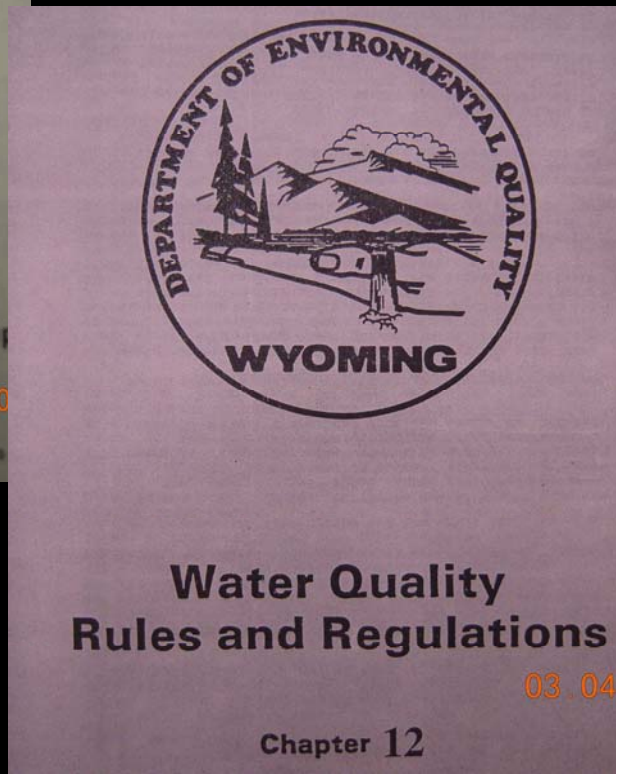
2) Large volumes of air are exchanged when the tank is being drawn down or filling up, and;

3) The water comes to zero pressure at the air/water interface.

Because there are no regulations and guidance is all over the place, this presentation will use the following guidance documents and attempt to distill what would be the <u>very best practices</u> to protect the finished water in storage tanks

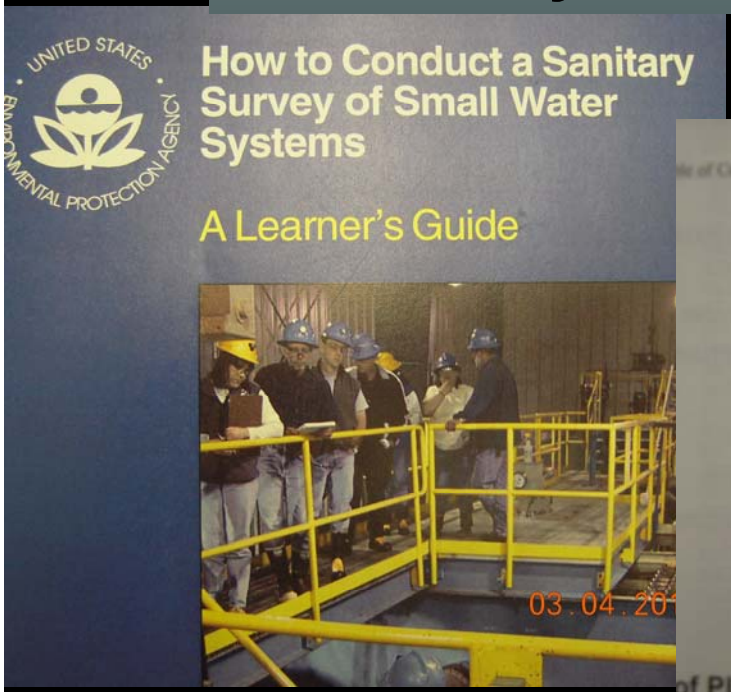


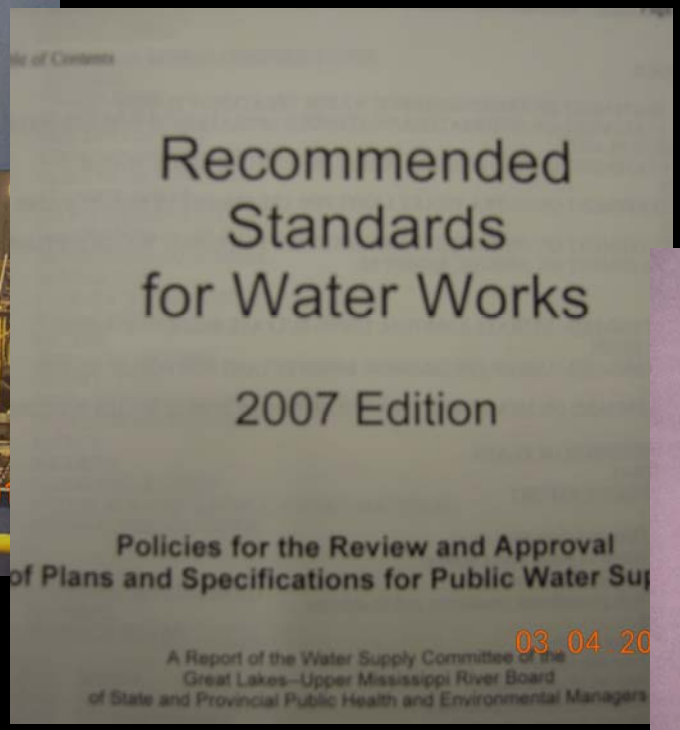


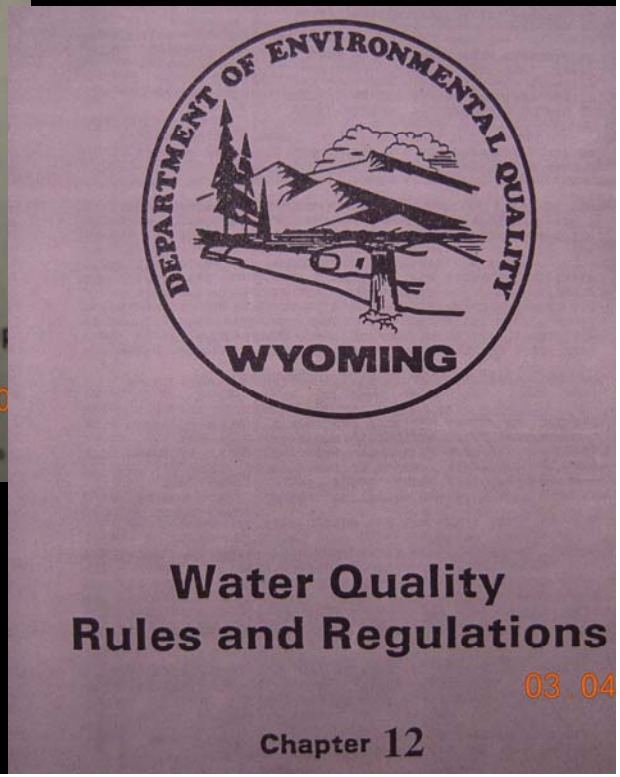


We'll also review the sanitary surveys for WY, SD, ND and MN

Actually, it really doesn't matter which guidance you look at. If the goal is to find <u>very best practices,</u> then once you have achieved that -- you're done!







What kind of stuff do these recommending manuals say we should keep out of our tanks?

Comparison of recommendations on what to keep out of finished water storage tanks

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) Animals, birds, insects, excessive dust	(Shall) Animals, birds, insects, excessive dust	-(Shall) Mammals, rodents, birds, insects, algae, airborne contamination (bird droppings, feathers, pieces of grass), swimmers and other things thrown in

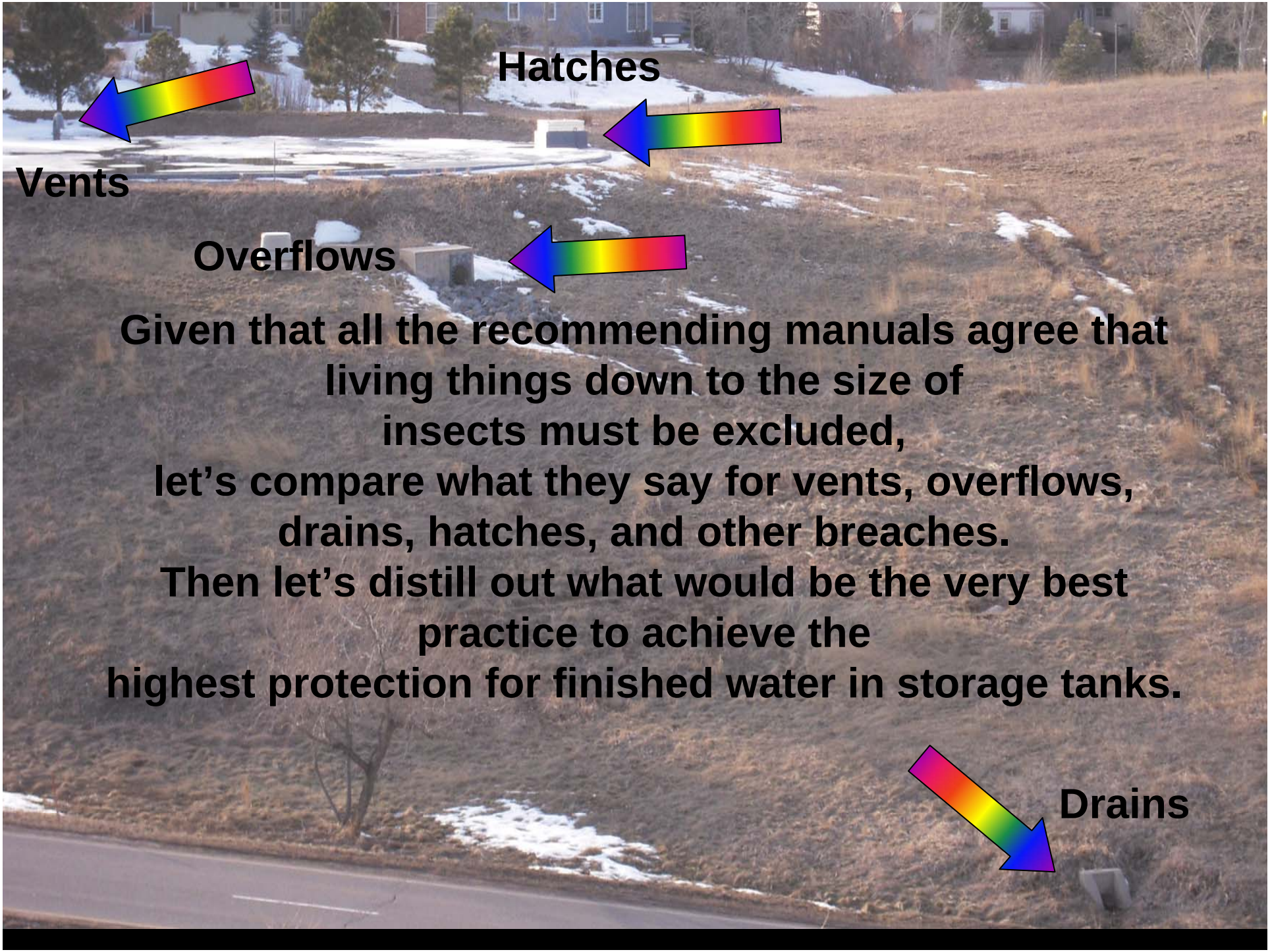
Clearly, all are in agreement that living things down to the size of insects must be excluded, and even airborne contamination and dust must be minimized.

Why? Because insects & dust can carry bacteria & viruses

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.



Given that all the recommending manuals agree that living things down to the size of insects must be excluded, let's compare what they say for vents, overflows, drains, hatches, and other breaches. Then let's distill out what would be the very best practice to achieve the highest protection for finished water in storage tanks.

Vents
What do our recommending manuals
and sanitary surveys say about vent screens
on ground-level tanks?

Comparison of recommendations on screens for vents for ground-level tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) # 24 non-corrodible screen -(Shall) exclude animals, birds, insects & dust -(Shall) Installed within - the pipe	-(Shall) # 24 non-corrodible screen -(Shall) exclude animals, birds -Installed within the pipe	-# 24 non-corrodible screen is necessary to control insects -(Shall) exclude animals & birds

Region 8's Sanitary Survey Form for Wyoming
-# 24 non-corrodible screen? -Installed within the pipe?

4 out of 4 say a # 24 non-corrodible screen is needed. Learner's guide meekly states a # 24 because it combines advice for elevated and ground-level tanks.

Only 10 State specifically says insects must be eliminated in the section on vents

3 out of 4 say screens need to be installed within the pipe, to prevent vandalism and to better protect the screen.

Comparison of recommendations on screens for vents for ground-level tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-# 24 non-corrodible screen -(Shall) exclude animals, birds insects & dust -Installed within the pipe	-# 24 non-corrodible screen is necessary to control insects -(Shall) exclude animals & birds	-Are the storage structures vented? -Are vents properly protected & screened? Size of vent screen ~not specified~
North Dakota's Sanitary Survey Form	**Minnesota's List of Survey Recommendations**	
-Roof vent condition? Size of vent screen ~not specified~	-# 24 non-corrodible screen -Installed within the pipe	SD & MN's SS mention screens. Only MN's specifies # 24 and installed within the pipe

What do our recommending manuals and sanitary surveys say about vent screens on elevated tanks?

Comparison of recommendations on screens for vents for elevated tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-Either a # 4 non-corrodible screen or finer with an automatic resetting pressure vacuum relief mechanism	-(May) # 24 non-corrodible screen	-# 24 non-corrodible screen is necessary to control insects. Must be designed to "give way" or fail to protect the tank from collapsing if a vacuum occurs.

Region 8's Sanitary Survey Form for Wyoming
-# 24 non-corrodible screen?

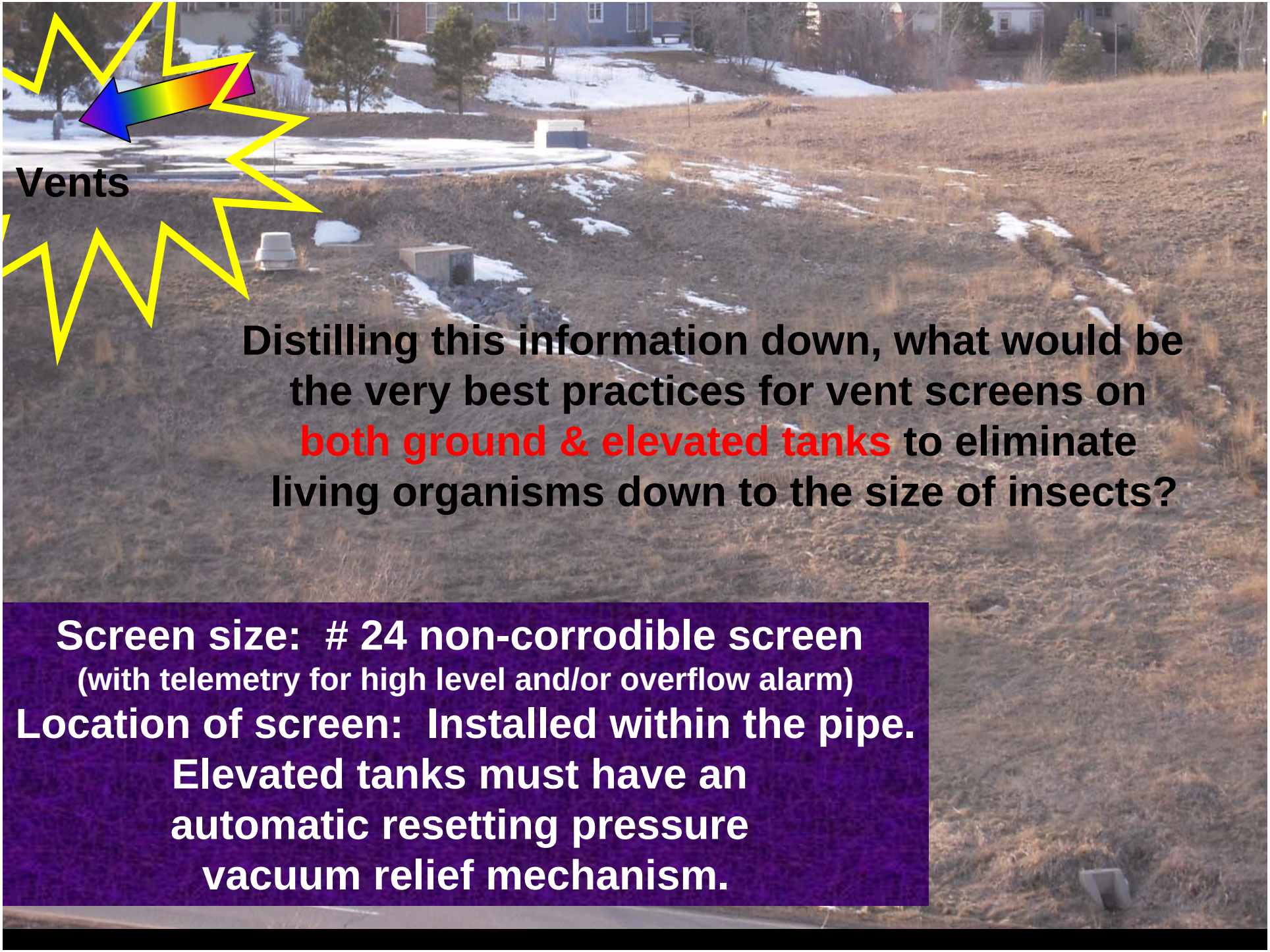
4 out of 4 make reference to the # 24 screen but with caveats. They need to be engineered to temporarily give way so the tank does not collapse. An automatic resetting pressure relief mechanism is needed.

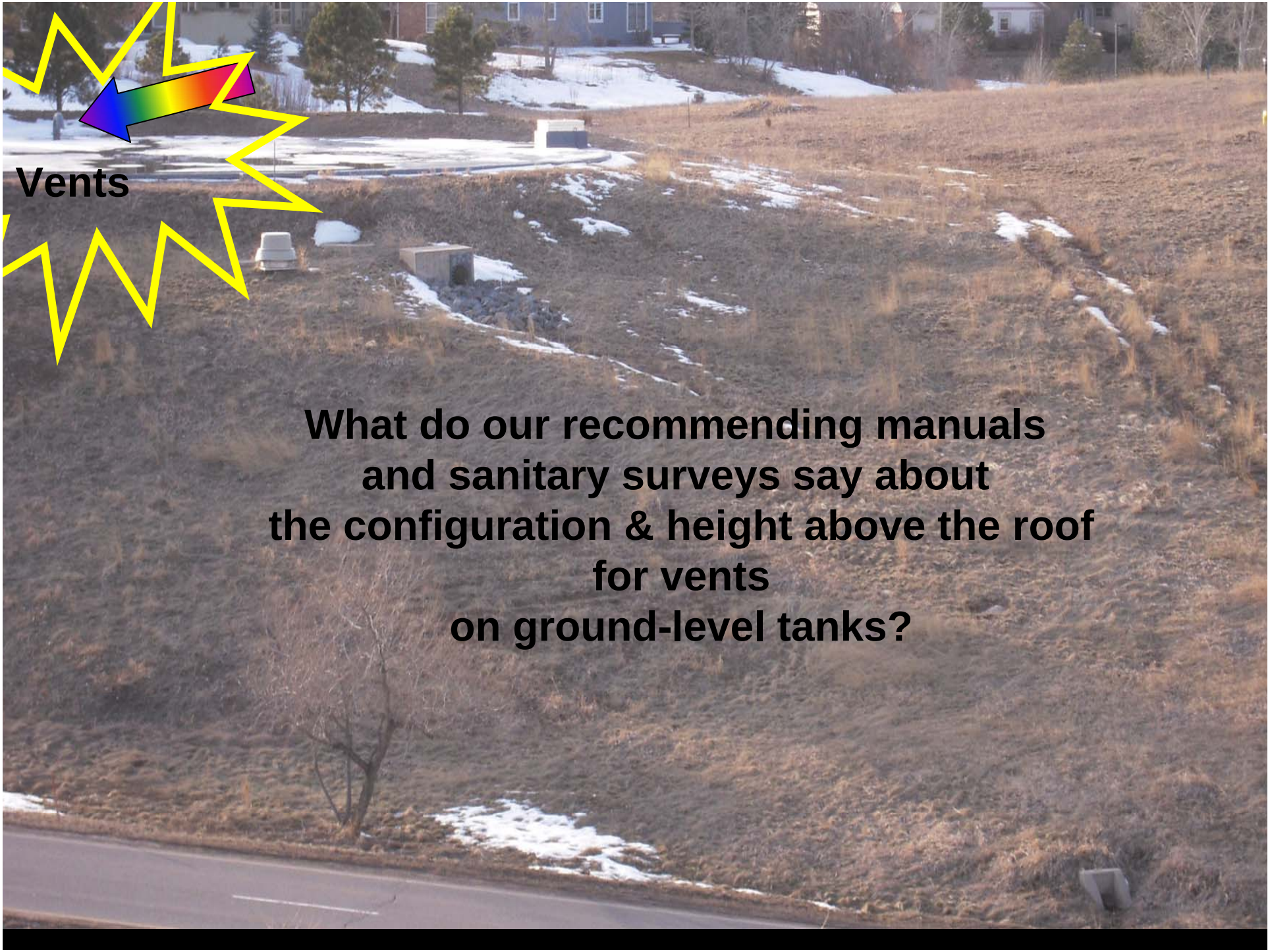
Comparison of recommendations on screens for vents for elevated tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-Either a #4 non-corrodible screen or **finer** with an automatic resetting pressure vacuum relief mechanism	-# 24 non-corrodible screen is necessary to control insects. Must be designed to "give way" or fail to protect the tank from collapsing if a vacuum occurs.	-Are the storage structures vented? -Are vents properly protected & screened?

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	
-Roof vent condition?	-Either a #4 non-corrodible screen or finer with an automatic resetting pressure vacuum relief mechanism	SD & MN's SS mention screens. Only MN's SS refers to # 24 with the vacuum relief mechanism


Vents
Distilling this information down, what would be the very best practices for vent screens on both ground & elevated tanks to eliminate living organisms down to the size of insects?
Screen size: # 24 non-corrodible screen
(with telemetry for high level and/or overflow alarm)
Location of screen: Installed within the pipe.
Elevated tanks must have an automatic resetting pressure vacuum relief mechanism.


Vents
What do our recommending manuals
and sanitary surveys say about
the configuration & height above the roof
for vents
on ground-level tanks?

Comparison of recommendations on configuration & height above the tank surface for vents for ground-level tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) Open downward	-(Shall) Inverted U	-Inverted U to exclude rain & wind blown debris
-(Shall) Minimum 24 inches above roof or sod	-(Shall) Minimum of 24 inches above roof	-24 to 36 inches above the roof or sod -Prevents dried bird droppings from being inhaled or blown into the vent

Region 8's Sanitary Survey Form for Wyoming
-Turned downward
-At least 24 inches or 3 pipe diameters, whichever is greater, above the roof

4 out of 4 say the configuration of the vent needs to open downward in an inverted U.

4 out of 4 say the vent needs to be at least 24 inches above the roof or sod. WY SS increases the height above the roof for vents greater than 8 inches to compensate for larger air flow and its increased capability to inhale contamination.

Comparison of recommendations on configuration & height above the tank surface for vents for ground tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-(Shall) Open downward -(Shall) Minimum 24 inches above roof or sod	-Inverted U or cover to exclude rain & wind blown debris 24 to 36 inches above the roof or sod -Prevents dried bird droppings from being inhaled or blown into the vent	-Not specified
North Dakota's Sanitary Survey Form	**Minnesota's List of Survey Recommendations**	
-Not specified	-(Shall) Open downward -(Shall) Minimum 24 inches above roof or sod	

Only MN's SS says that the configuration is downward and the height is at least 24 inches above the roof

What do our recommending manuals and sanitary surveys say about the configuration & height above the roof for vents on elevated tanks?

Comparison of recommendations on configuration & height above the tank surface for vents for elevated tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) Open downward -(Shall) prevent the entrance of surface and rainwater	-(Shall) prevent the entrance of surface and rainwater	Inverted U or cover to exclude rain & wind blown debris
-Configuration of the vent ~not specified~	Otherwise, the configuration is ~not specified~	-3 pipe diameters above roof prevents dried bird droppings from being inhaled or blown into the vent
Region 8's Sanitary Survey Form for Wyoming -Turned downward -At least 24 inches or 3 pipe diameters, which ever is greater, above the roof. -For elevated, if not 24 inches, is it covered?		

For elevated tanks, 3 of 4 say open downward and/or covered to prevent the entrance of rainwater and dust

Only 2 of 4 specify height above the roof, even though inhalation is as much, if not more, a factor as for ground-level tanks

Comparison of recommendations on configuration & height above the tank surface for vents for elevated tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-(Shall) Open downward -(Shall) Prevent the entrance of surface and rainwater -Configuration of the vent ~not specified~	-Inverted U or cover to exclude rain & windblown debris -3 pipe diameters above roof prevents dried bird droppings from being inhaled or blown into the vent	-Not specified

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations
-Not specified	-Open downward -Height above roof ~not specified~

Only MN's SS says downward.
No SS specifies the height above the roof

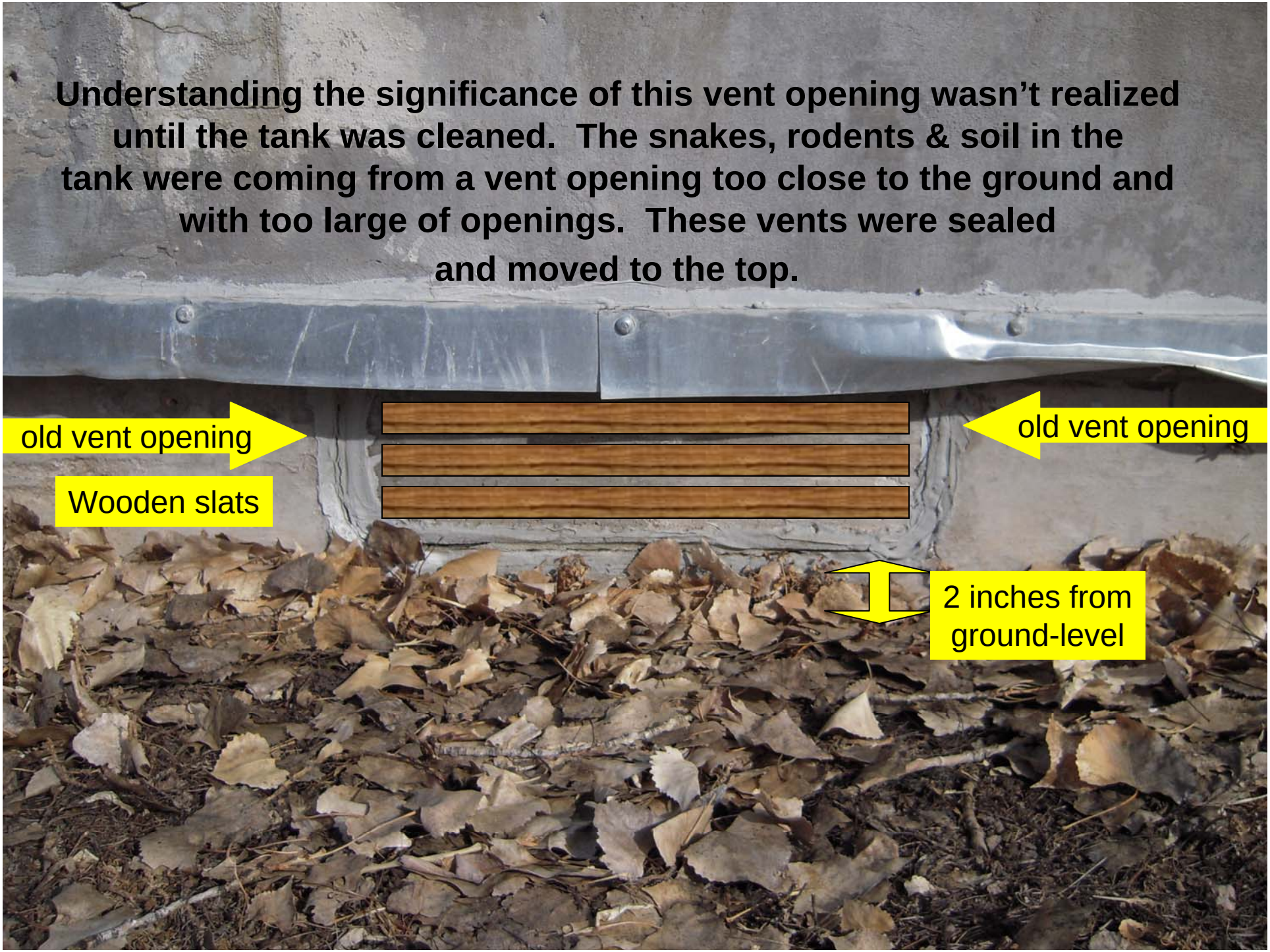
Vents

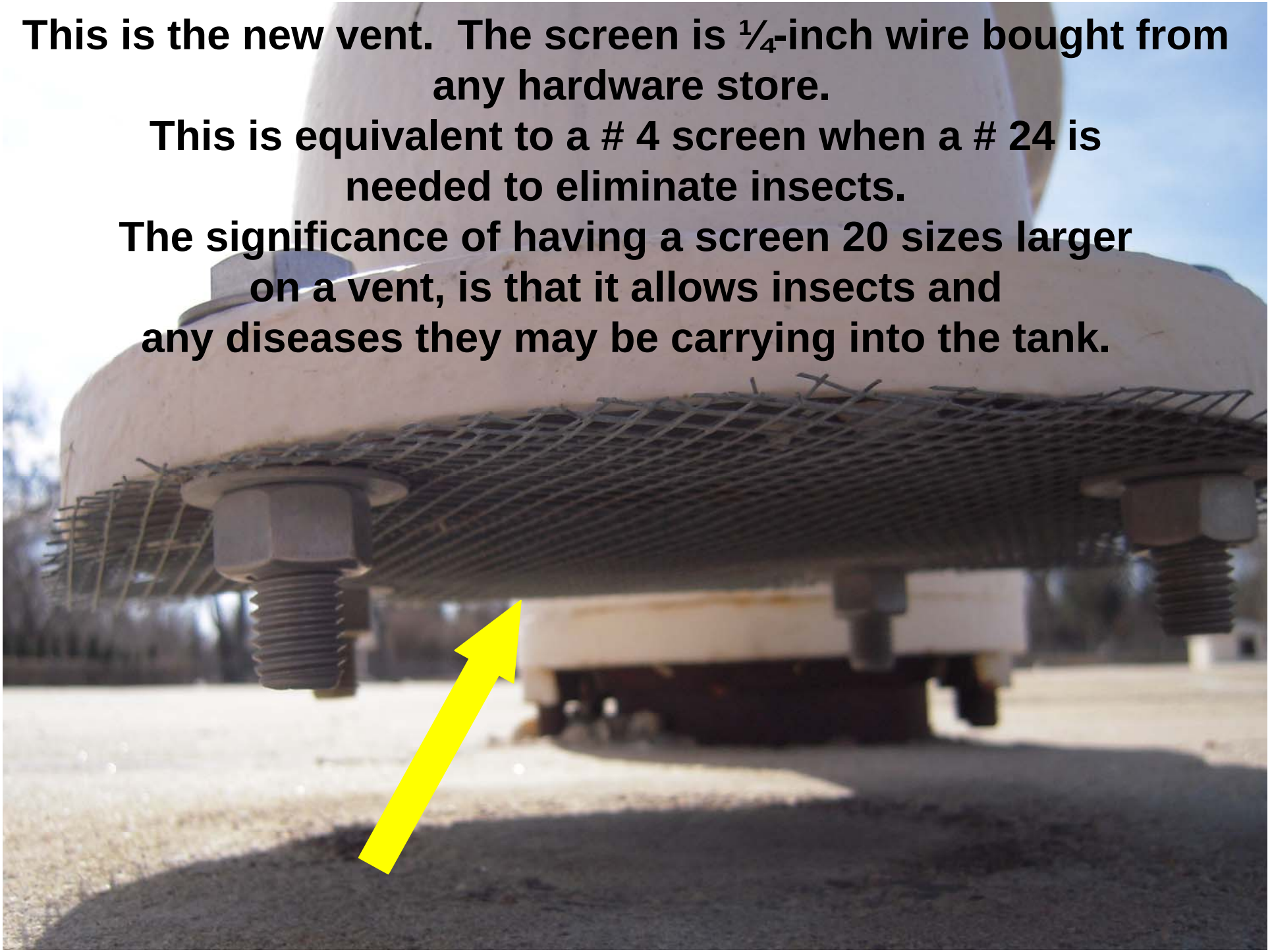
Distilling this information down, what would be the very best practices for the configuration & height above the roof for vents on both ground & elevated tanks to protect against inhalation of bird feces, windblown dust and protect against rain and surface water?

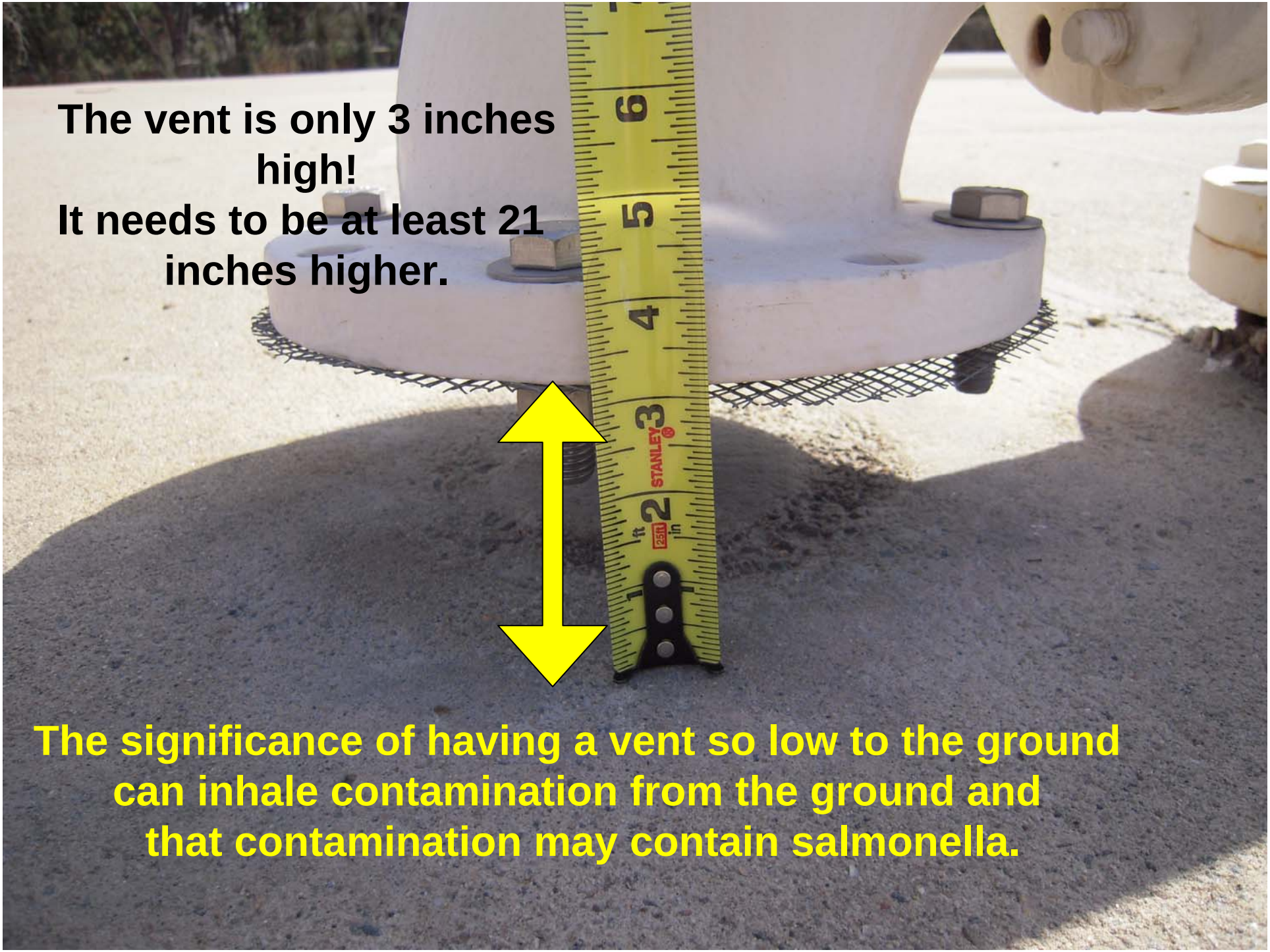
Configuration: Inverted U or cover to exclude rain and windblown debris.

Height above roof: At least 24 inches or 3 pipe diameters, whichever is greater.

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



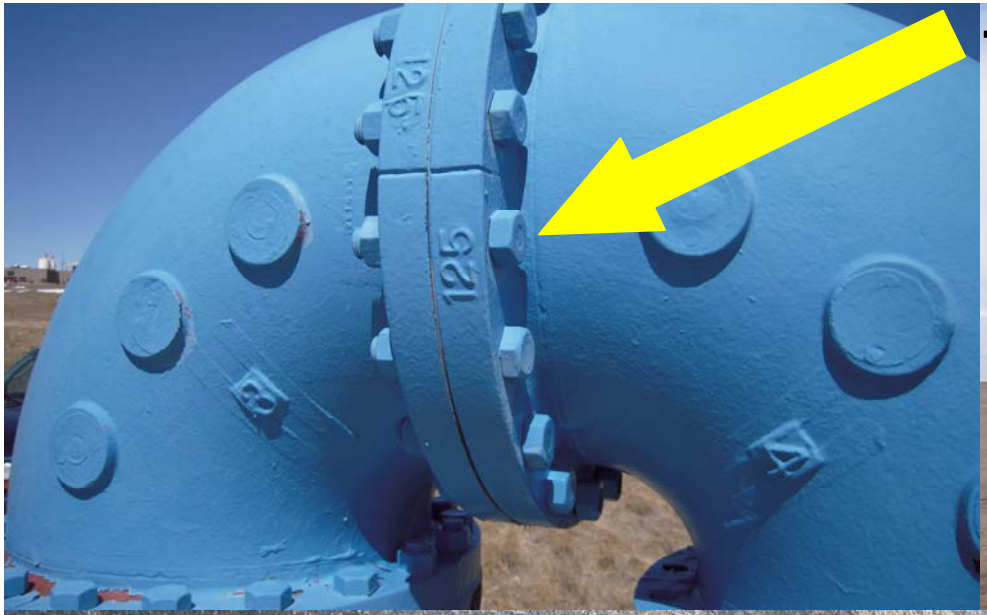

This is the new vent. The screen is ¼-inch wire bought from any hardware store.
This is equivalent to a # 4 screen when a # 24 is needed to eliminate insects.
The significance of having a screen 20 sizes larger on a vent, is that it allows insects and any diseases they may be carrying into the tank.


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 can inhale contamination from the ground and that contamination may contain salmonella.
STANLEY

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

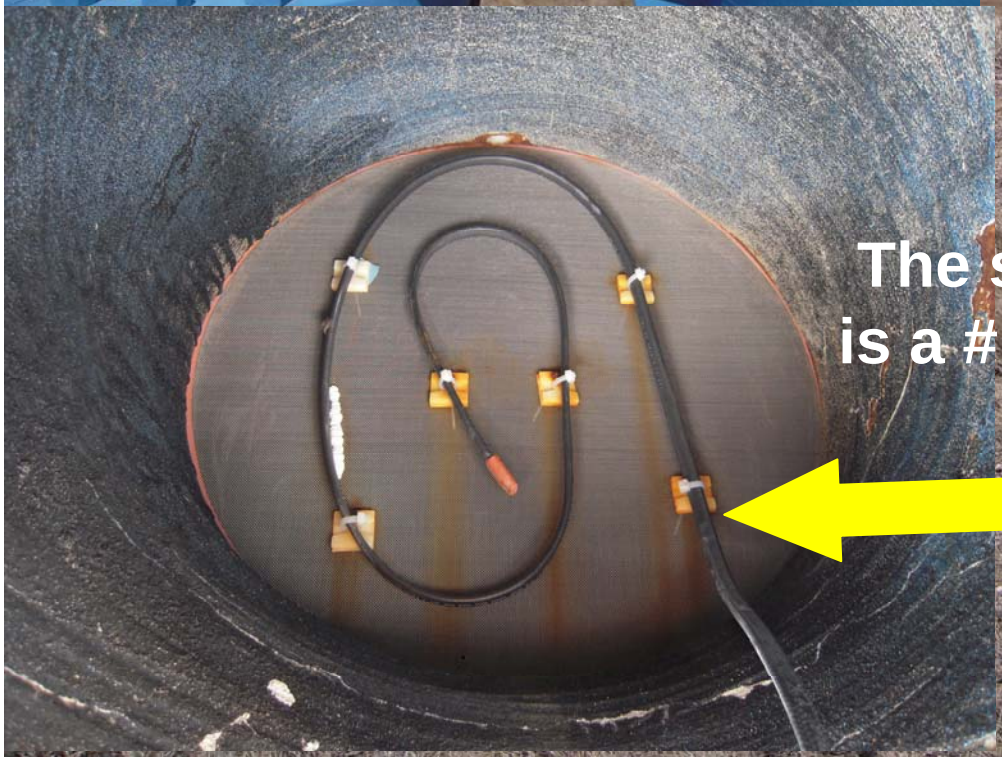
This is the other roof vent that was moved from the side to top. Clearly, no recommending guidance was followed and no survey corrected it.

This screen was welded to the pipe. That's slightly better, but only a # 4 screen was used, freely allowing insects in.



The screen is well within the pipe

Is this a perfect example of a vent screen?



The screen can be inspected and is a # 24 mesh (with a heating coil to prevent ice buildup)

The height can easily be fixed by adding a pipe extension here
What about the height?
The 24 inches would not be measured from the ground but rather the closest platform to an inhalation hazard where bird and animal excrement may be inhaled.

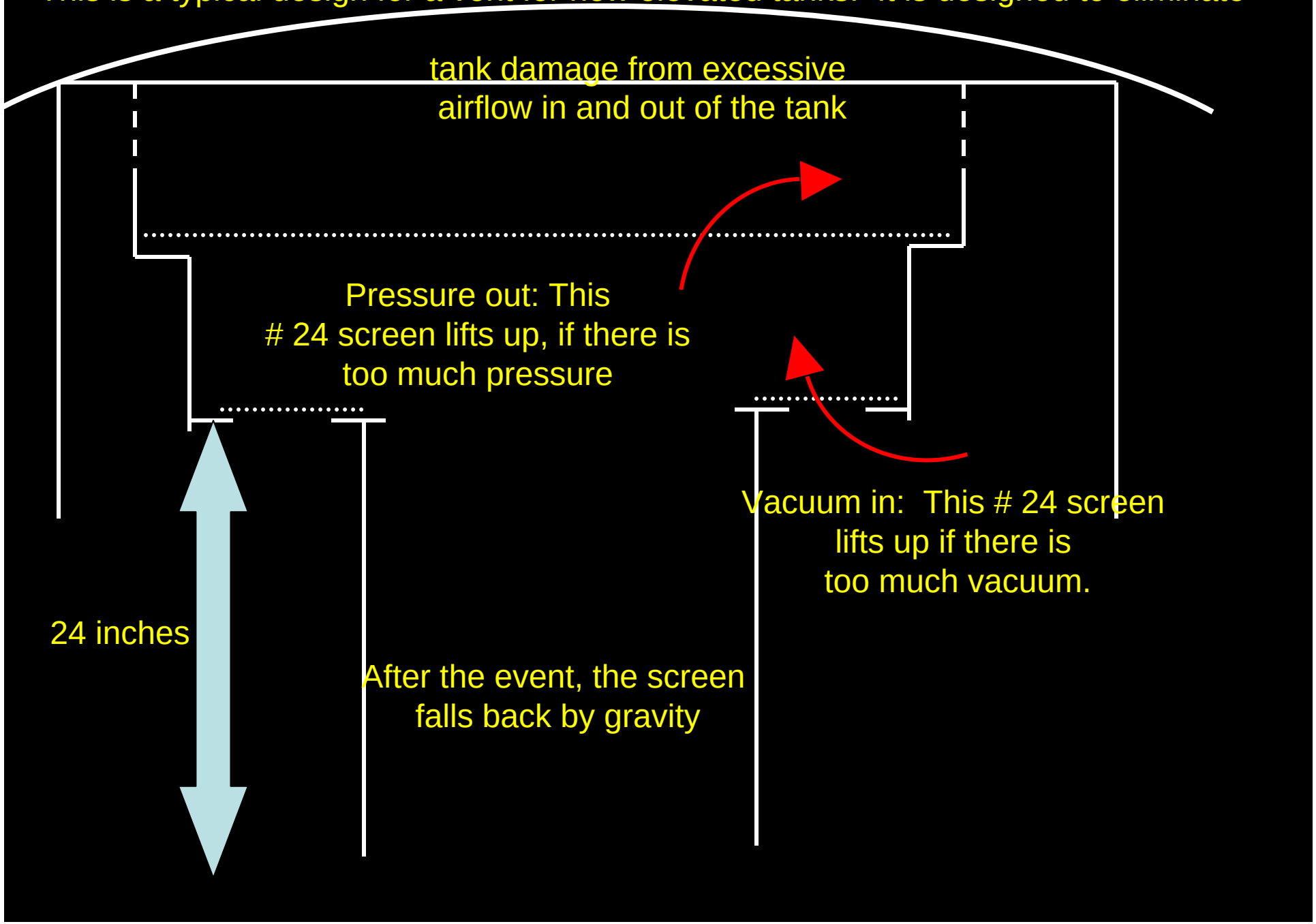
Elevated tanks may have blinking lights on top so planes don't fly into them. The lights can attract a high concentration of flying insects around a vent that is inadequate to prevent them from entering.

This vent is not down turned or covered sufficiently to protect against windblown dust rain, snow, or sunlight.

The significance of having a # 4 screen or less on any tank is that it can allow a high concentration of flying insects into the tank and finished water-in this case, thousands of wasps

With permission from Clyde Zelch, President, Tomcat Consultants.

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



It is ridiculous to think that elevated tanks cannot have the same level of protection from insects as ground-level tanks. Proprietary designs like this can be designed with a # 24 screen, designed to prevent freezing and designed to have vacuum/pressure relief to protect against tank damage.

What about the vent in our example?

Overflows

What do our recommending manuals and sanitary surveys say about the screens for overflows on ground-level tanks?

Comparison of recommendations on screens for overflows for ground-level tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) # 24 non-corrodible screen -(Shall) be installed within pipe -(Shall) if flapper valve is used screen within pipe	-(Shall) non-corrodible screen -Size of screen ~not specified~ -(Shall) be installed within pipe	-(Should) removable # 24 non-corrodible screen to prevent entrance of birds rodents, insects and contaminating materials

Region 8's Sanitary Survey Form for Wyoming
-# 24 non-corrodible screen? -installed within pipe? -flapper valve and screen?

All say a screen is needed. 2 say a # 24 screen is needed, 1 refers to a removable # 24 screen and 1 gives no screen size

3 out of 4 say the screen needs to be installed inside the pipe

2 out of 4 say if a flapper valve is used it also needs a screen inside the pipe-presumably a # 24 mesh.

Comparison of recommendations on screens for overflows for ground-level tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-(Shall) # 24 non-corrodible screen -(Shall) be installed within pipe -(Shall) if flapper valve is used screen within pipe	-(Should) removable # 24 non-corrodible screen to prevent entrance of birds rodents, insects, and contaminating materials	-Screened? -Size of screen ~not specified~

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	SD, ND & MN's SS say a screen is needed. Only MN's says # 24 mesh and installed within the pipe. ND and MN's SS refer to a flapper, but only MN's refers to flapper and screen
-Screened or weighted flap? (not both) -Size of screen ~not specified~	-(Shall) # 24 non-corrodible screen -(Shall) be installed within pipe -(Shall) if flapper valve is used screen within pipe	

What do our recommending manuals and sanitary surveys say about screens for overflows on elevated tanks?

Comparison of recommendations on screens for overflows for elevated tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) #4 non-corrodible screen -(Shall) be installed within pipe -(Shall) if flapper valve is used screen within pipe	-No mention of any size screen for elevated tanks	-(Should) removable # 24 non-corrodible screen to prevent entrance of birds rodents, insects and contaminating materials

Region 8's Sanitary Survey Form for Wyoming
-# 24 non-corrodible Screen?
-installed within pipe?
-flapper valve and screen?

2 out of 4 say a # 24 mesh is needed. 1 refers to a # 4 screen, and 1 has no mention of any size screen

2 out of 4 say the screen needs to be installed inside the pipe

2 out of 4 say if a flapper valve is used it also needs a screen inside the pipe-presumably a # 24 mesh.

Comparison of recommendations on screens for overflows for elevated tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-(Shall) #4 non-corrodible screen -(Shall) be installed within pipe -(Shall) if flapper valve is used screen within pipe	-(Should) removable # 24 non-corrodible screen to prevent entrance of birds rodents, insects, and contaminating materials	-Screened? -Size of screen ~not specified~

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	SD, ND & MN's SS's says a screen is needed. MN's says # 4 mesh and installed within the pipe. ND and MN's SS refer to a flapper, but only MN's refers to flapper and screen
-Screened or weighted flap? (not both) -Size of screen ~not specified~	-(Shall) #4 non-corrodible screen -(Shall) be installed within pipe -(Shall) if flapper valve is used screen within pipe	

Overflows

Distilling this information down, what would be the very best practices for screens for overflows on both ground & elevated tanks down to the size of insects?

Screen size: # 24 non-corrodible screen
(with telemetry for high level and/or overflow alarm)
Location of screen: Installed within the pipe.
Flapper valve: If used, a # 24 non-corrodible screen needs to be installed inside the pipe

Overflows

What do our recommending manuals and sanitary surveys say about the configuration & height above the ground for overflows on ground and elevated tanks?

Comparison of recommendations on configuration and height of overflows for ground & elevated tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) no direct connection to a sewer or storm drain	-(Shall) no direct connection to a sewer or storm drain	-(Shall) no direct connection to a sewer or storm drain
-(Shall) terminate 12 and 24 inches above the ground	-(Shall) terminate 12 and 24 inches above the ground	-(Should) terminate 12 and 24 inches above the ground
-(Shall) open downward and onto a splash plate -(Shall) discharge visible	-(Shall) open downward and onto a splash plate -(Shall) discharge visible	-(Should) discharge freely onto a splash plate or designed to prevent erosion

Region 8's Sanitary Survey Form for Wyoming
Piped to sewer or storm drain?
-Downturned?
-Terminate no less than 12 inches but no more than 24 onto a splash plate?

4 out of 4 say the overflow must not be directly connected to a sewer or storm drain.

4 out of 4 say the discharge needs to terminate 12 to 24 inches above a splash. WY's SS says no less than 12 but no more than 24 inches.

3 out of 4 say the discharge needs to be downward or downturned,1 says discharge freely. 2 say discharge needs to be visible.

Comparison of recommendations on configuration and height of overflows for ground & elevated tanks (SD, ND, MN)

SD, ND & MN use 10 State
for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey a Learner's Guide 2003	South Dakota's Sanitary Survey Form
-(Shall) no direct connection to a sewer or storm drain -(Shall) terminate 12 and 24 inches above the ground -(Shall) open downward and onto a splash plate -(Shall) discharge visible	-(Shall) no direct connection to a sewer or storm drain -(Should) terminate 12 and 24 inches above the ground -(Should) discharge freely onto a splash plate or designed to prevent erosion	-Piped between 12 and 24 inches above the ground? -Discharge to a splash plate or drainage inlet that is not connected to a storm or sanitary sewer?

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	
-Piped between 12 and 24 inches above the ground?	-(Shall) no direct connection to a sewer or storm drain -(Shall) terminate 12 and 24 inches above the ground -(Shall) open downward and onto a splash plate -(Shall) discharge visible	SD, ND & MN's SS say it must terminate 12 to 24 inches. SD's SS says no connection to sewer; MN no direct connection. MN says downward and discharge must be visible

Overflows

Distilling this information down, what would be the very best practices for the configuration and height for overflows on both ground & elevated tanks?

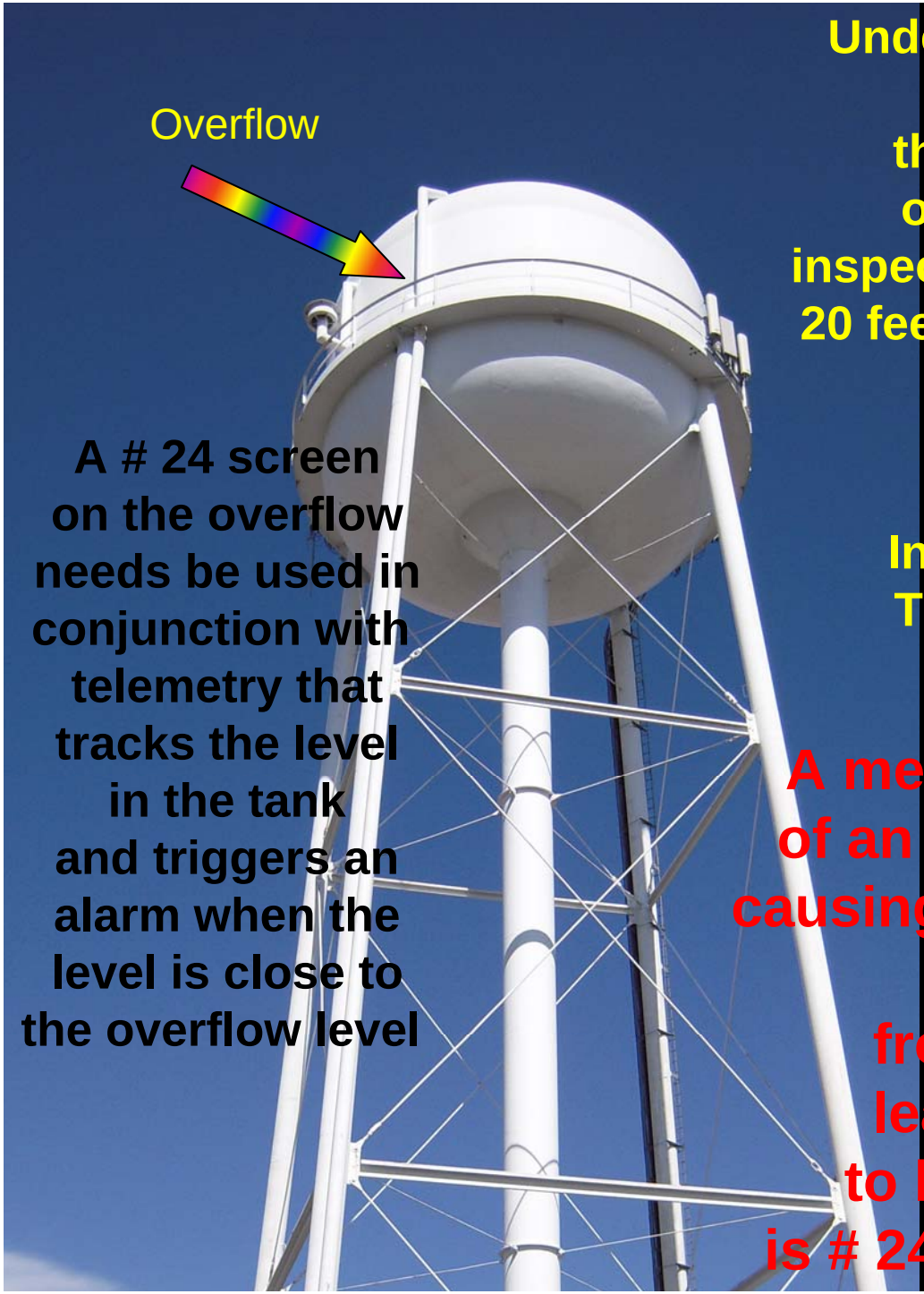
Direct or indirect connection to a sewer or storm drain: Never
Height above splash plate: No less than 12 inches but no more than 24 inches
Configuration: Downward or horizontal with a flapper valve and # 24 screen inside the pipe
Discharge visible: Yes

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 and the overflow clogged.

It was clogged with bloated mice.

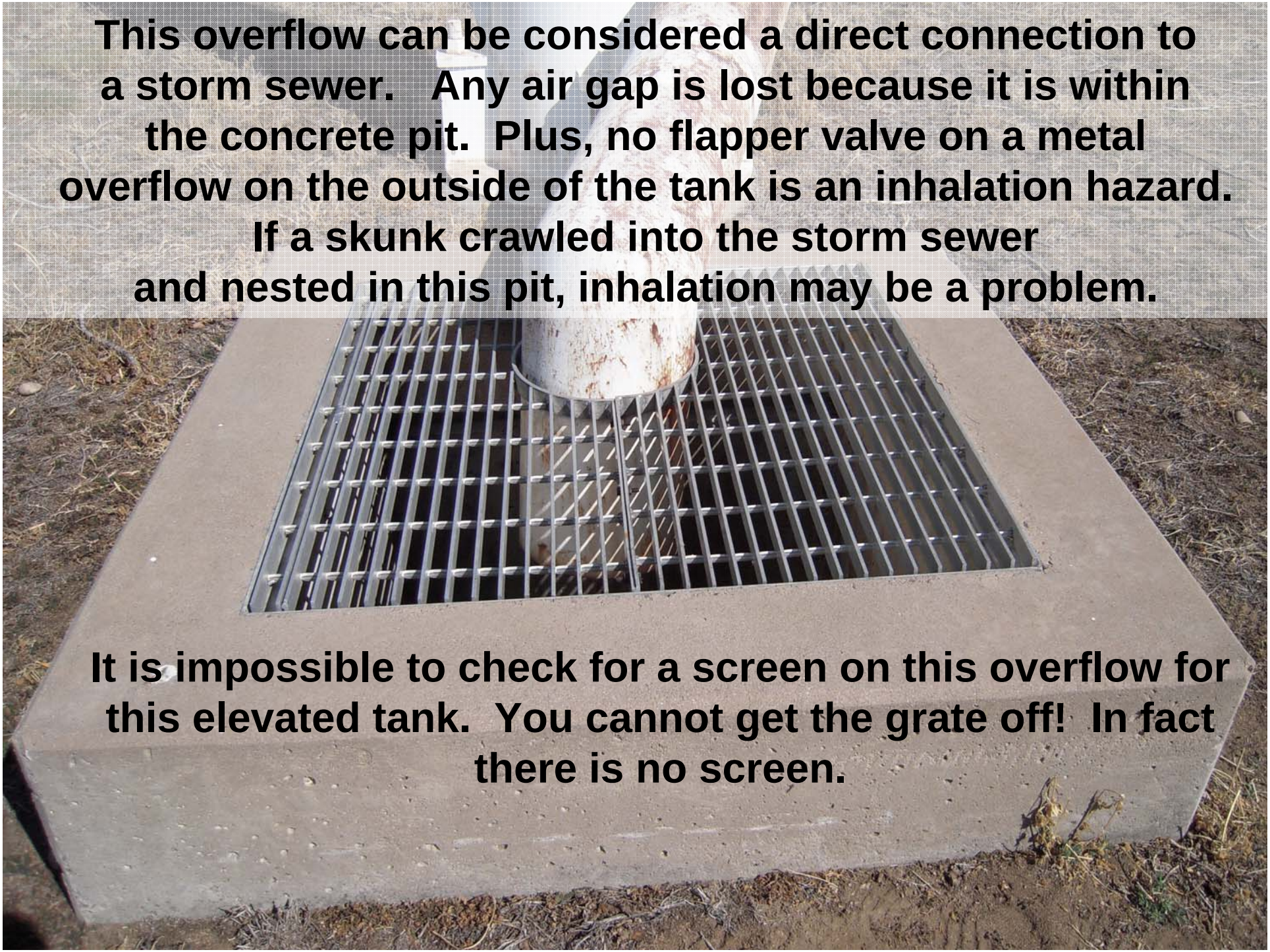


A # 24 screen on the overflow needs be used in conjunction with telemetry that tracks the level in the tank and triggers an alarm when the level is close to the overflow level

Understanding the significance of breaches is frustrated by the lack of understanding of other fields of science. One inspector asked, "can an insect travel 20 feet up an overflow?" in reference to trying to justify the use of a # 4 screen.

Insects are highly migratory. They can travel hundreds of miles.

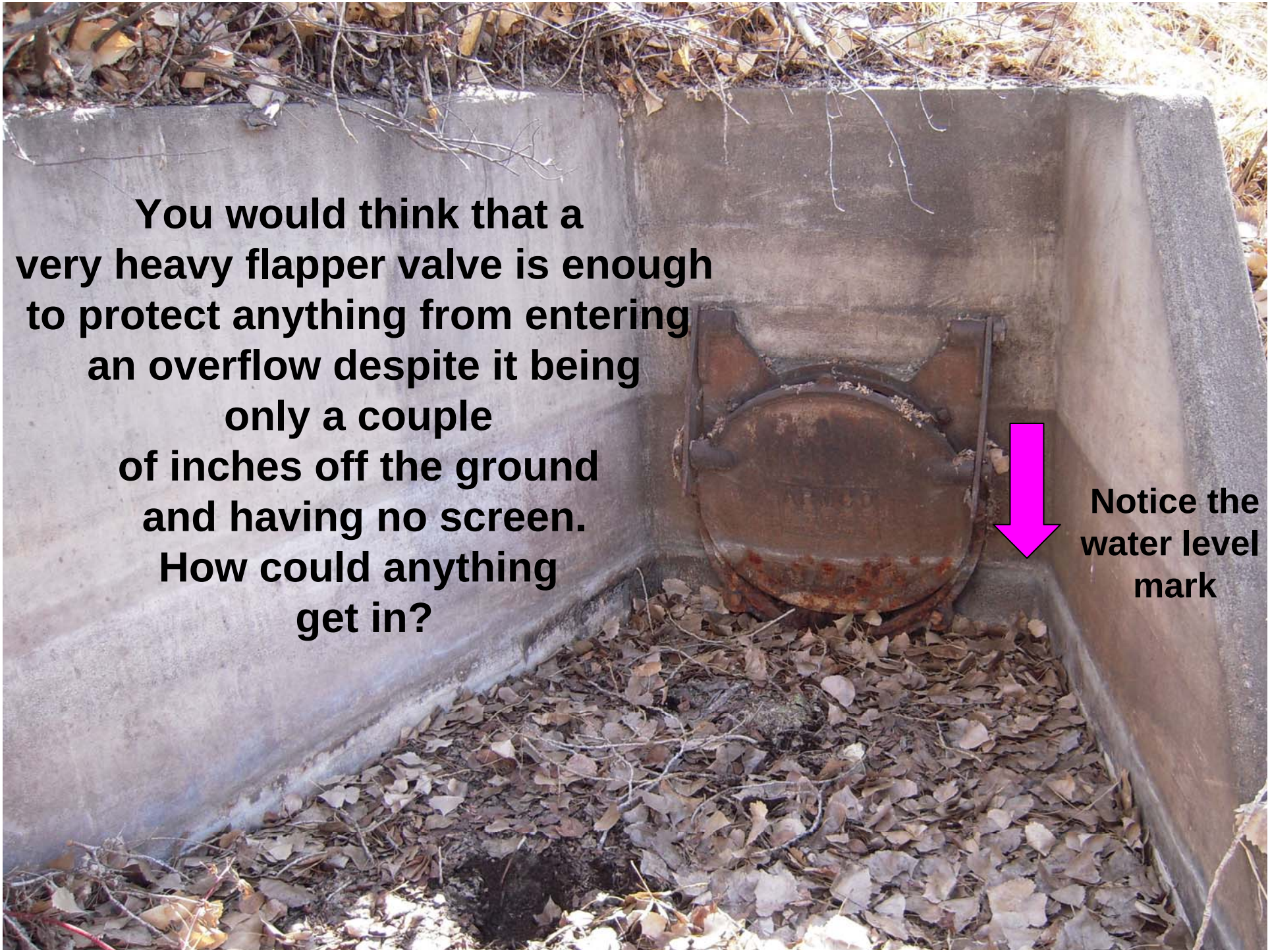
A metal overflow on the outside of an elevated tank can heat up, causing convection currents, which brings up cool air from the ground causing leaves, dust, and insects to be inhaled. Best solution is # 24 screen and a flapper valve.

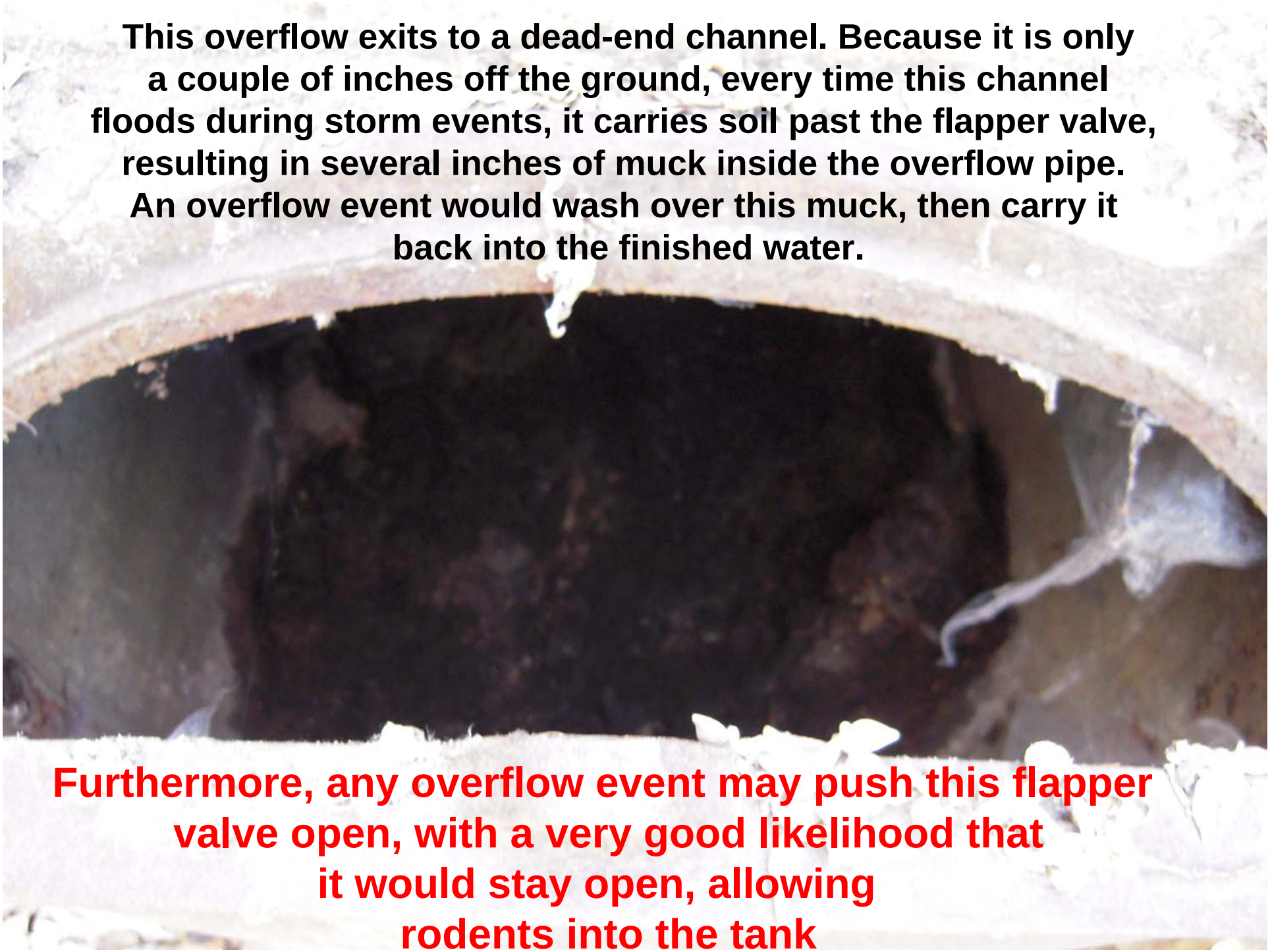

This overflow can be considered a direct connection to a storm sewer. Any air gap is lost because it is within the concrete pit. Plus, no flapper valve on a metal overflow on the outside of the tank is an inhalation hazard. If a skunk crawled into the storm sewer and nested in this pit, inhalation may be a problem.
It is impossible to check for a screen on this overflow for this elevated tank. You cannot get the grate off! In fact there is no screen.

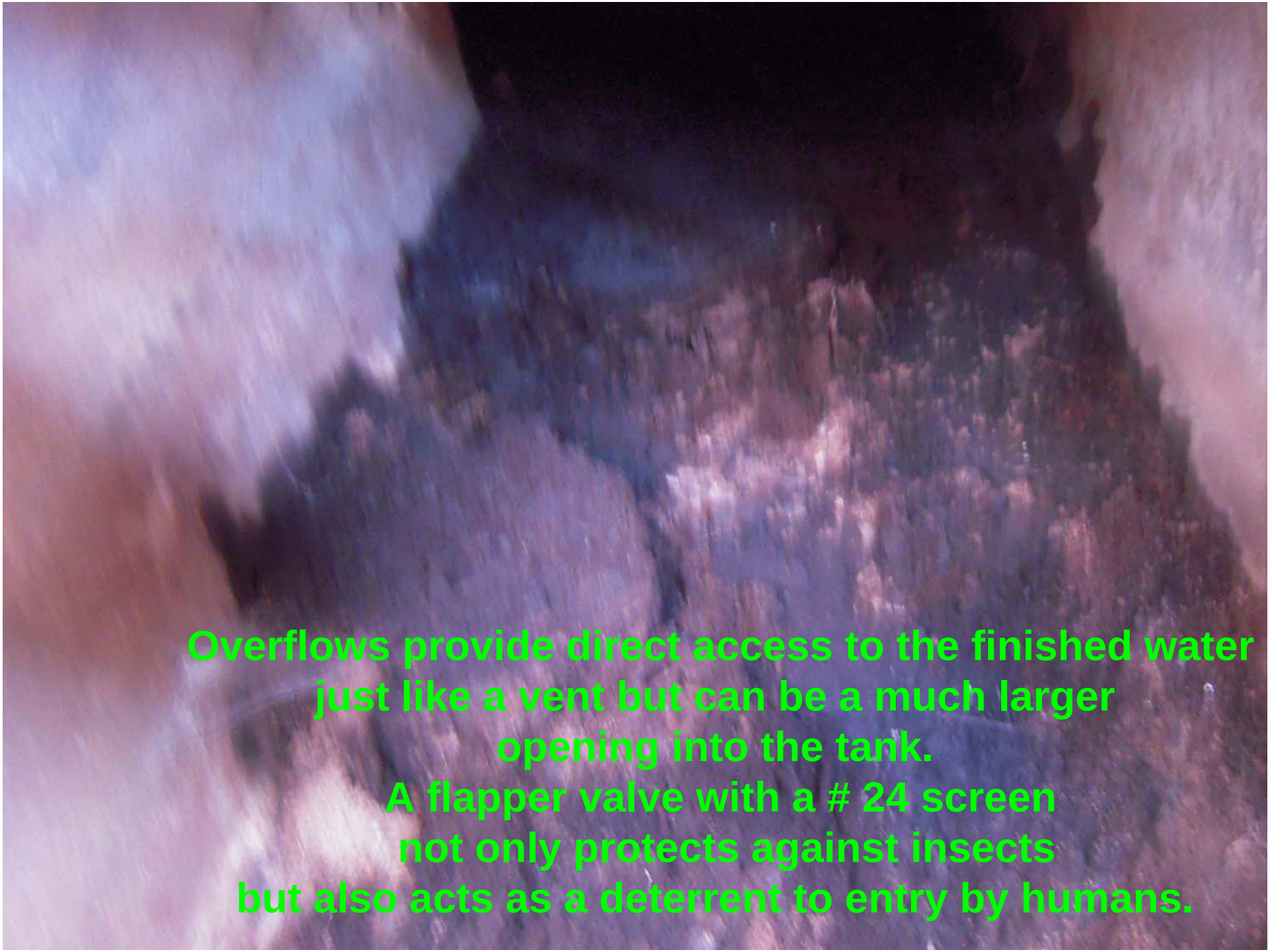
This is a # 24 screen on a drain which was subject to high water flow and it did not blow out. The screen can also be supported by a metal grate.

Another misconception: "What's the use of putting a # 24 screen on an overflow? It will just be blown off when the tank overflows." First, if your tank overflows, all sorts of alarms should be going off. If not, there is a very serious operational flaw with your system.

Fact is, overflows on tanks should be very rare.


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 mark


This overflow exits to a dead-end channel. Because it is only a couple of inches off the ground, every time this channel floods during storm events, it carries soil past the flapper valve, resulting in several inches of muck inside the overflow pipe. An overflow event would wash over this muck, then carry it back into the finished water.
Furthermore, any overflow event may push this flapper valve open, with a very good likelihood that it would stay open, allowing rodents into 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.

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

Finally, a flapper valve with a # 24 screen. However, the screen is damaged. This would be caught if weekly inspections were performed as recommended.

The significance of an overflow not being 12 to 24 inches above the ground and having a damaged screen is that it makes it easy for rodents to climb up, fall in and drown in the water.

A mouse can fit into the opening of a plastic soda bottle ~ ½ inch.

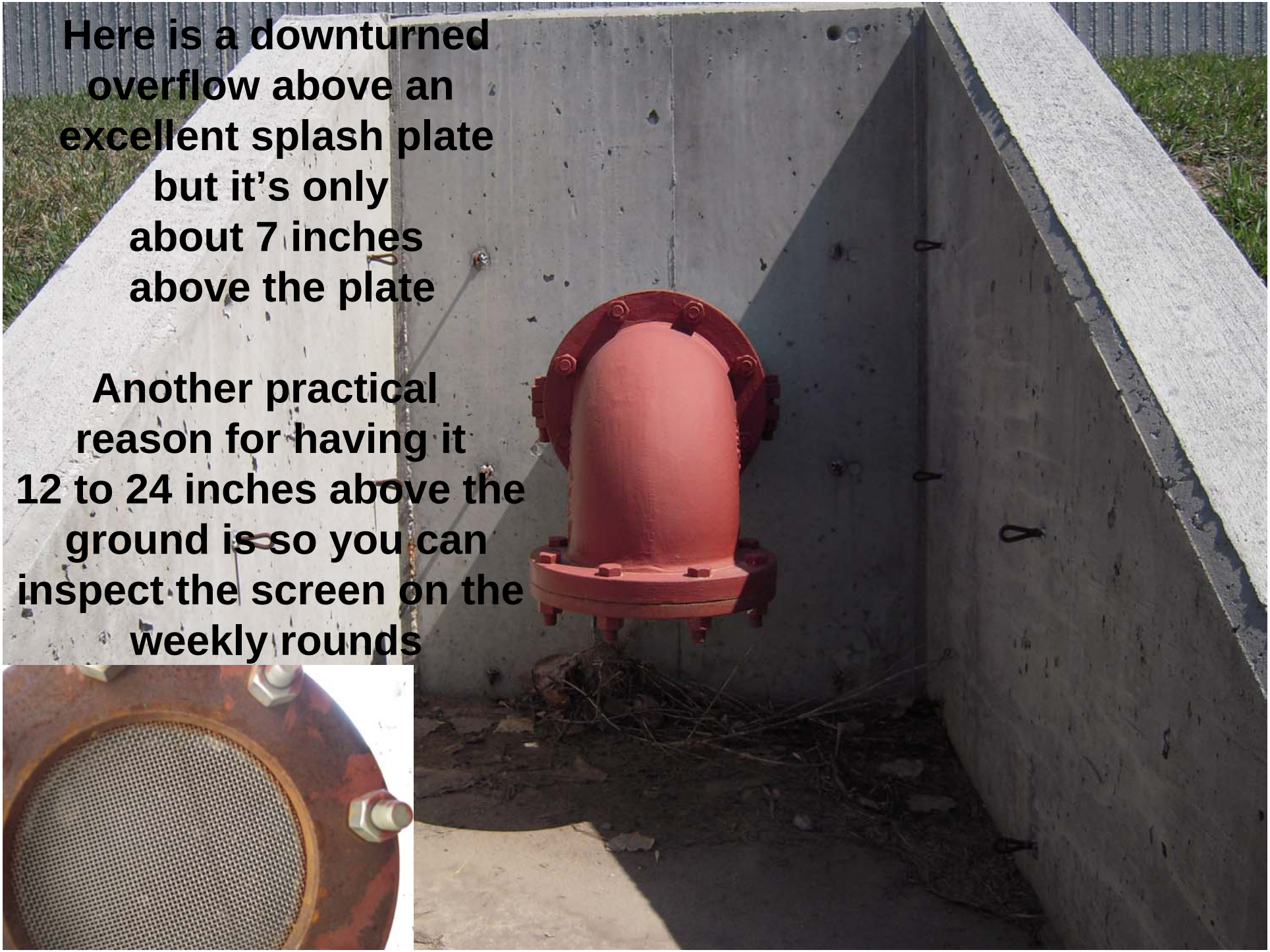
The significance of no screen at all on an overflow of an elevated tank is that it will allow birds to enter the tank.

With permission from Clyde Zelch, President, Tomcat Consultants.

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 when they begin to decay are a source of fecal coliform. This would not be found unless the tank was drained and cleaned.

The only logical response to any breach large enough to allow an animal to enter the tank is immediate draining and cleaning of the tank, along with repair of the breach.

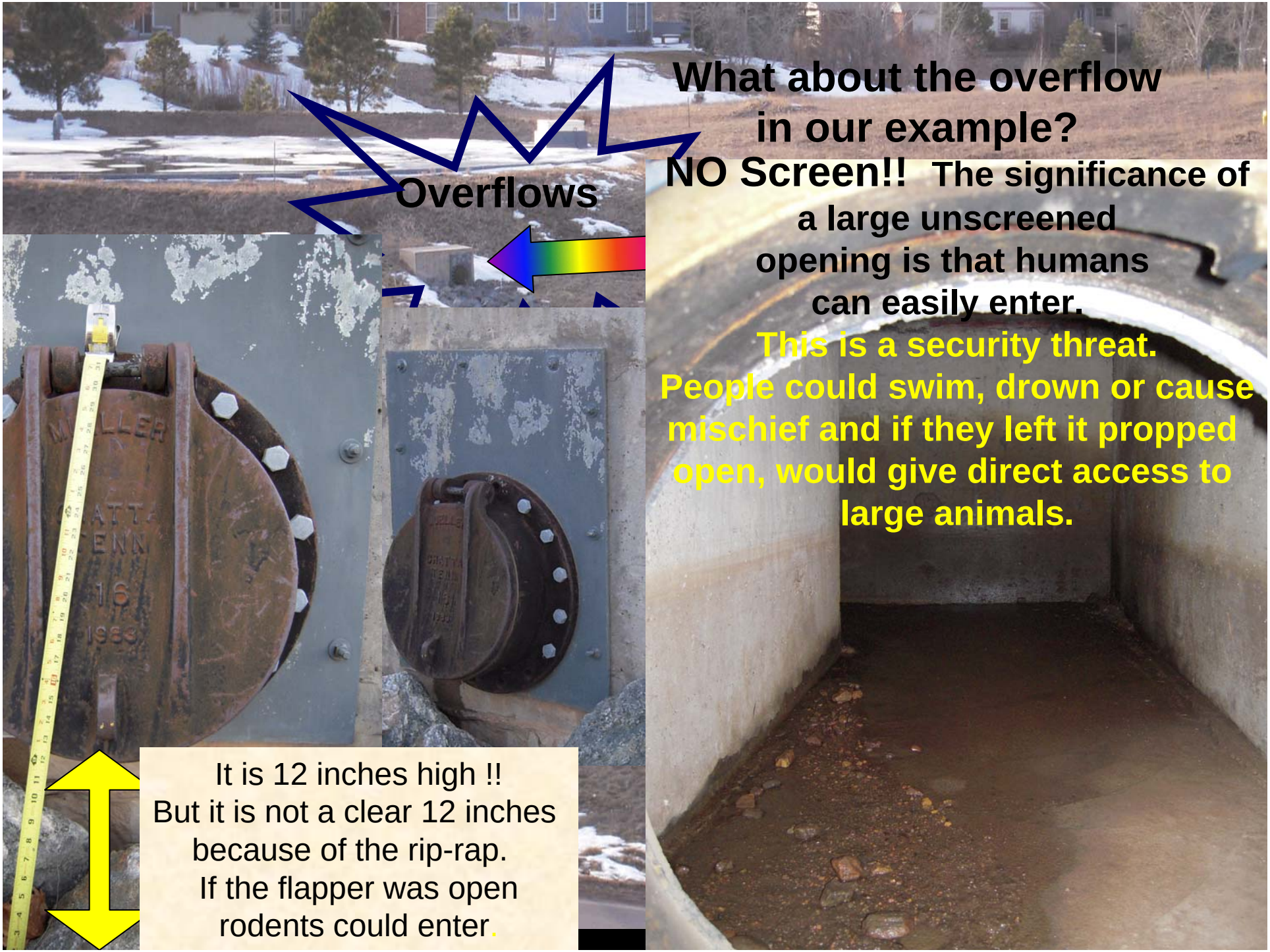
With permission from Clyde Zelch,
President, Tomcat Consultants.



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 weekly rounds

Overflows



What about the overflow in our example?

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

What do our recommending manuals
and sanitary surveys say about
the screens and the configuration & height
above the ground
for drains on
ground and elevated tanks?
Drains

Comparison of recommendations on screens & configuration on drains for elevated and ground-level tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) no direct connection to a sewer or storm drain -Screen and configuration ~not specified~ -(Shall) drain w/o losing pressure	-(Shall) no direct connection to a sewer or storm drain but if drained to them (shall) have air gap of 3 pipe diameters -Screen and configuration ~not specified~	-(Should) terminate 12 and 24 inches above the ground -(Should) discharge freely onto a splash plate or designed to prevent erosion -Screen ~not specified~

Region 8's Sanitary Survey Form for Wyoming
-Piped directly to sewer or storm drain? Storm drain 3 pipe diameter, air gap?
-Terminate 12 -24 inches
-# 24 non-corrodible screen? Downturned?

3 out of 4 say the drain must not to be directly connected to a sewer or storm drain. WY DEQ & WY SS say you can connect if there is an air gap of 3 pipe diameters.

2 out of 4 say the discharge needs to terminate 12 to 24 inches above a splash.

Only 1 says # 24 non-corrodible screen is needed and gives the configuration as downturned

Comparison of recommendations on screens & configuration on drains for elevated and ground-level (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey a Learner's Guide 2003	South Dakota's Sanitary Survey Form
(Shall) no direct connection to a sewer or storm drain -Screen and configuration ~not specified~ -(Shall) drain w/o losing pressure	-(Should) terminate 12 and 24 inches above the ground -(Should) discharge freely onto a splash plate or designed to prevent erosion -Screen ~not specified~	-Piped between 12 and 24 inches above the ground? -Discharge to a splash plate or drainage inlet that is not connected to a storm or sanitary sewer? (Shall) screen but not specified

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	
-Tank drain?	-All water storage structures (Shall) no direct connection to a sewer or storm drain -(Shall) terminate 12 and 24 inches above the ground -Discharge to a splash plate -Screen ~not specified~	SD & MN's SS say it needs to terminate at 12 to 24 inches. SD's SS says no connection to sewer; MN no direct connection. None reference screen size.

Distilling this information down, what would be the very best practices for the screen size and configuration and height for drains on both ground & elevated tanks?

Direct connection to sewer or storm drain: Never direct.

Indirect connection to storm drain: At least a 3 pipe diameter air gap

Screen size: Removable # 24 non-corrodible screen

Location of screen: Installed within the pipe.

Height above splash plate: No less than 12 inches but no more than 24 inches

Configuration: Downward or horizontal with a flapper valve and a # 24 non-corrodible screen inside the pipe

Discharge visible: Yes

Drains

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

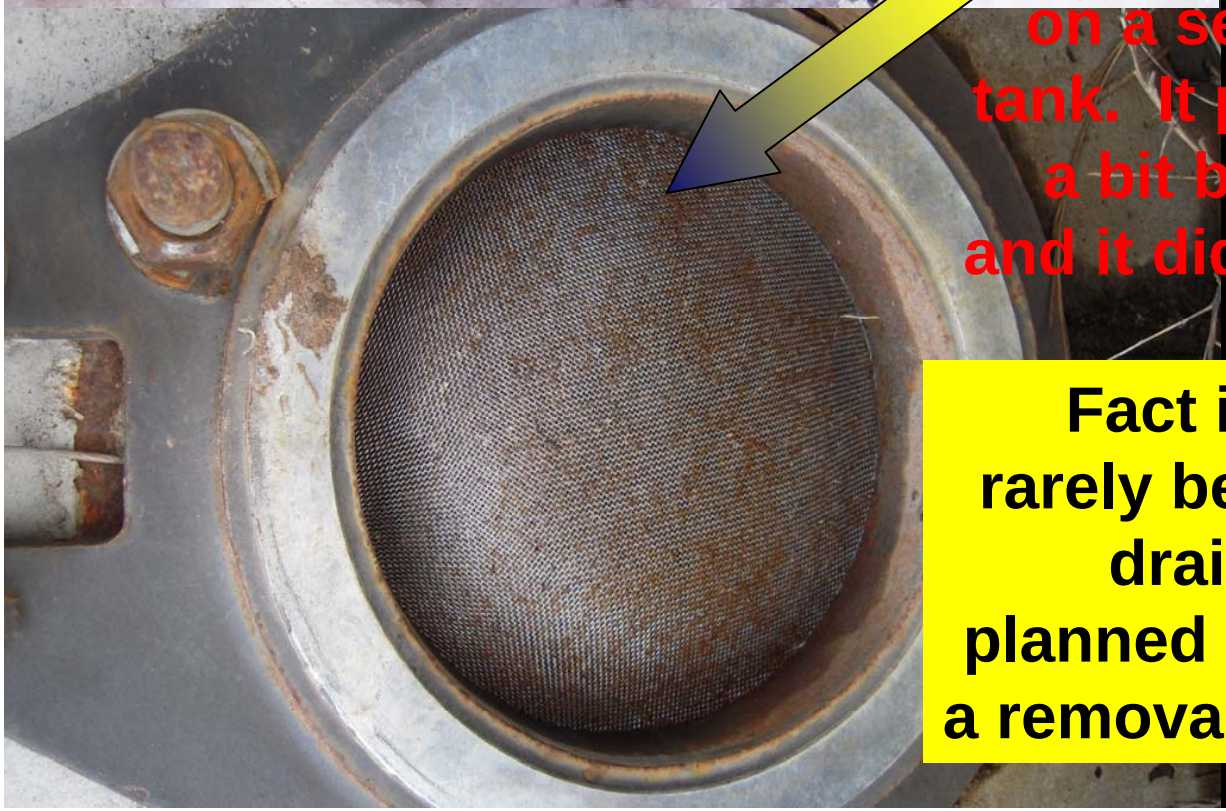
Insects, rodents, animals can't get through a gate valve. So, what's the concern?

Drains

The drain on this tank is directly connected to a storm sewer. Direct connections should never be allowed

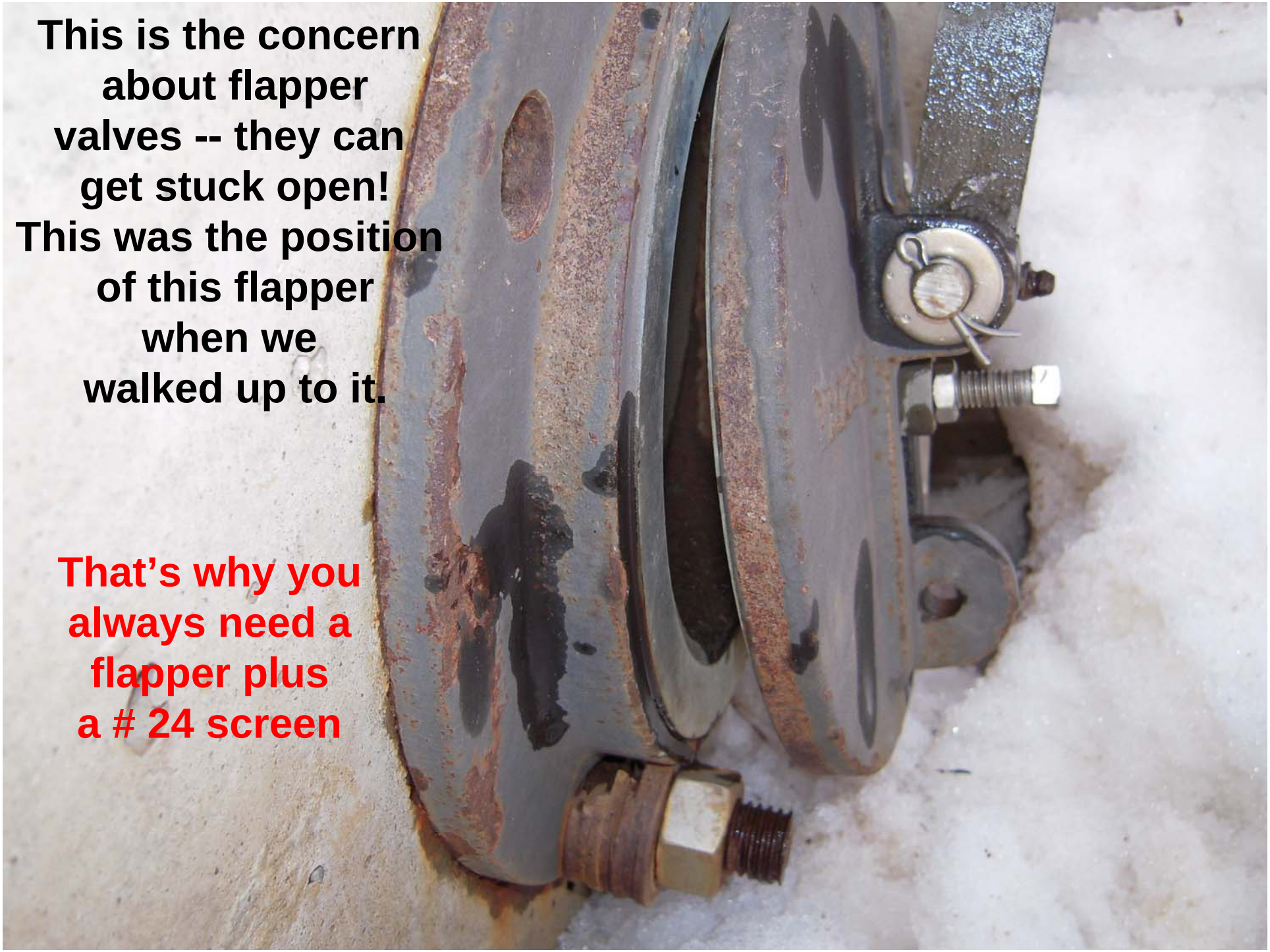
In another example, a land owner complained that occasional draining of his tank was washing a gully through his property. The solution was a direct connection to a storm sewer, violating State regulations that strictly forbid it.

There is concern that you can not use a # 24 screen because you would block the flow of water or knock the screen off



This is a # 24 screen on a several million gallon tank. It pushed the screen out a bit but the water got out and it did not knock the screen off.

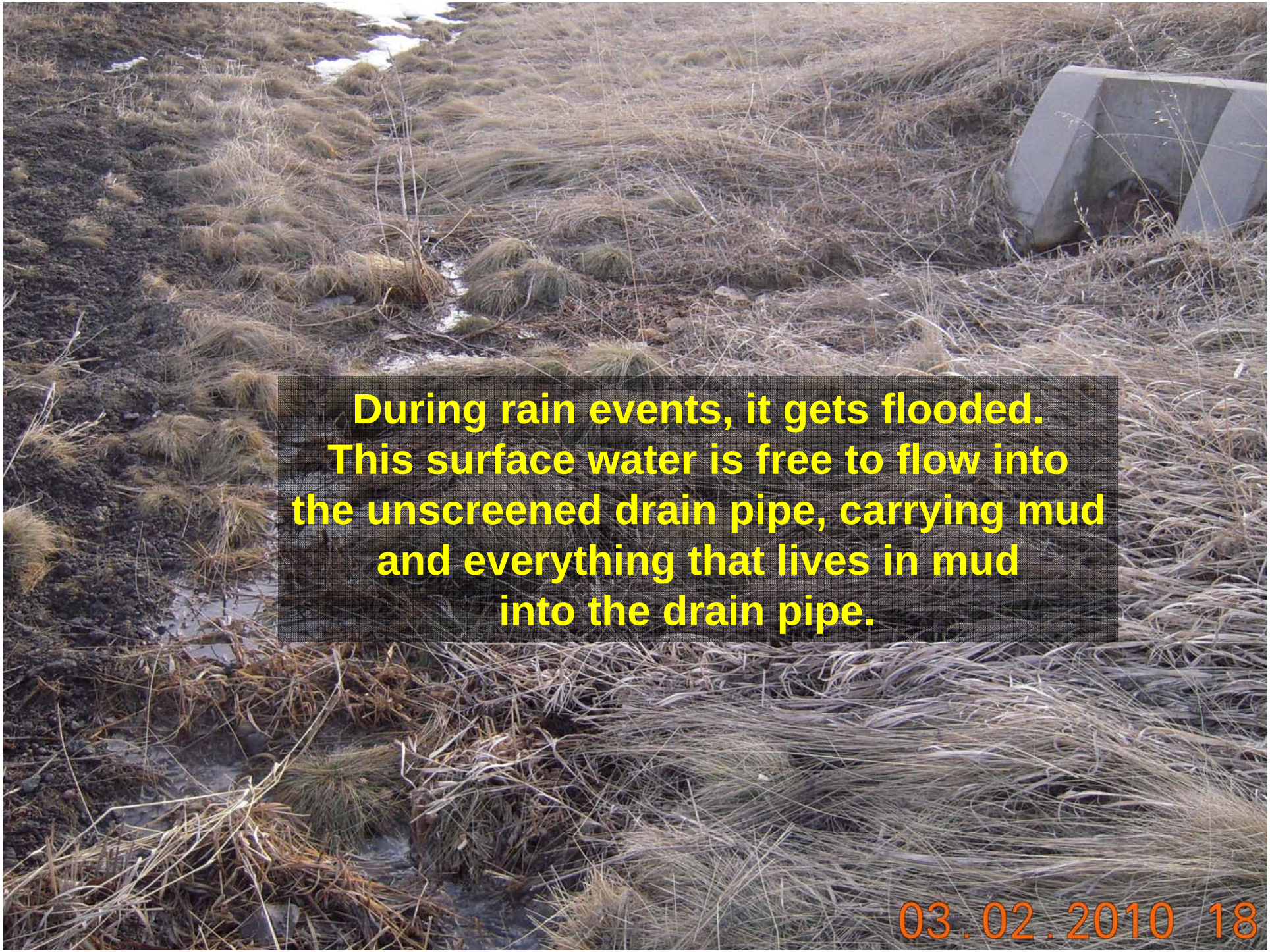
Fact is, water would rarely be gushing out of a drain except in a planned event. That's why a removable screen is used.

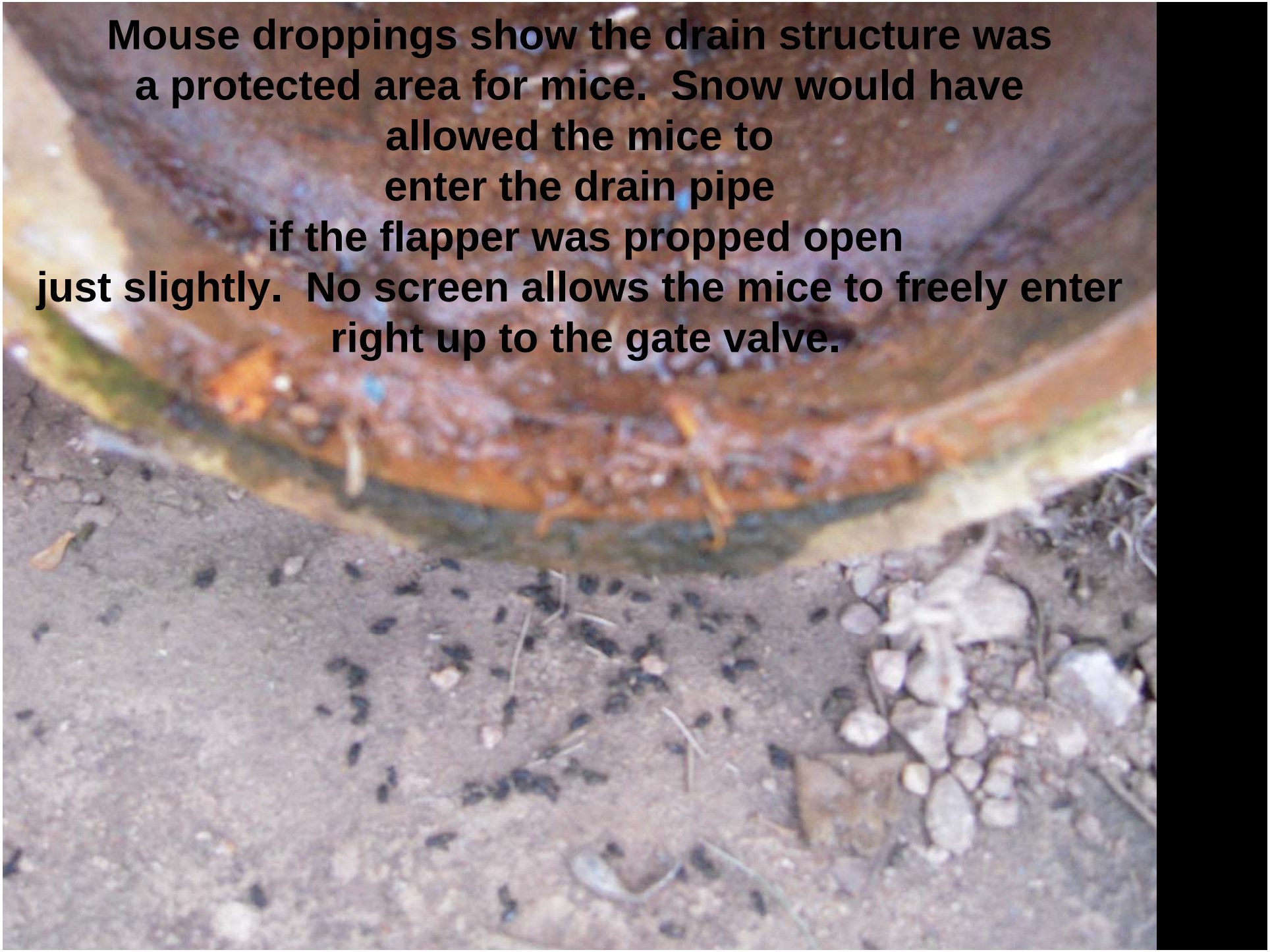

This is the concern about flapper valves -- they can get stuck open! This was the position of this flapper when we walked up to it.
That's why you always need a flapper plus a # 24 screen

Here is a wonderful example
of flapper with a screen inside
the pipe,
but is it # 24 mesh?
If it is there will be 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"

So, what about the drain in our example?
How does it measure up against the best
sanitary criteria?
Drains

It does not meet the minimum of 12 inches above the splash plate. It's short by 8 inches! And there's no screen at all!


During rain events, it gets flooded.
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


Mouse droppings show the drain structure was
a protected area for mice. Snow would have
allowed the mice to
enter the drain pipe
if the flapper was propped open
just slightly. No screen allows the mice to freely enter
right up to the gate valve.

So what if animals get into the drain on which we have a gate valve?
Animals are a vector for disease transmission through bacteria, viruses, and protozoa

Raccoons!
Snakes!
Mice, and let’s not forget that rats
can get into unscreened drain pipes also!

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 and the height above the splash protect animals and insects from carrying this invisible to the naked eye contaminant into the tank

What do our recommending manuals and sanitary surveys say about the configuration & height above the ground for hatches on ground-level and elevated tanks?

Comparison of recommendations on configuration of hatches for ground & elevated tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) elevated at least 24 inches (4 inches for elevated) above the tank top	-(Shall) elevated at least 24 inches (4 inches for elevated) above the tank top	-(Should) elevated at least 4 inches above the tank top
-(Shall) overlap at least a 4 inch framed opening by at least 2	-(Shall) overlap at least a 4 inch framed opening by at least 2	-(Should) overlap by at least 2
inches, solid, water-tight, locked & hinged at one side	inches, solid, water tight, locked & hinged at one side	inches, solid, water-tight, to prevent bird droppings & dust from being inhaled or blown in, locked to prevent people

Region 8's Sanitary Survey Form for Wyoming

-Is the hatch at least 24 inches above roof (4 for elevated tanks)?

-At least a 2-inch overlap?
-Rubber gasket between lid and lip of the hatch?

-Is it tight and locked?

3 out of 4 say the hatch needs to be elevated 24 inches (4 for elevated tanks).

4 out of 4 say the hatch needs to be a shoebox type lid with a 2 inch overlap. 2 say a 4-inch frame. Only 1 refers to a rubber gasket between the lid and the lip of the hatch.

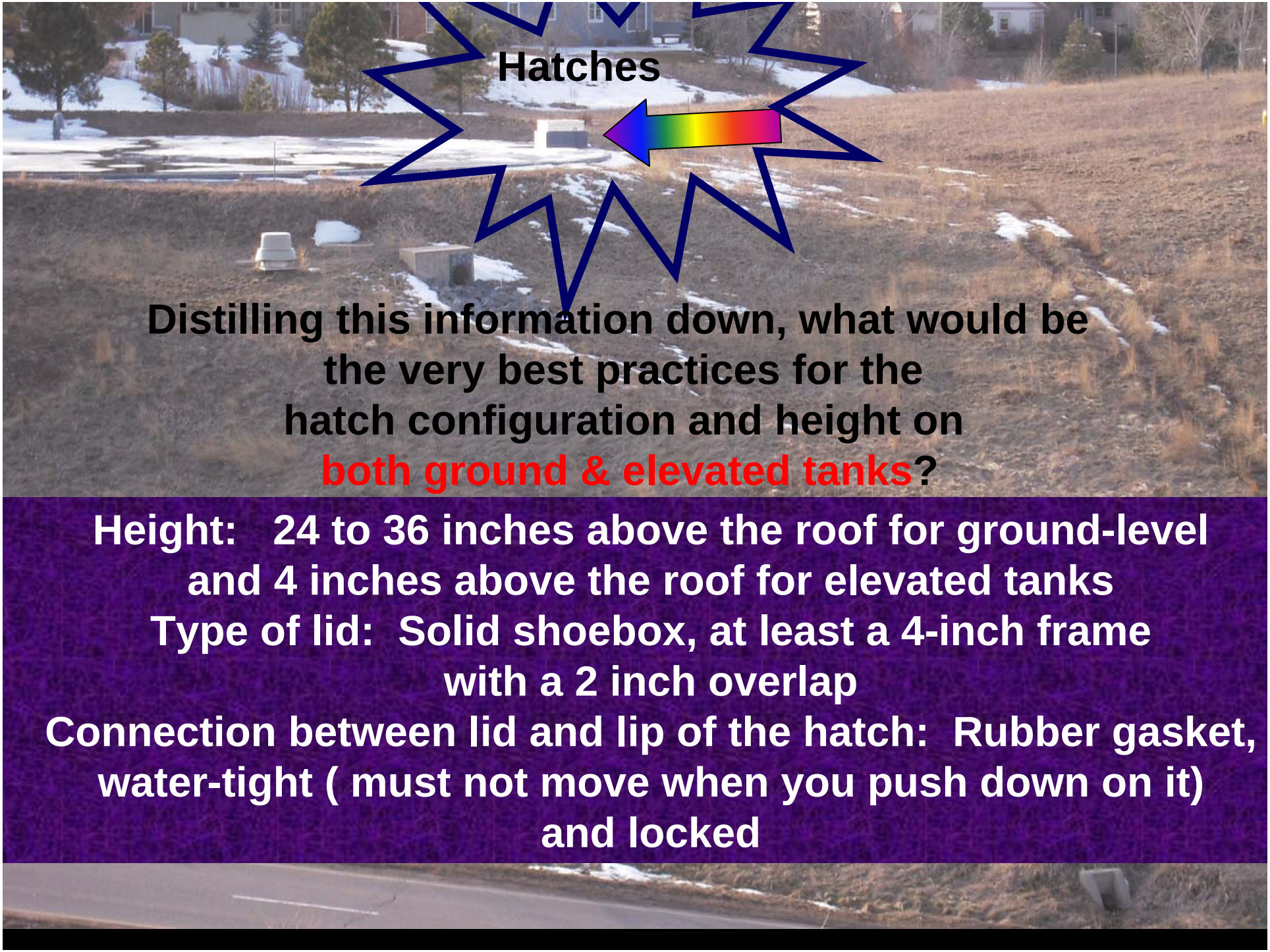
4 out of 4 say the hatch needs to be solid, water-tight, and locked.

Comparison of recommendations on configuration of hatches for ground & elevated tanks (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey a Learner's Guide 2003	South Dakota's Sanitary Survey Form
(Shall) elevated at least 24 inches (4 inches for elevated) above the tank top (Shall) overlap at least a 4-inch framed opening by at least 2 inches, solid, water-tight, locked & hinged at one side	(Should) elevated at least 4 inches above the tank top (Should) overlap by at least 2 inches, solid, water-tight, to prevent bird droppings & dust from being inhaled or blown in, locked to prevent people	Are covers & hatches locked?

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	
Access openings?	(Shall) be elevated at least 24 to 36 inches (4 inches for elevated) above the tank top (shall) overlap at least a 4-inch framed opening by at least 2 inches, solid, water-tight, locked & hinged at one side	Only MN's SS says the hatch needs to be 24 to 36 inches (4 for elevated) above the roof, overlap a 4-inch frame by 2 inches, be solid and water-tight. SD and MN's SS refer to locked hatches.



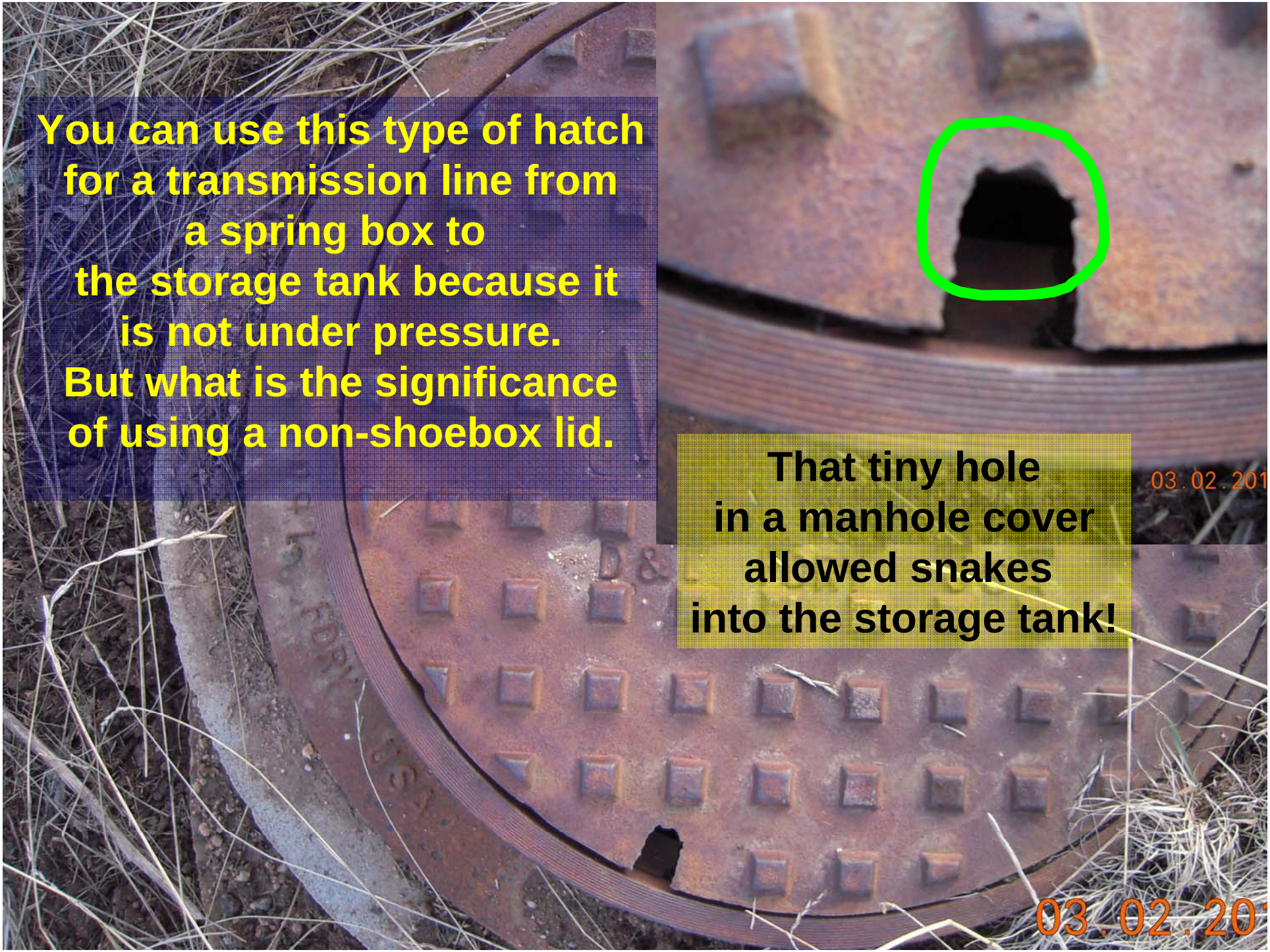
Hatches

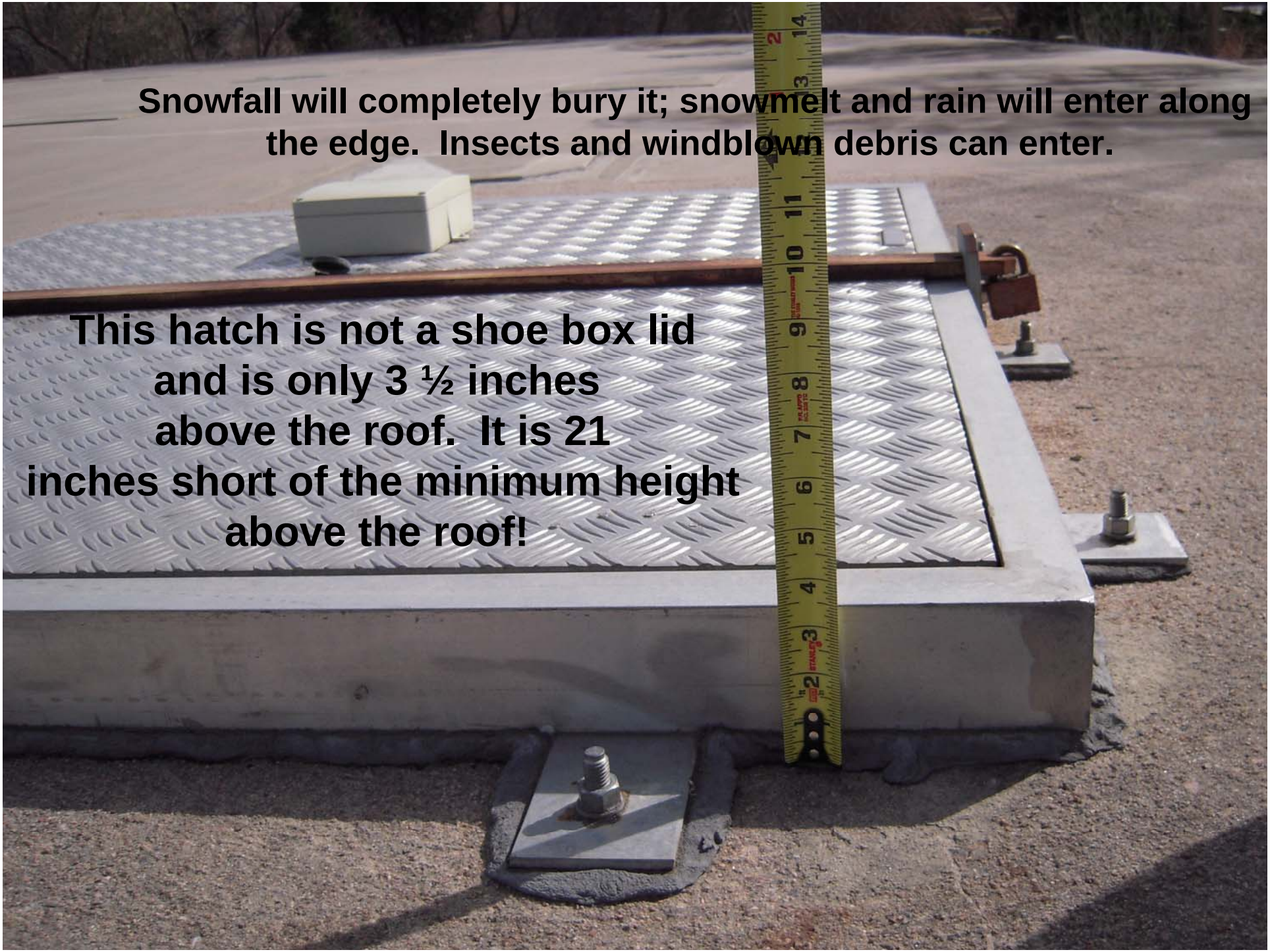
Distilling this information down, what would be the very best practices for the hatch configuration and height on both ground & elevated tanks?

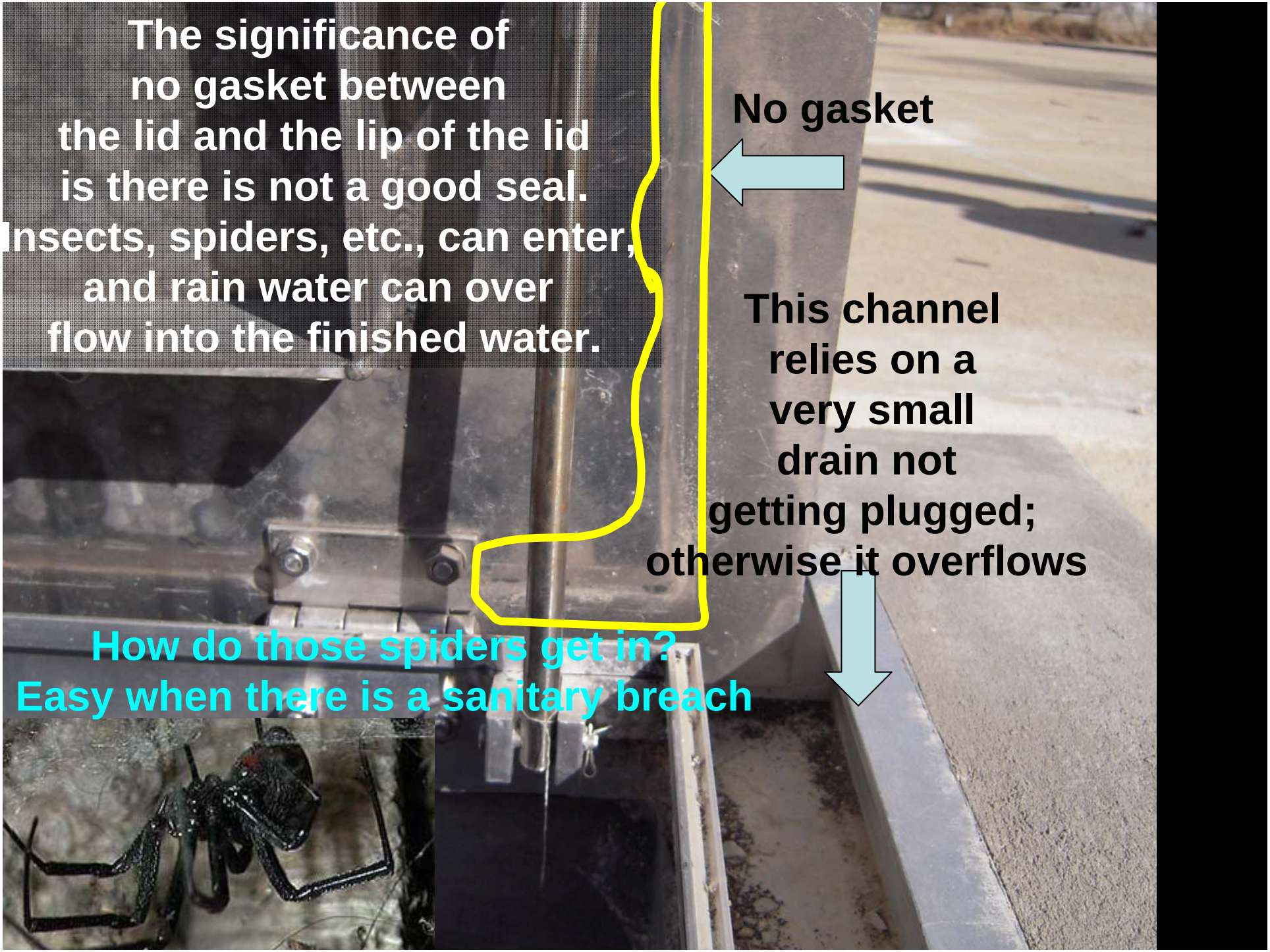
Height: 24 to 36 inches above the roof for ground-level and 4 inches above the roof for elevated tanks

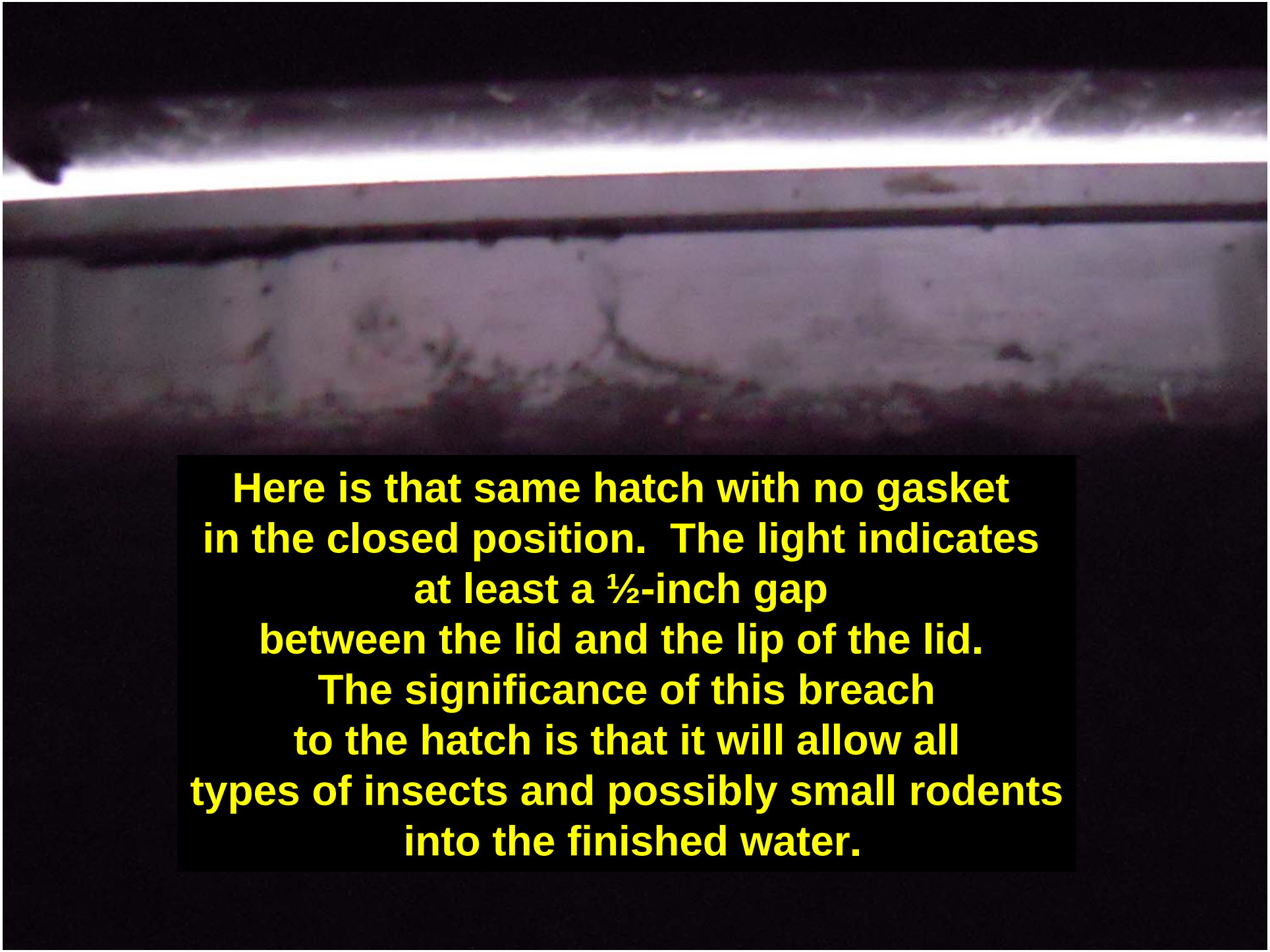
Type of lid: Solid shoebox, at least a 4-inch frame with a 2 inch overlap

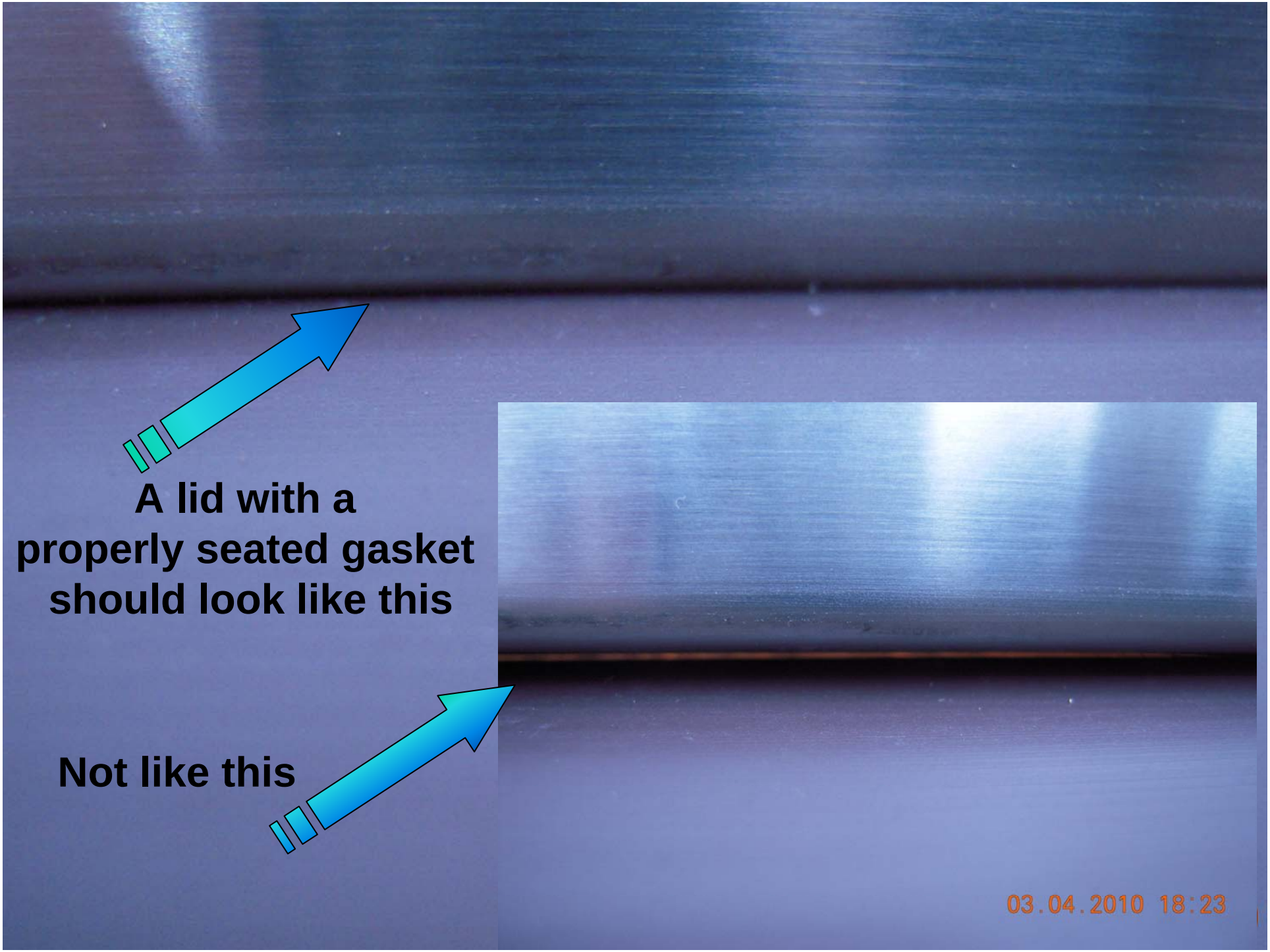
Connection between lid and lip of the hatch: Rubber gasket, water-tight (must not move when you push down on it) and locked


You can use this type of hatch for a transmission line from a spring box to the storage tank because it is not under pressure. But what is the significance of using a non-shoebox lid.
That tiny hole in a manhole cover allowed snakes into the storage tank!
03.02.201
03.02.20

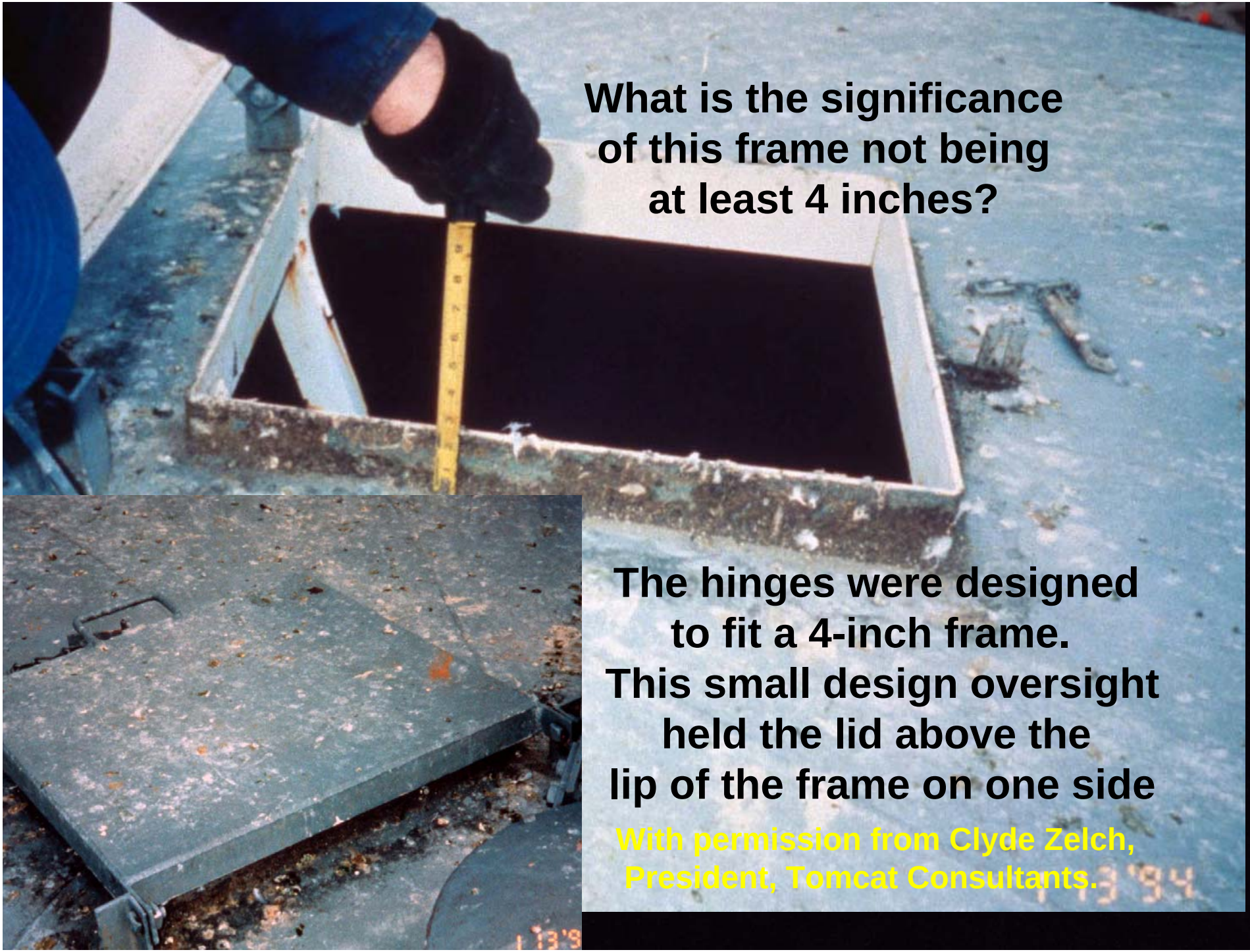

Snowfall will completely bury it; snowmelt and rain will enter along the edge. Insects and windblown debris can enter.
This hatch is not a shoe box lid and is only 3 ½ inches above the roof. It is 21 inches short of the minimum height above the roof!

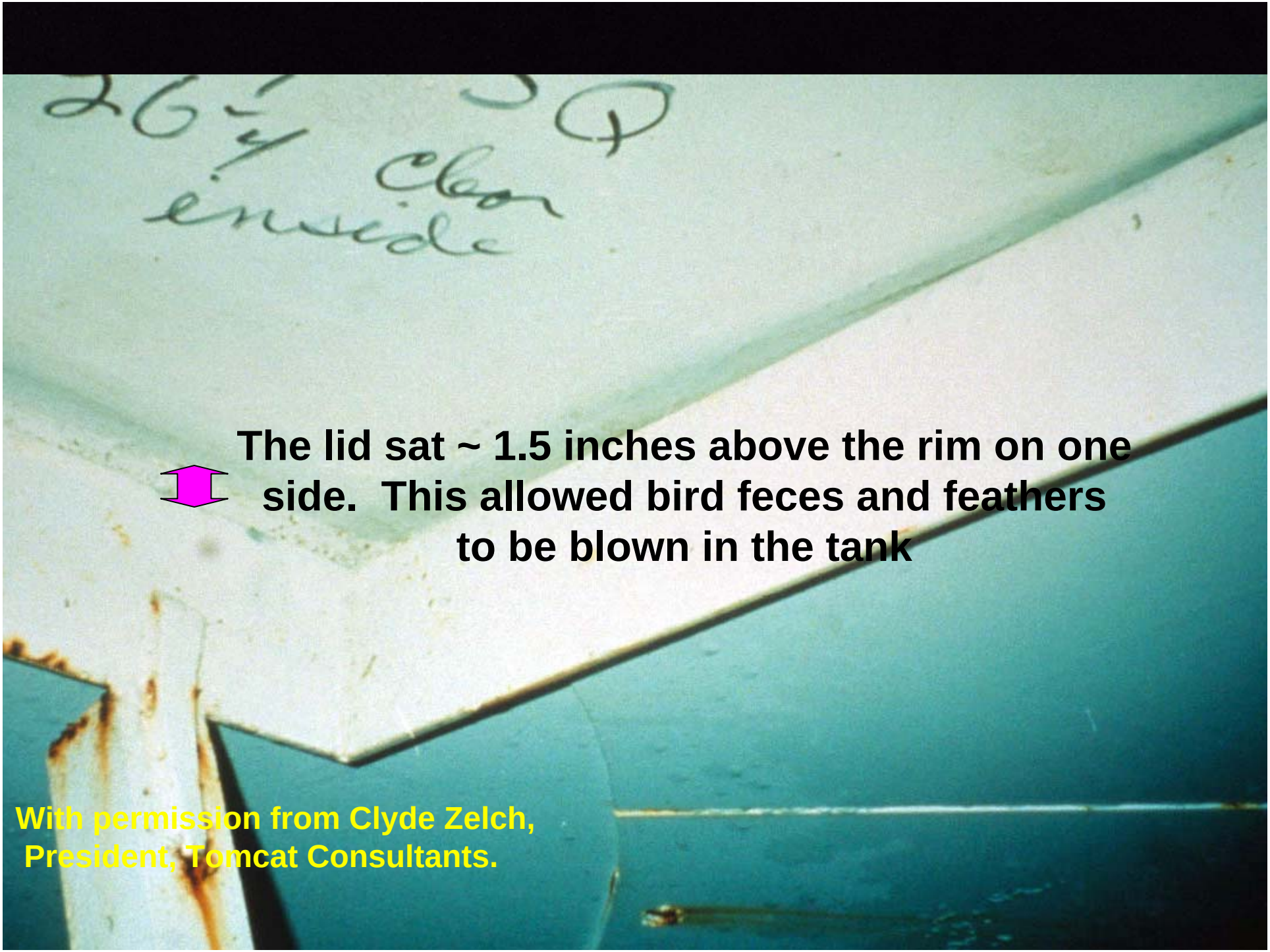

The significance of
no gasket between
the lid and the lip of the lid
is there is not a good seal.
Insects, spiders, etc., can enter,
and rain water can over
flow into the finished water.
No gasket
This channel
relies on a
very small
drain not
getting plugged;
otherwise it overflows
How do those spiders get in?
Easy when there is a sanitary breach

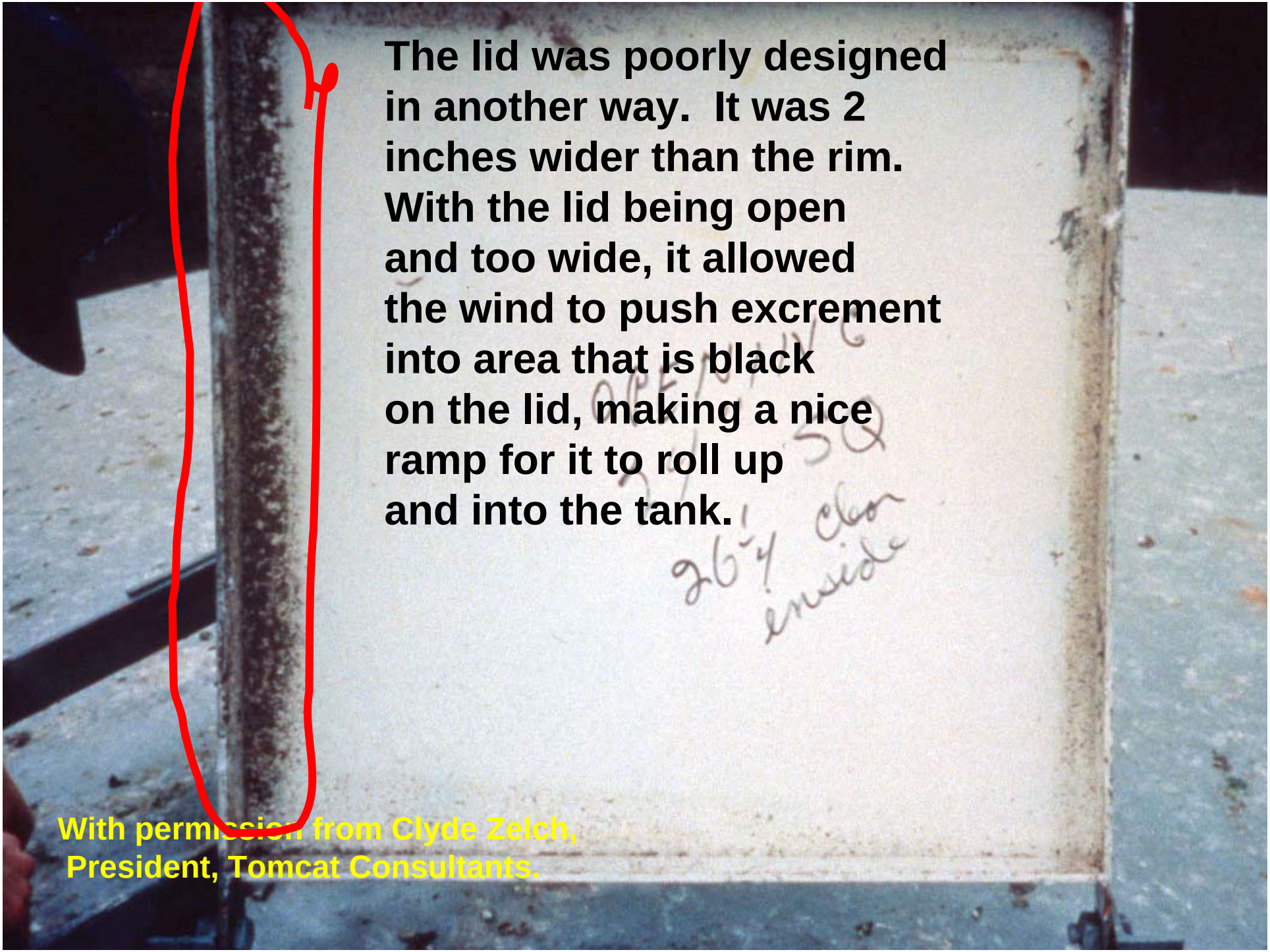

Here is that same hatch with no gasket
in the closed position. The light indicates
at least a ½-inch gap
between the lid and the lip of the lid.
The significance of this breach
to the hatch is that it will allow all
types of insects and possibly small rodents
into the finished water.


A lid with a
properly seated gasket
should look like this
Not like this
03.04.2010 18:23

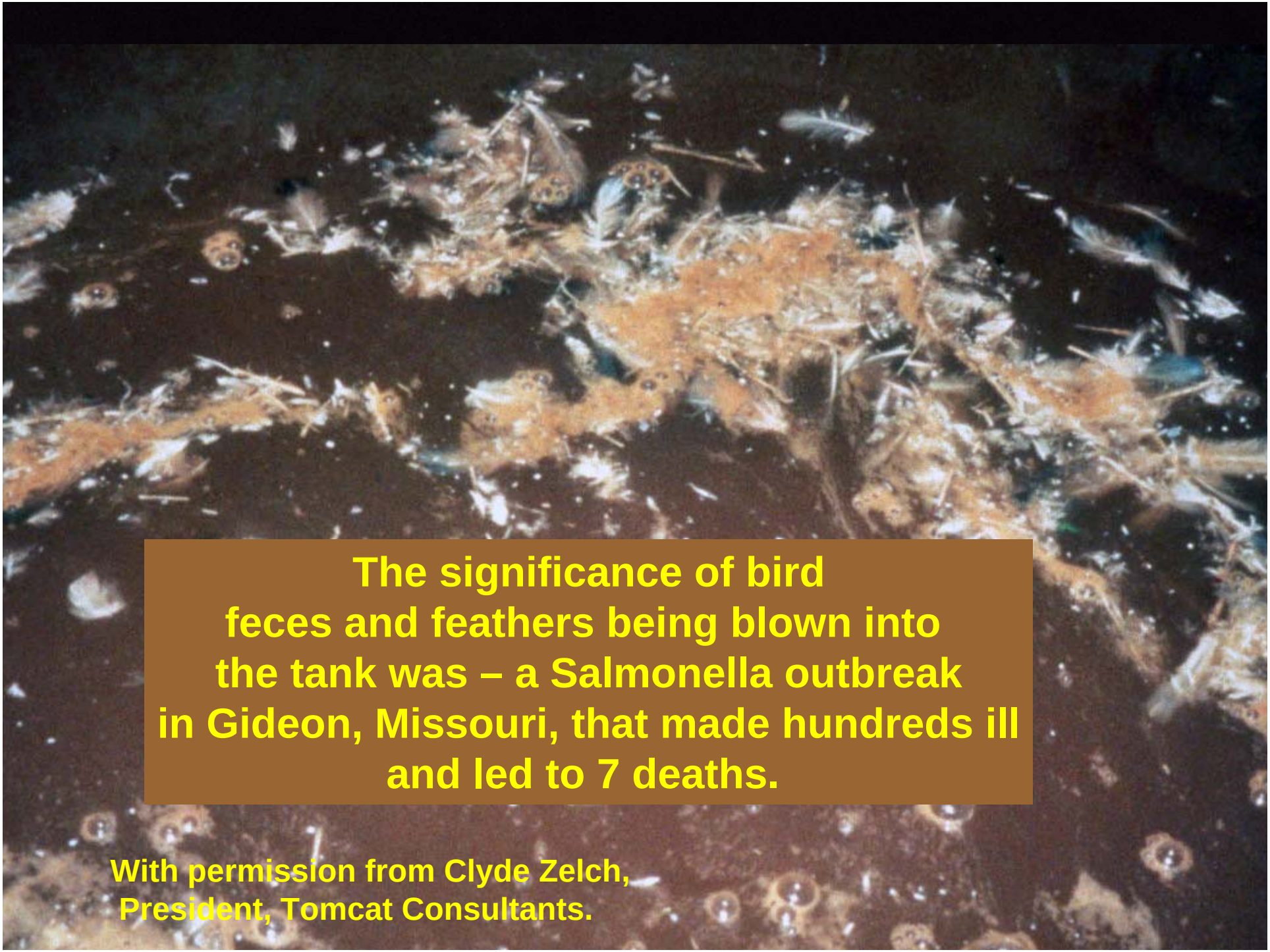
With a hatch that is tight against the gasket and an inverted U for the vents, the inside of your tank should look like this. No light at all. No light is very important. It eliminates the possibility of algae growth.


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.

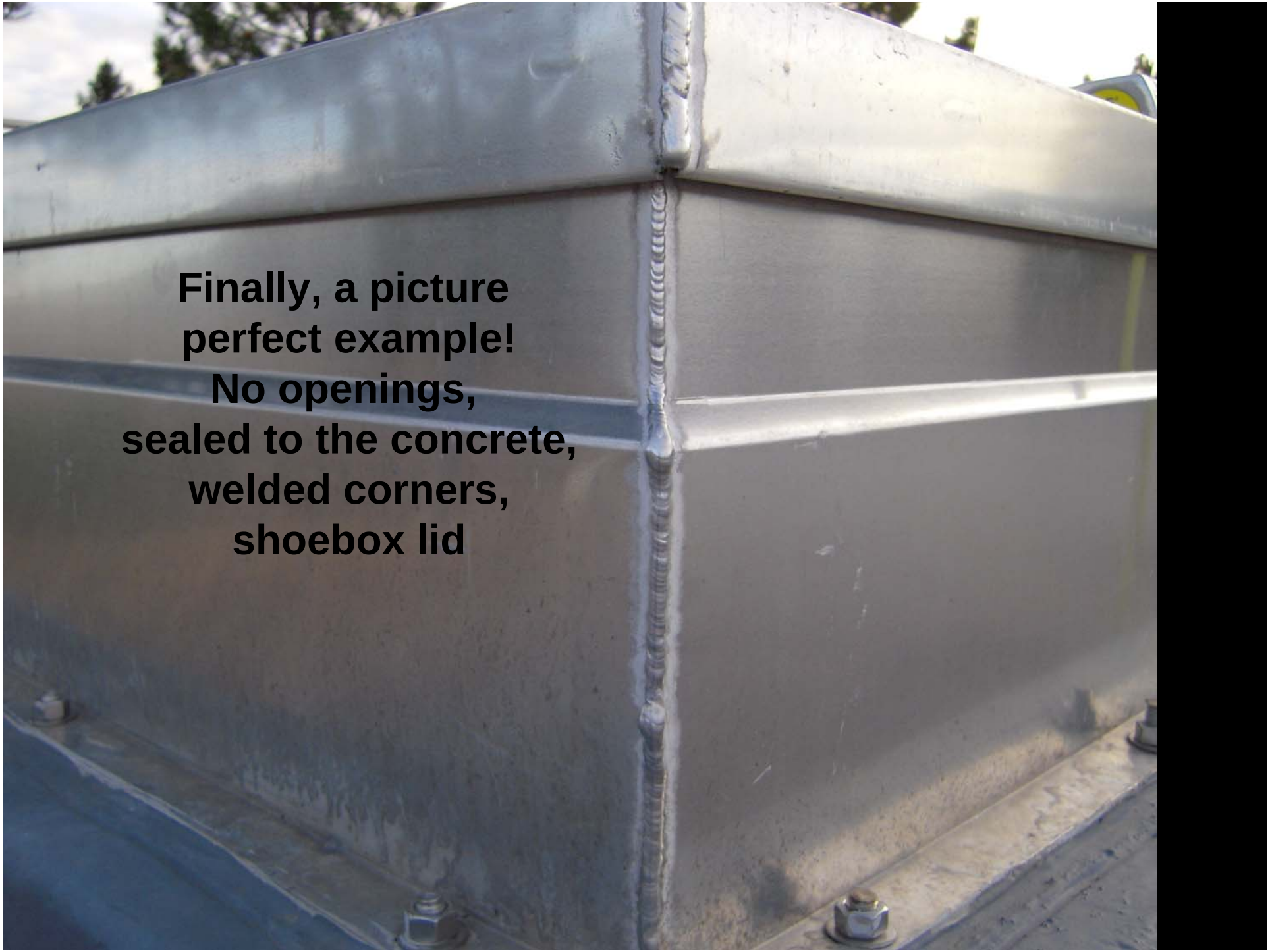

The lid sat ~ 1.5 inches above the rim on one side. This allowed bird feces and feathers to be blown in the tank
With permission from Clyde Zelch, President, Tomcat Consultants.



With permission from Clyde Zelch, President, Tomcat Consultants.


The significance of bird
feces and feathers being blown into
the tank was – a Salmonella outbreak
in Gideon, Missouri, that made hundreds ill
and led to 7 deaths.
With permission from Clyde Zelch,
President, Tomcat Consultants.

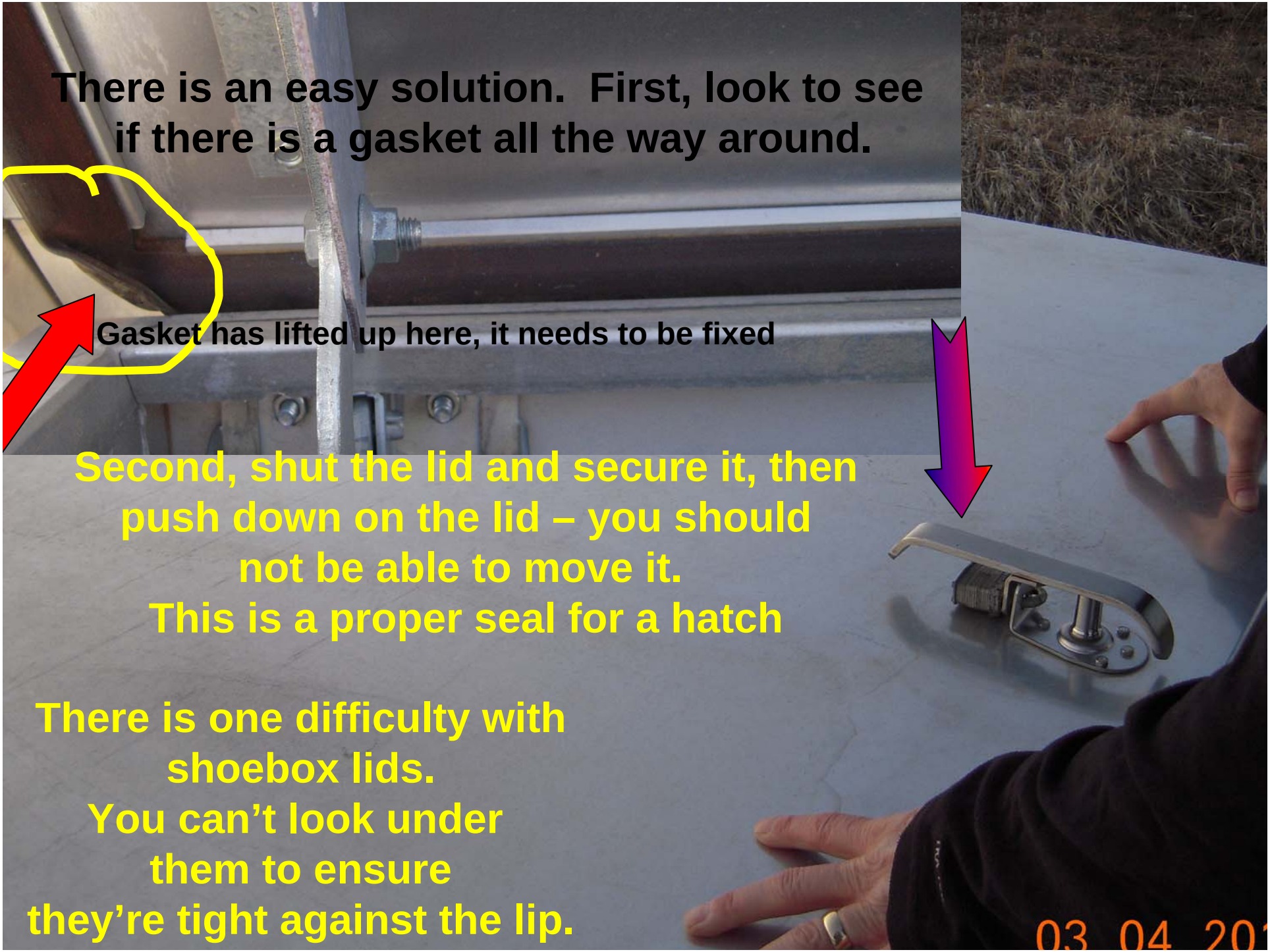
What about the hatch in our example? How does it measure up against the best sanitary criteria?

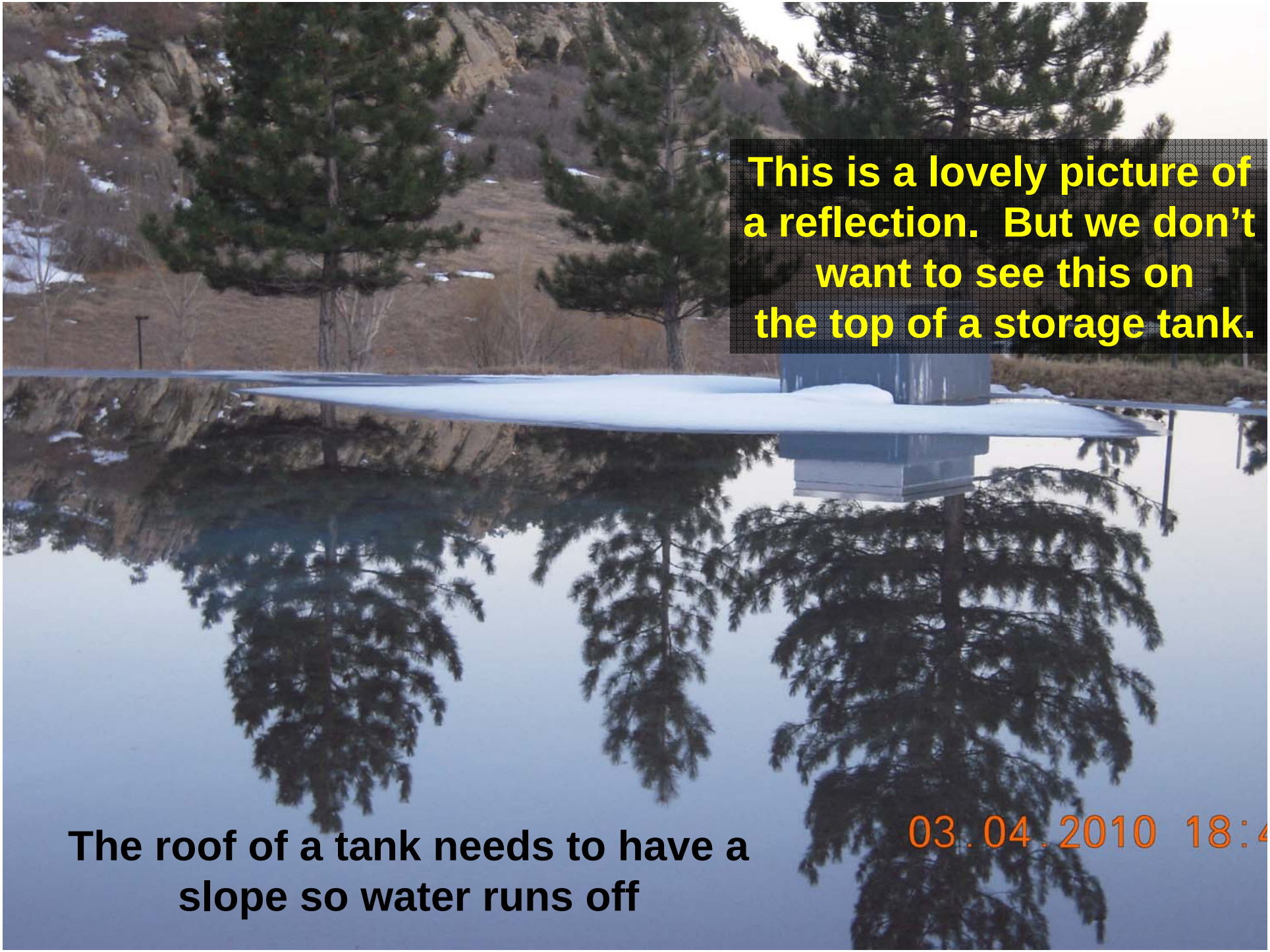

Finally, a picture
perfect example!
No openings,
sealed to the concrete,
welded corners,
shoebox lid

Perfect! The electric lines for telemetry are sealed beautifully!

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

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


There is an easy solution. First, look to see if there is a gasket all the way around.
Gasket has lifted up here, it needs to be fixed
Second, shut the lid and secure it, then push down on the lid – you should not be able to move it.
This is a proper seal for a hatch
There is one difficulty with shoebox lids.
You can't look under them to ensure they're tight against the lip.
03 04 201


This is a lovely picture of a reflection. But we don't want to see this on the top of a storage tank.
The roof of a tank needs to have a slope so water runs off
03.04.2010 18:4

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

We could fix that with different designs

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

That's a lot of specific criteria to remember! That's why it's important to include it on the sanitary survey template.

Sanitary Survey **page 3**

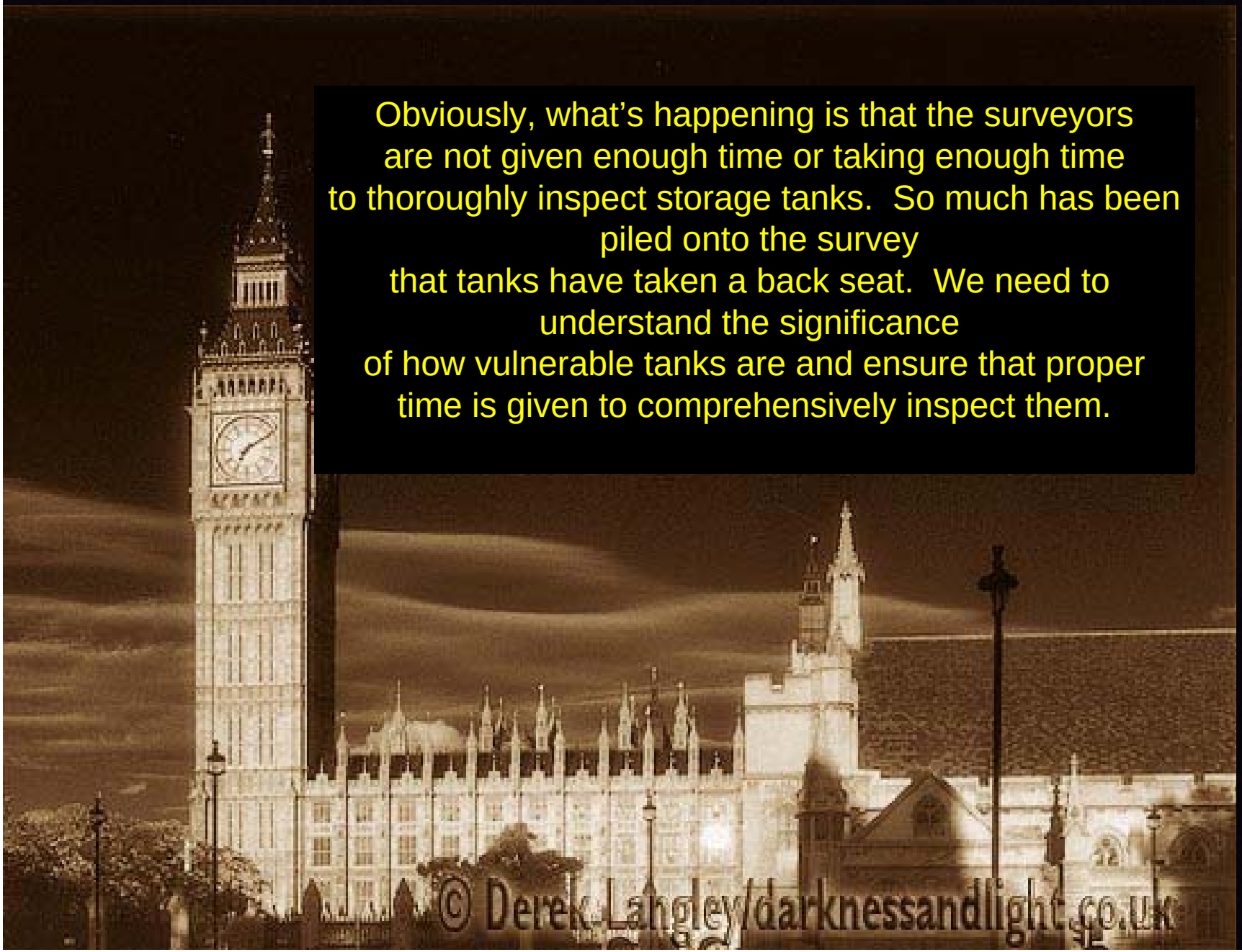
Baloney

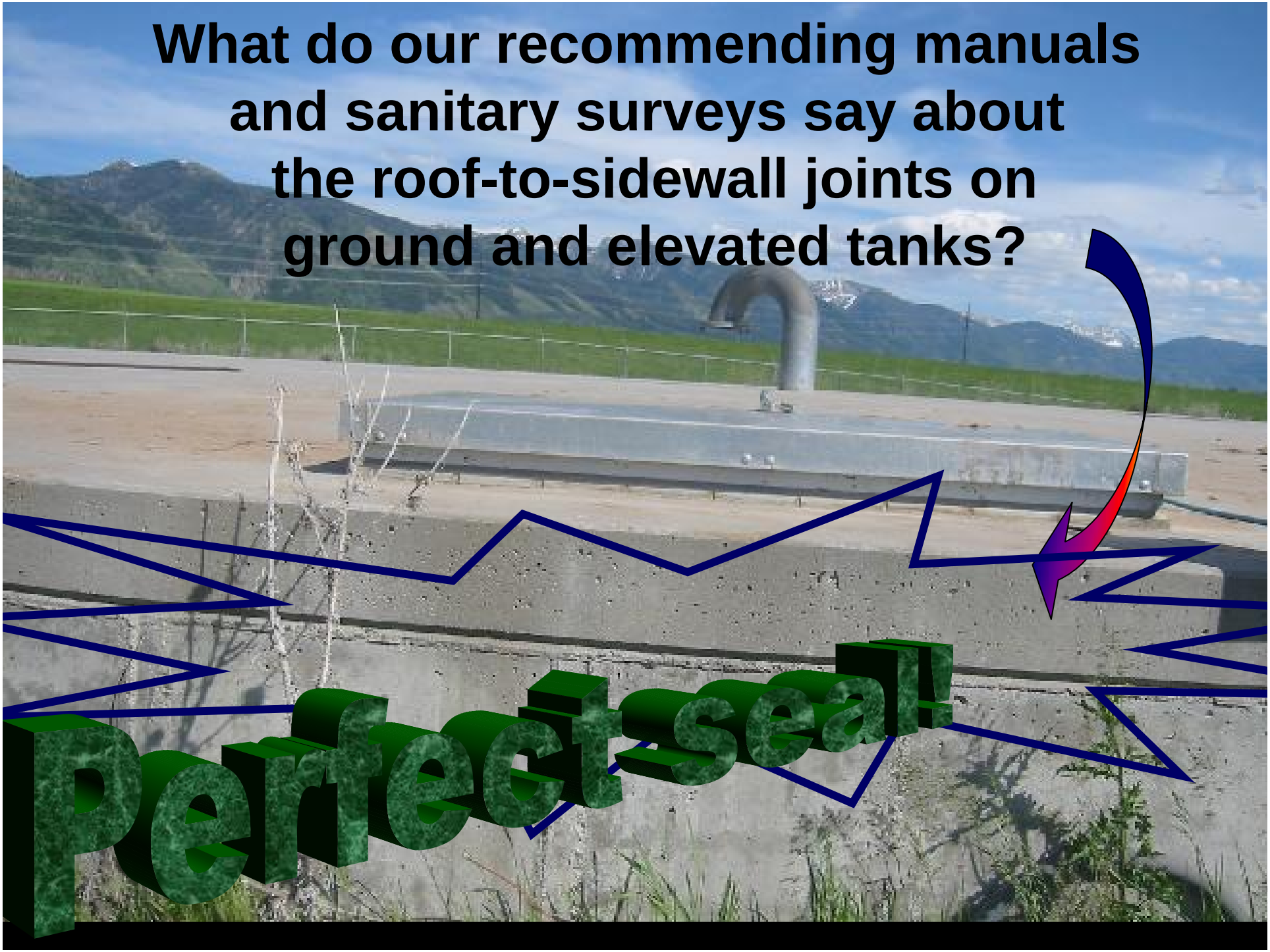
Drains:
Is it downturned? **NO**
or horizontal with flapper? **YES**
Does it have a # 24 screen? **YES**
Does it terminate at least
12 inches above splash plate? **YES**

Sometimes surveyers don't have the time to look at the storage tanks and just fill in the forms!

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.




What do our recommending manuals and sanitary surveys say about the roof-to-sidewall joints on ground and elevated tanks?
Perfect-seal!

Comparison of recommendations on the roof-to-sidewall joints (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) water-tight with no openings. -Any appurtenances into the tank must be welded or sealed. -Sloped to facilitate drainage	-(Shall) water-tight with no openings except properly constructed vents, overflows, drains, manholes, pump Not less than 18 inches from ground to roof of ground-level tank	-(Shall) Roof-to-sidewall joint must be sealed. -Roof penetrations for water lines, chlorine lines, electrical must be sealed to prevent bird droppings from washing in.

Region 8's Sanitary Survey Form for Wyoming
Are the side and roof joints -caulked?
-Are there any openings other than a properly designed vent, overflow, drain, or hatch?

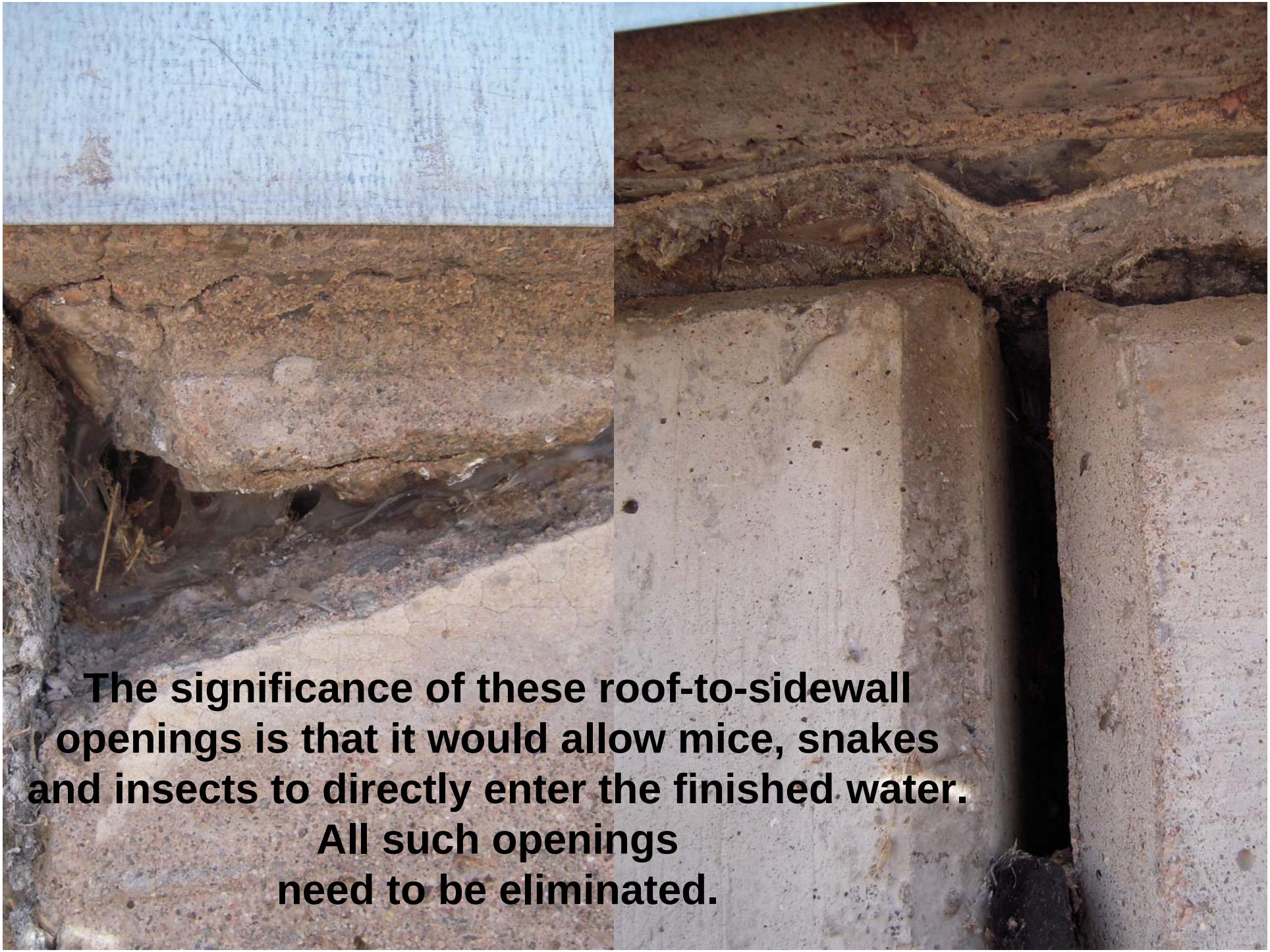
✔ 4 out of 4 say no openings in the sidewall-to-roof joints, no openings where appurtenances enter the tank.

✔ WY's SS is essentially asking are there any openings greater than what is afforded by a # 24 mesh screen. This is also stated in 10 State Standards in the general discussion on storage tanks.

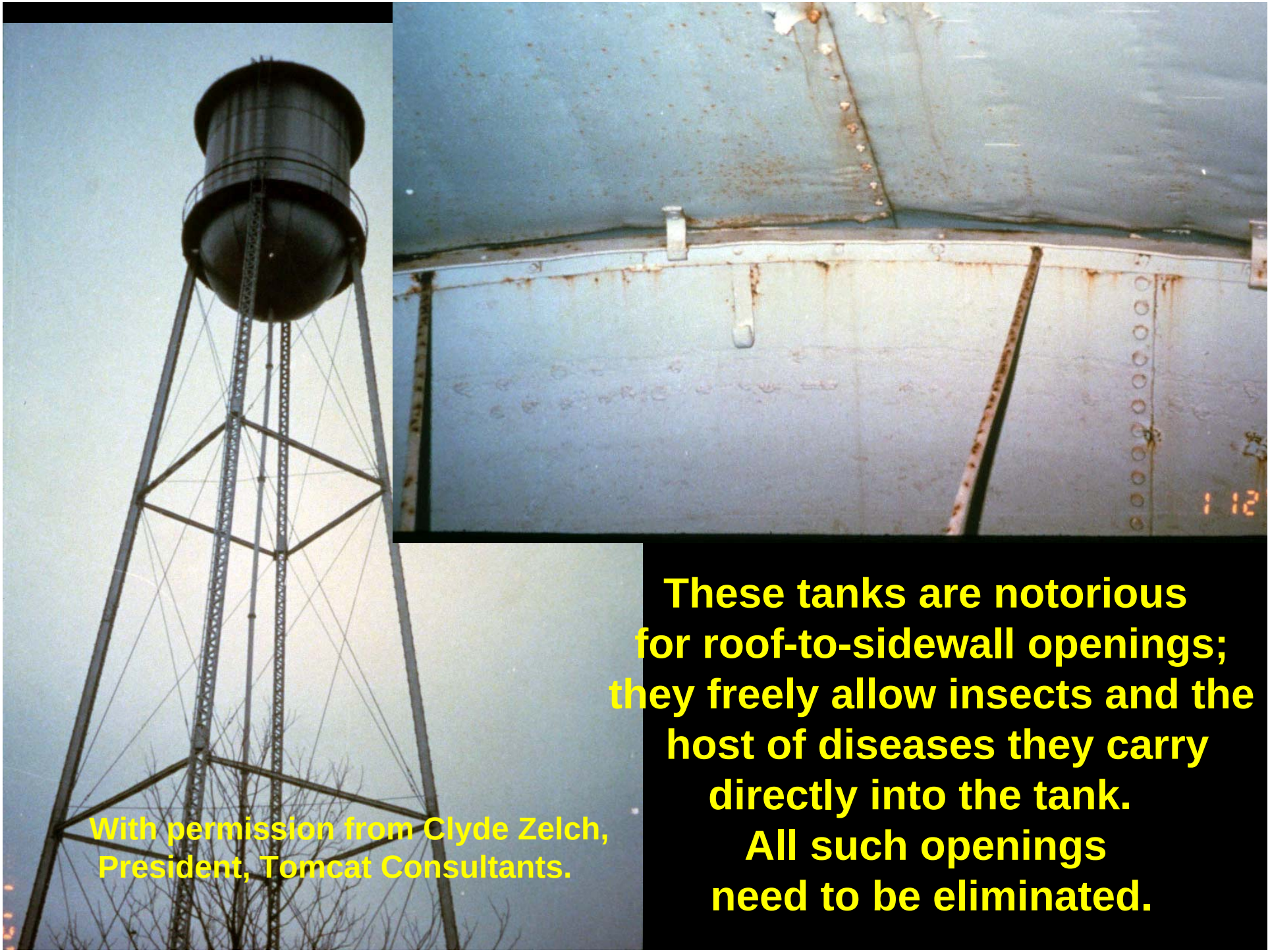
Comparison of recommendations on the roof-to-sidewall joints (SD, ND, MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
-(Shall) water-tight with no openings -Any appurtenances into the -Tank must be welded or sealed. -Sloped to facilitate drainage	-Roof-to-sidewall joint must be sealed. -Roof penetrations for water lines, chlorine lines, electrical must be sealed to prevent bird droppings from washing in.	-Do they have a water-tight roof or cover and are they sloped so that water will drain?
North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	MN's SS says open construction between the roof and sidewall is not permissible. SD's SS asks if the roof is water-tight
-Condition of the tank -exterior?	-Open construction between the sidewall and the roof is not permissible.	

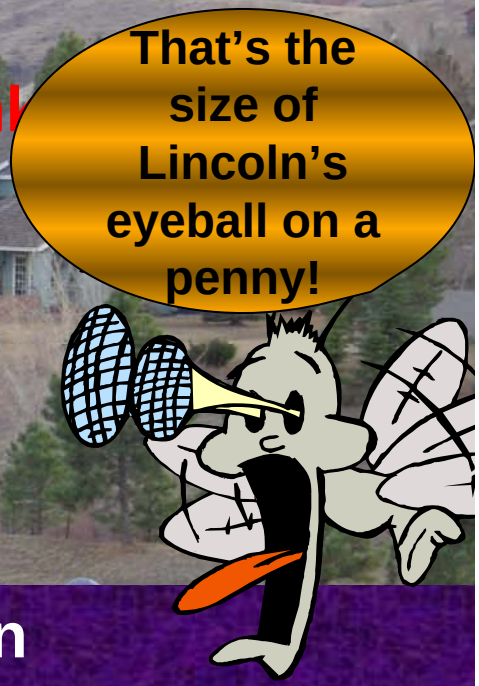


The significance of these roof-to-sidewall openings is that it would allow mice, snakes and insects to directly enter the finished water. All such openings need to be eliminated.

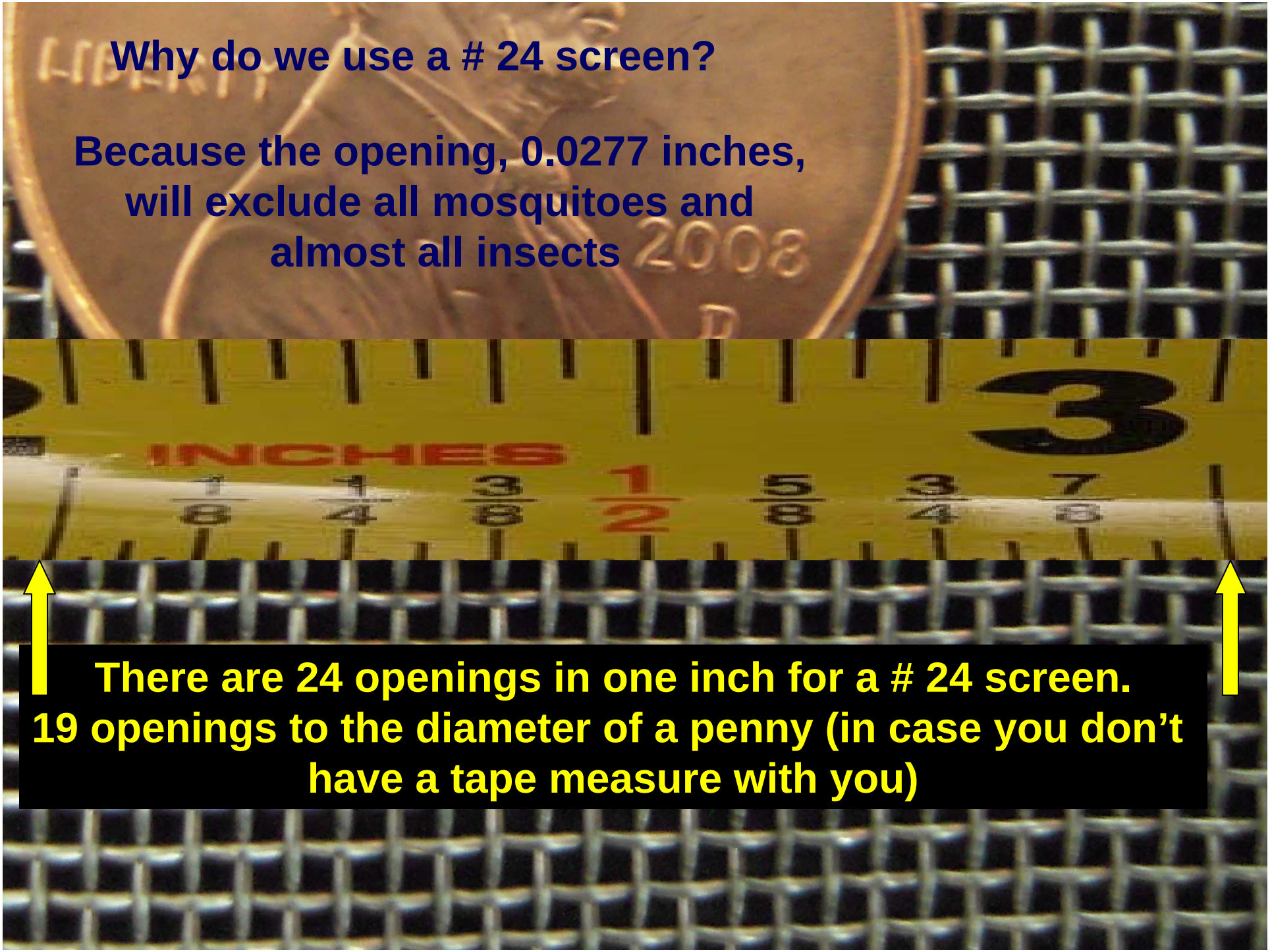

With permission from Clyde Zelch,
President, Tomcat Consultants.
These tanks are notorious
for roof-to-sidewall openings;
they freely allow insects and the
host of diseases they carry
directly into the tank.
All such openings
need to be eliminated.

Why must tanks be designed to exclude insects?
Where do flies dine? Calves excrete billions of Crypto and Giardia. The Crypto are small enough to be ingested and excreted and stick to the legs and body of a fly and be transported to the finished water.
With permission from Clyde Zelch, President, Tomcat Consultants.

Distilling this information down, what would be the very best practices for the roof-to-sidewall joints, or any other openings besides properly constructed vents, overflows and drains for both ground & elevated tank



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
2008
INCHES
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 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

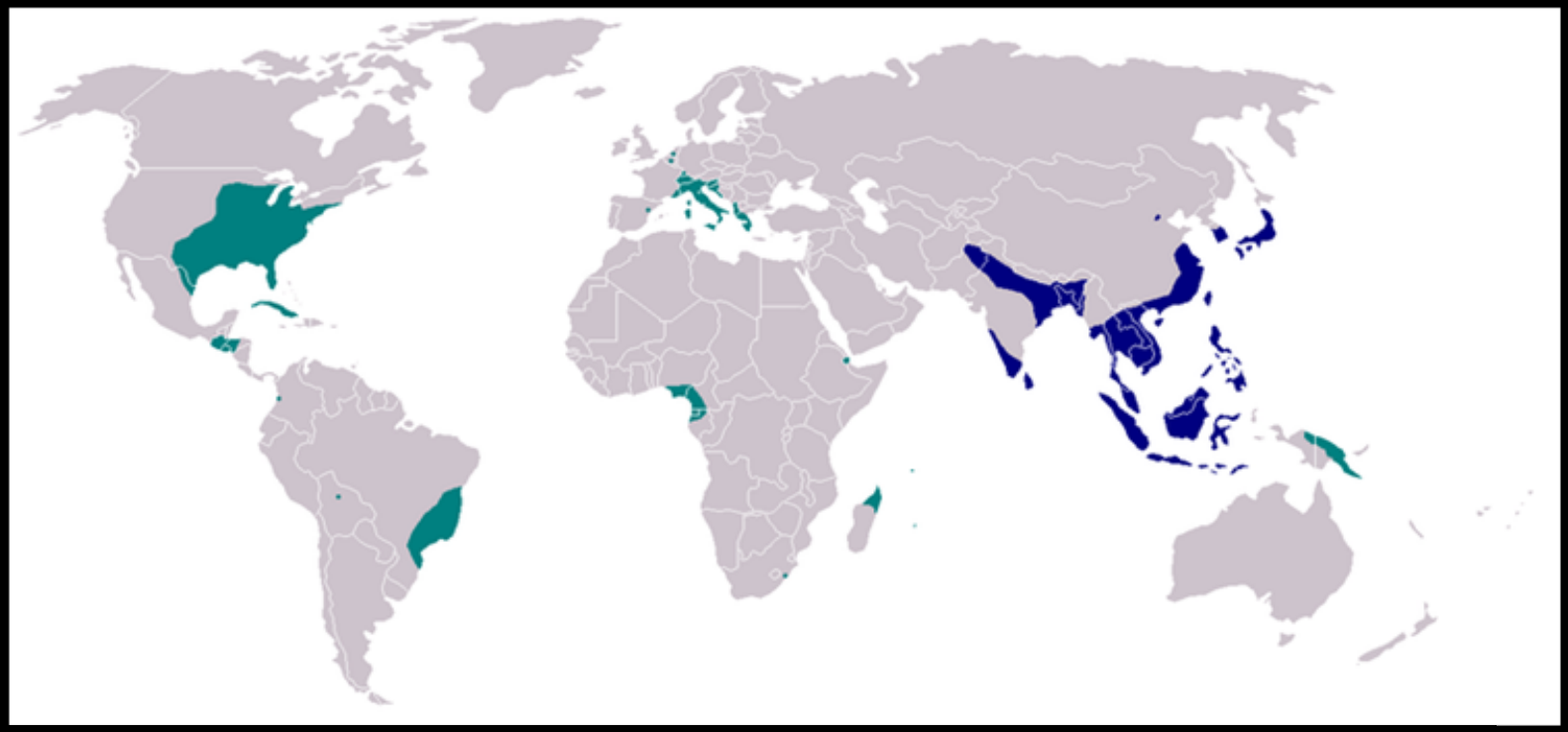
Asian Tiger Mosquito: 0.078 inch

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.

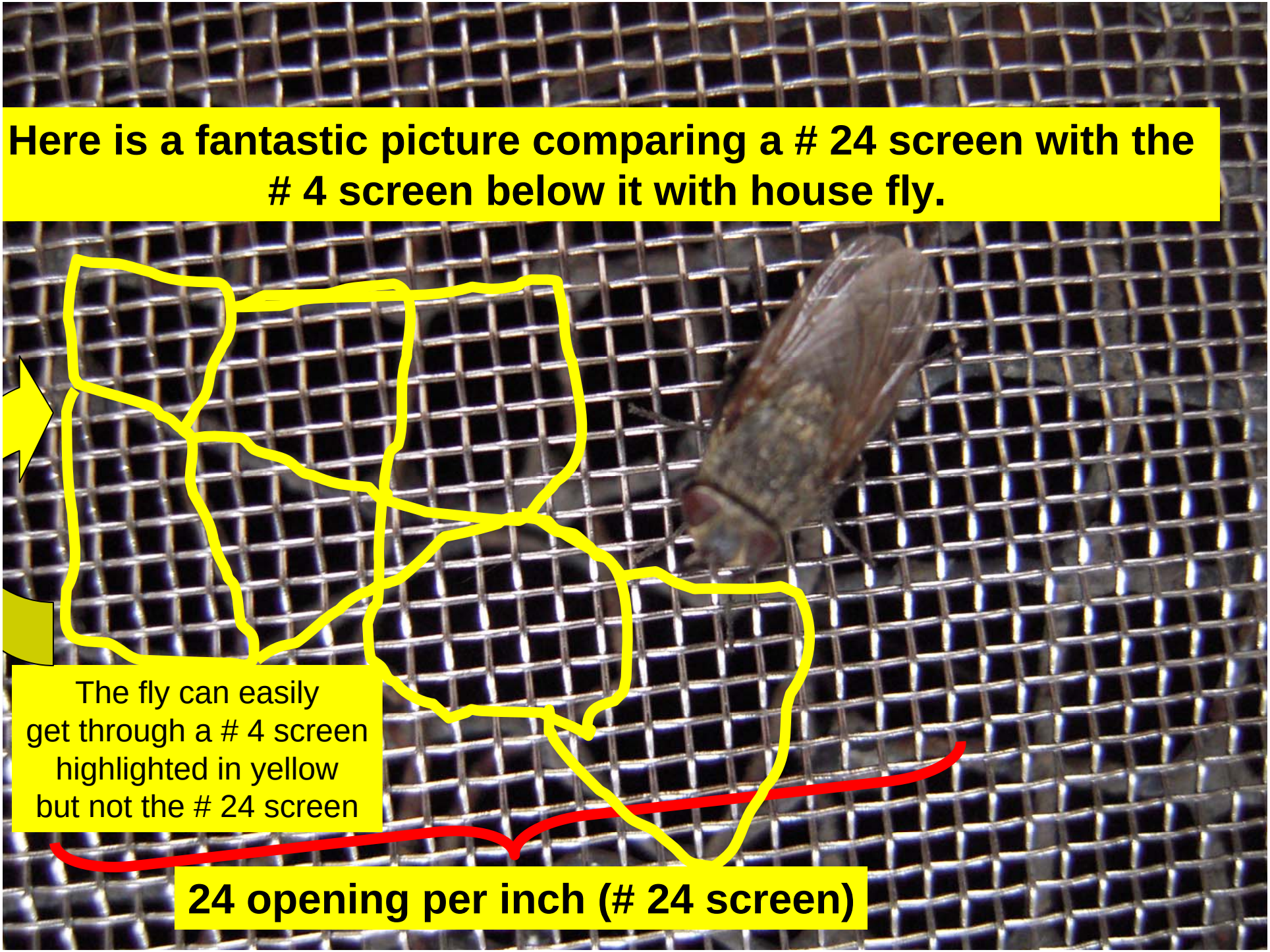
Why is it important to keep insects out? Because of the diseases they carry!

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).

Housefly as a vector of disease

Mechanical transmission of organisms on its hairs, mouthparts, vomitus, and feces:
Parasitic diseases: cysts of protozoa e.g. *Entamoeba histolytica*, *Giardia lamblia*
Bacterial diseases: typhoid, cholera, dysentery, pyogenic cocci...etc. House flies have been demonstrated to be vectors of *Campylobacter* and *E. coli* O157:H7
Viruses: enteroviruses: poliomyelitis, (A & E).etc.


Here is a fantastic picture comparing a # 24 screen with the # 4 screen below it with house fly.
The fly can easily get through a # 4 screen highlighted in yellow but not the # 24 screen
24 opening per inch (# 24 screen)

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

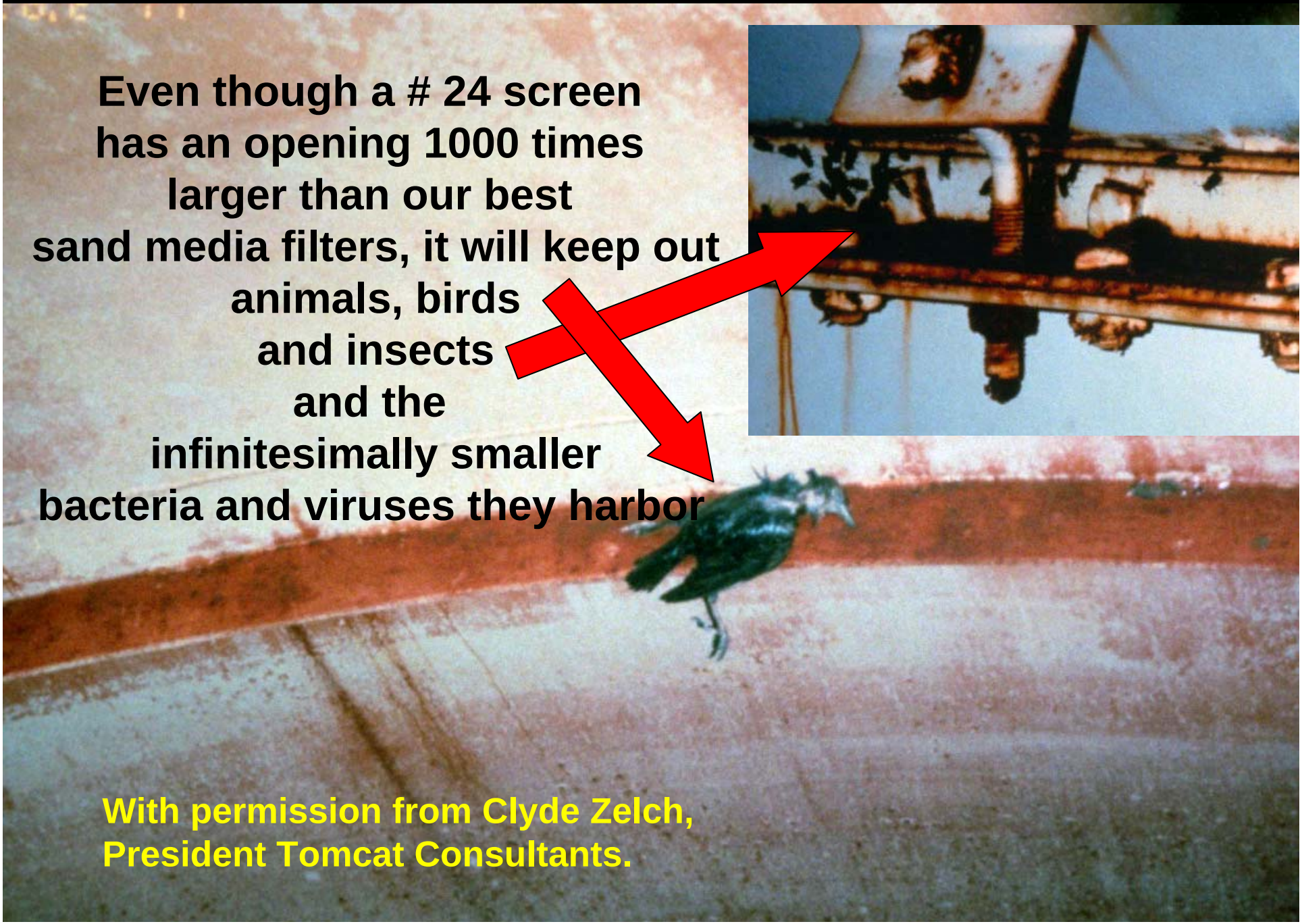
Not when you compare it to what size opening the water has already come through in a well-operated filter or aquifer

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

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.

Comparison of recommendations on frequency of inspection and cleaning of tanks (WY)

Recommended Standards for Water Works 2007	DEQ Wyoming Water Quality Rules & Regulations	How to Conduct a Sanitary Survey: A Learner's Guide 2003
-(Shall) allow for cleaning without losing pressure in the distribution system	-(Shall) be designed with access to the interior For cleanings	-A thorough structural and coating inspection should be carried out every five years

Region 8's Sanitary Survey Form for Wyoming
-Date last inspected and cleaned? If longer than 5 years, then significant deficiency

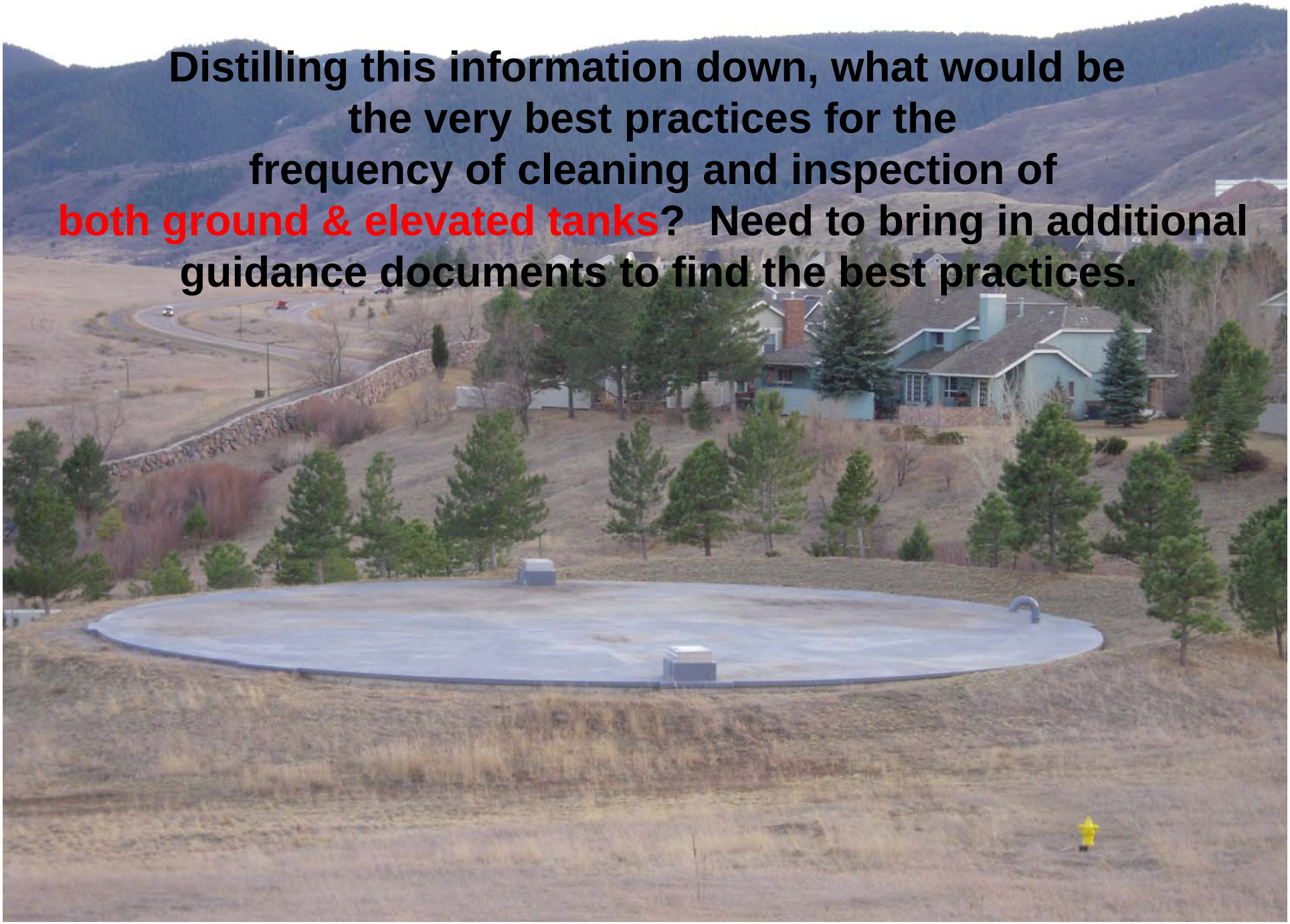
1 out of 4 says cleaning every 5 years, and 2 out of 4 says inspection every 5 years

Comparison of recommendations on frequency of inspection and cleaning of tanks (SD, ND & MN)

SD, ND & MN use 10 State for their plan and spec regs

Recommended Standards for Water Works 2007	How to Conduct a Sanitary Survey: A Learner's Guide 2003	South Dakota's Sanitary Survey Form
(Shall) allow for cleaning without losing pressure in the distribution system	A thorough structural and coating inspection should be carried out every five years	-Is there a service contract for cleaning and inspection?

North Dakota's Sanitary Survey Form	Minnesota's List of Survey Recommendations	
-Date of last inspection? -Date of last cleaning?	-All tanks should be inspected cleaned on an annually, and more frequently when there are water quality issues	SD & ND's SS ask about the inspection and cleaning frequency. MN's SS says they should be cleaned annually. But, there are no requirements to inspect or clean.



Distilling this information down, what would be the very best practices for the frequency of cleaning and inspection of both ground & elevated tanks? Need to bring in additional guidance documents to find the best practices.

Comparison of recommendations on frequency of inspection and cleaning of tanks

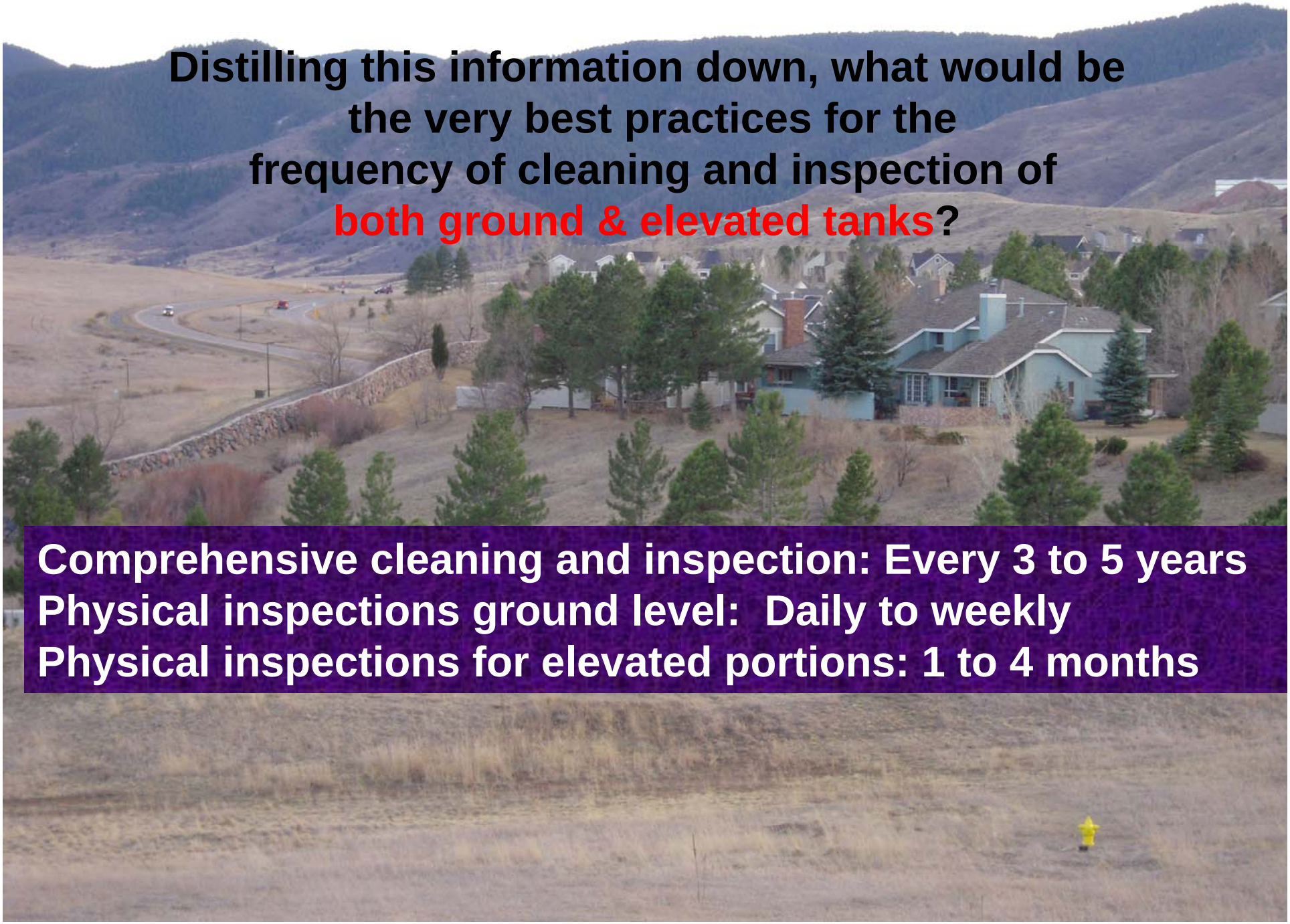
AWWA Manual M42	EPA's White Paper on Finished Water Storage Facilities (Kirmeyer)
Recommends tanks be drained, inspected and cleaned at least every 3 years.	Recommends tanks be drained, cleaned, and have a comprehensive inspection every 3 to 5 years

Kirmeyer also recommends 3 types of inspections:

Routine inspection: Daily to weekly, entails a physical inspection of the tank and would include vents, overflows, drains, hatches, and other openings

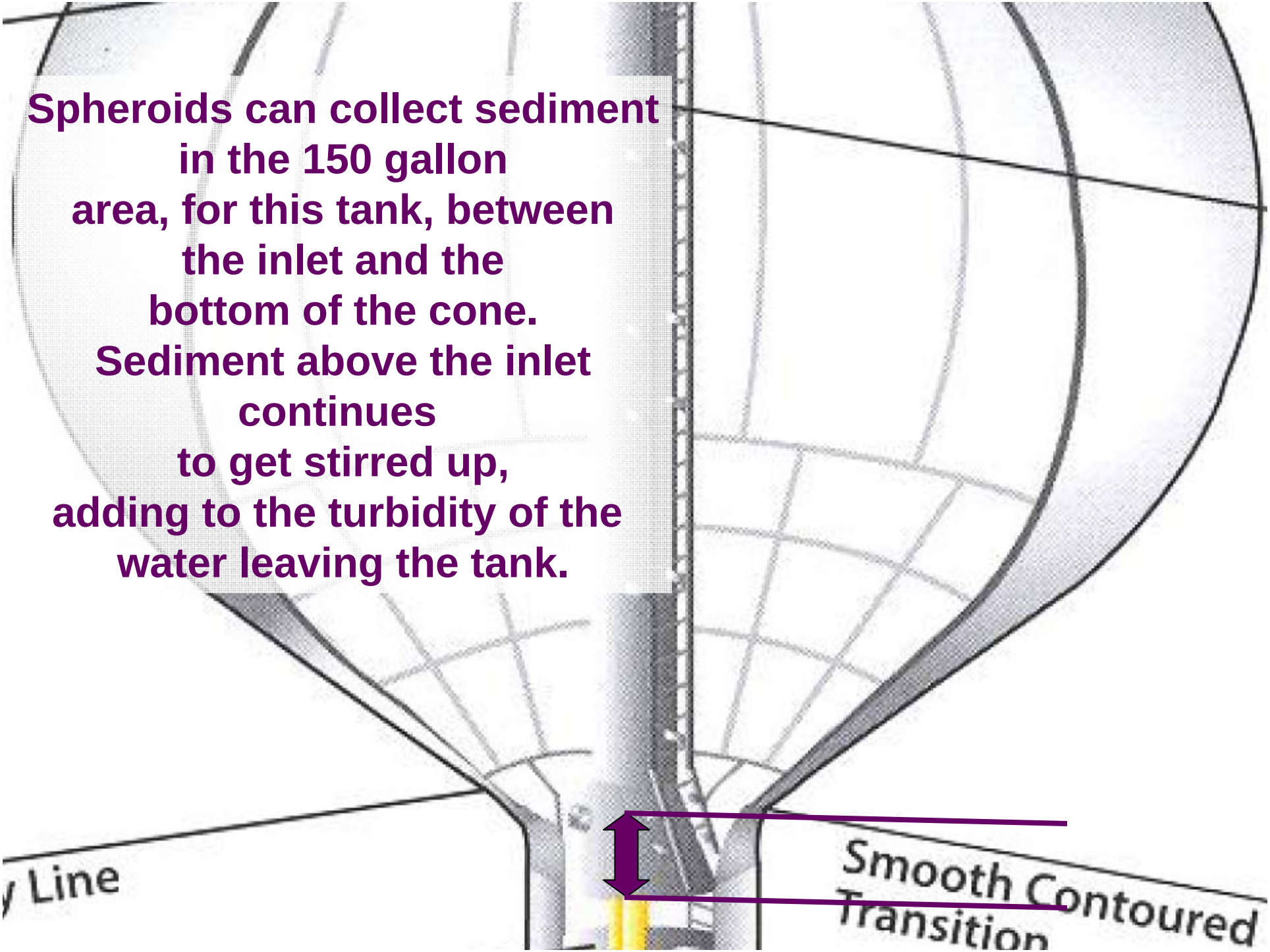
Periodic Inspection: 1 to 4 months, principally a physical inspection of the areas of the tank not normally accessible. Usually requires climbing.

Comprehensive inspection: 3 to 5 years, requires the tank be drained & cleaned for a comprehensive inspection inside and out.



Distilling this information down, what would be the very best practices for the frequency of cleaning and inspection of both ground & elevated tanks?

Comprehensive cleaning and inspection: Every 3 to 5 years
Physical inspections ground level: Daily to weekly
Physical inspections for elevated portions: 1 to 4 months


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.
y Line
Smooth Contoured Transition

This is what a spheroid tank looks like
when that concentric area is full of sediment.
All tanks need to be
comprehensively cleaned and inspected at least
every 3 to 5 years
With permission from Clyde Zelch,
President Tomcat Consultants.

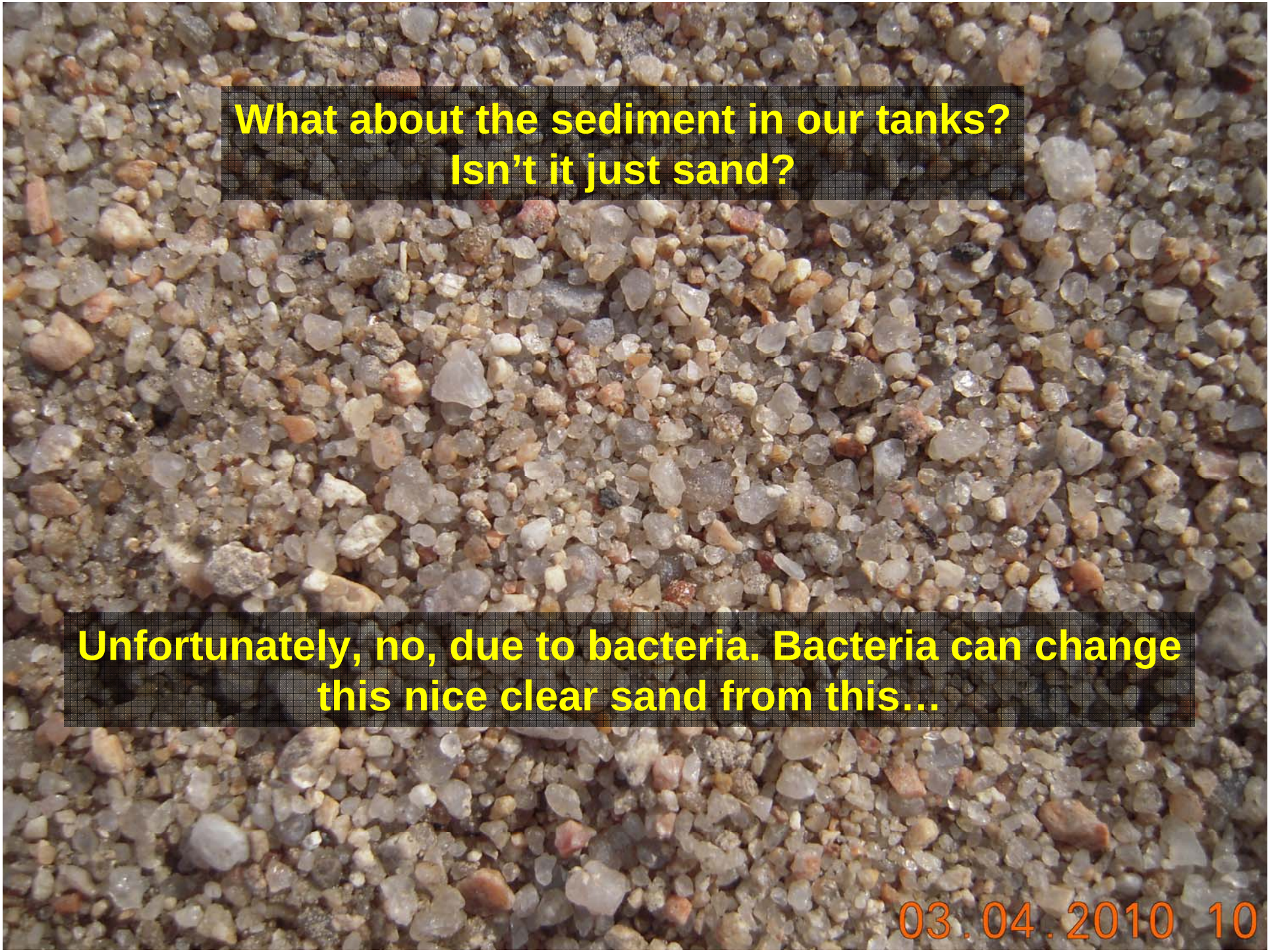
Time between cleanings increases the depth of the sediment

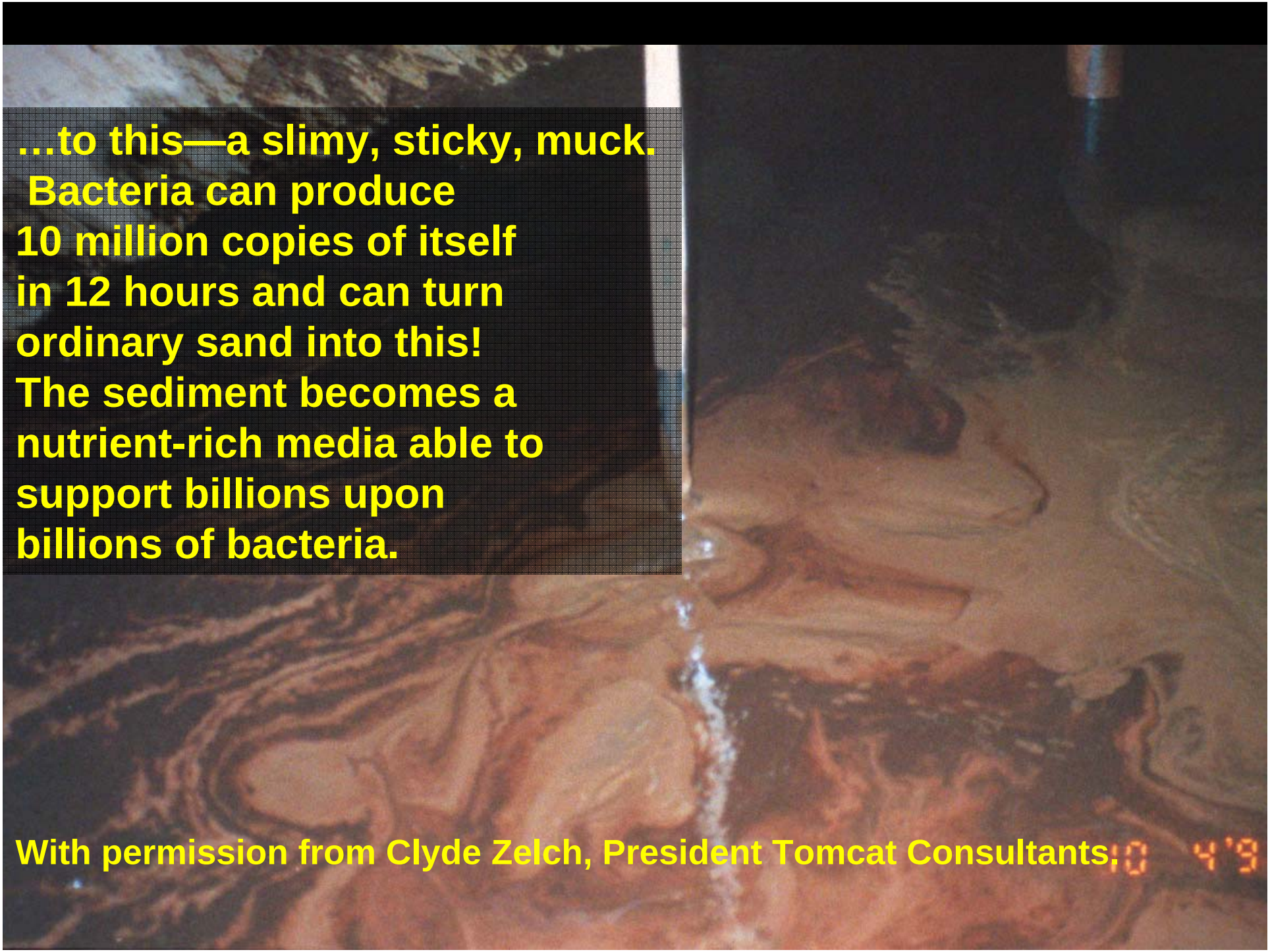
Brookfield, Wisconsin, had 3 spheroids.

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

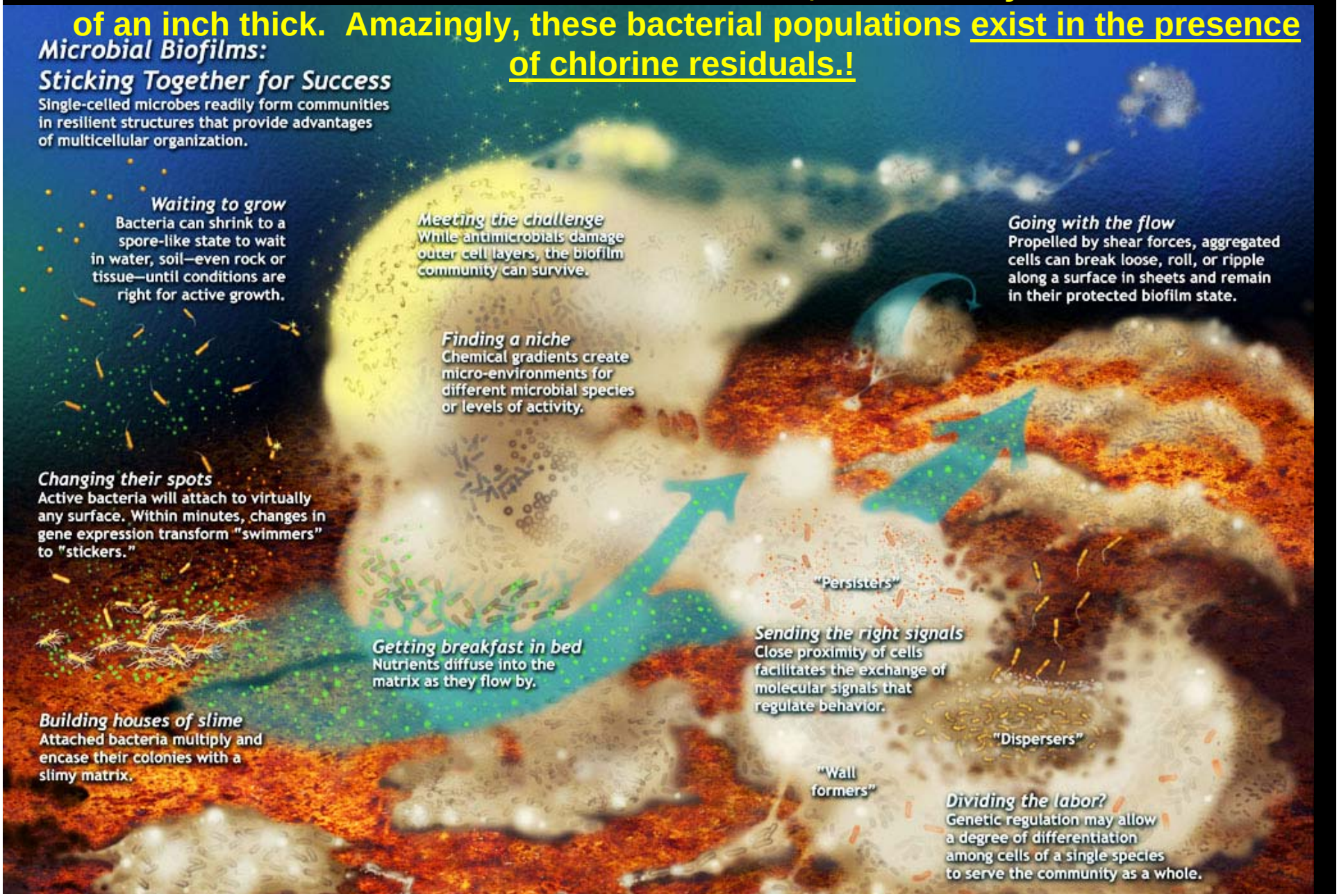
One tank was cleaned 15 years ago. The result:
28 inches of sediment

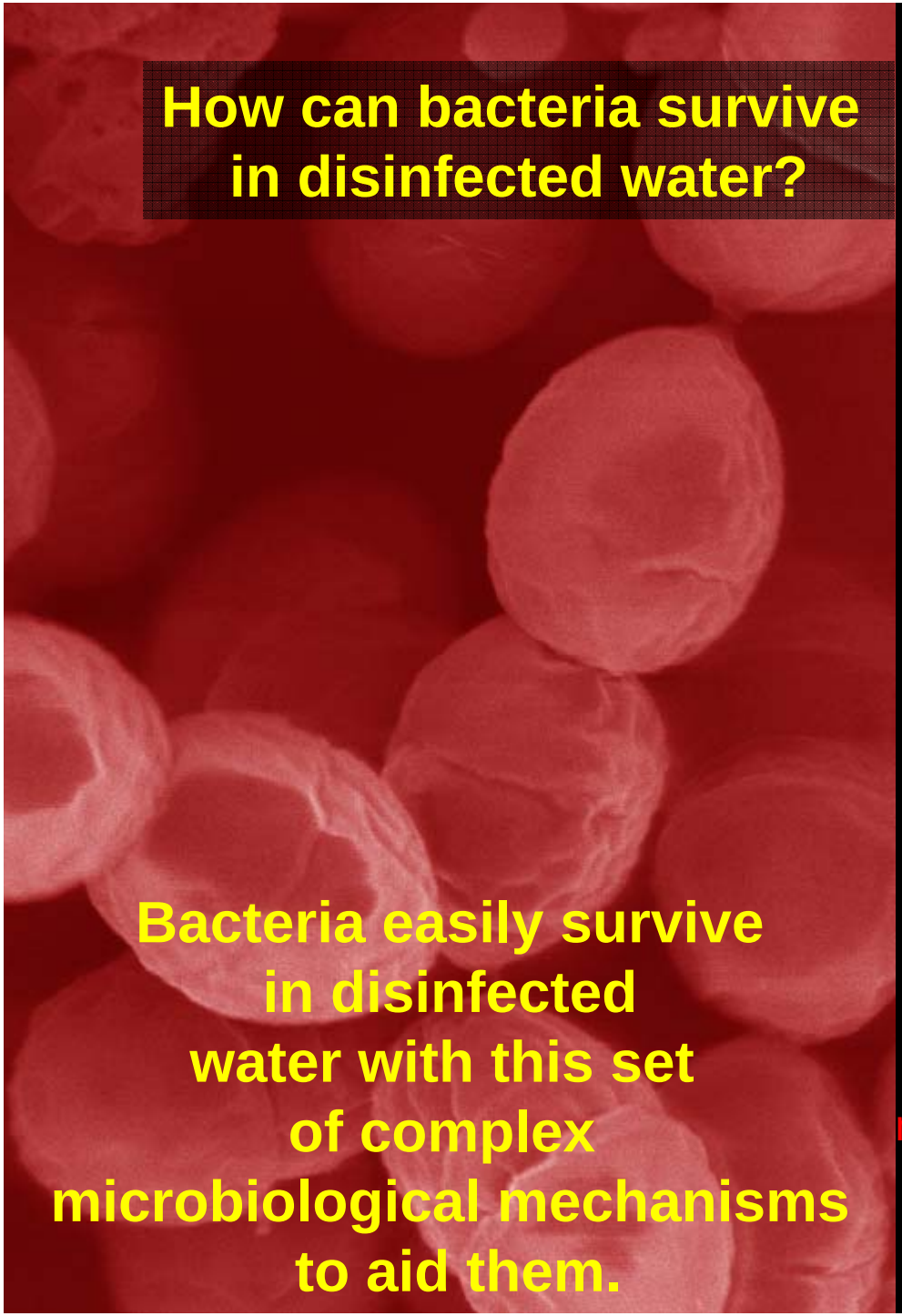
Wisconsin had recommendations for inspections every 5 years


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—a slimy, sticky, muck.
Bacteria can produce
10 million copies of itself
in 12 hours and can turn
ordinary sand into this!
The sediment becomes a
nutrient-rich media able to
support billions upon
billions of bacteria.
With permission from Clyde Zelch, President Tomcat Consultants.

For a normal healthy biofilm on a pipe wall a 3/8-by 3/8-inch area will be home to ~1 million bacteria, but it is only ~1/64 of an inch thick. Amazingly, these bacterial populations <u>exist in the presence of chlorine residuals.!</u>





How can bacteria survive in disinfected water?

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

1) Attachment: Bacteria are more than 600 X more resistant when attached to particles.

2) Encapsulation: Bacteria in low nutrient environments create an extracellular polysaccharide capsule which increases resistance 3 X.

3) Aggregation: When bacteria are in clumps, their resistance to free chlorine increases 100 X.

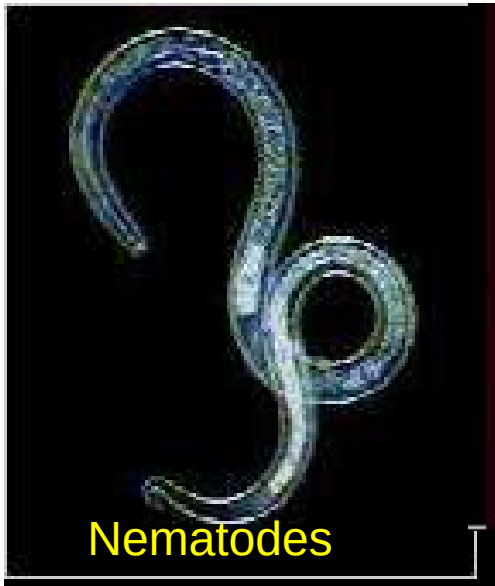
4) Low nutrients/low temperatures: Bacteria grown in these conditions are up to 9 X more resistant than agar-grown.

5) Strain variation: Disinfection selects for bacteria with resistance mechanisms.

6) Resistance mechanisms are multiplicative: For example, attached to glass (150 X) & encapsulated (3 X) resultant resistance 450 X.

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

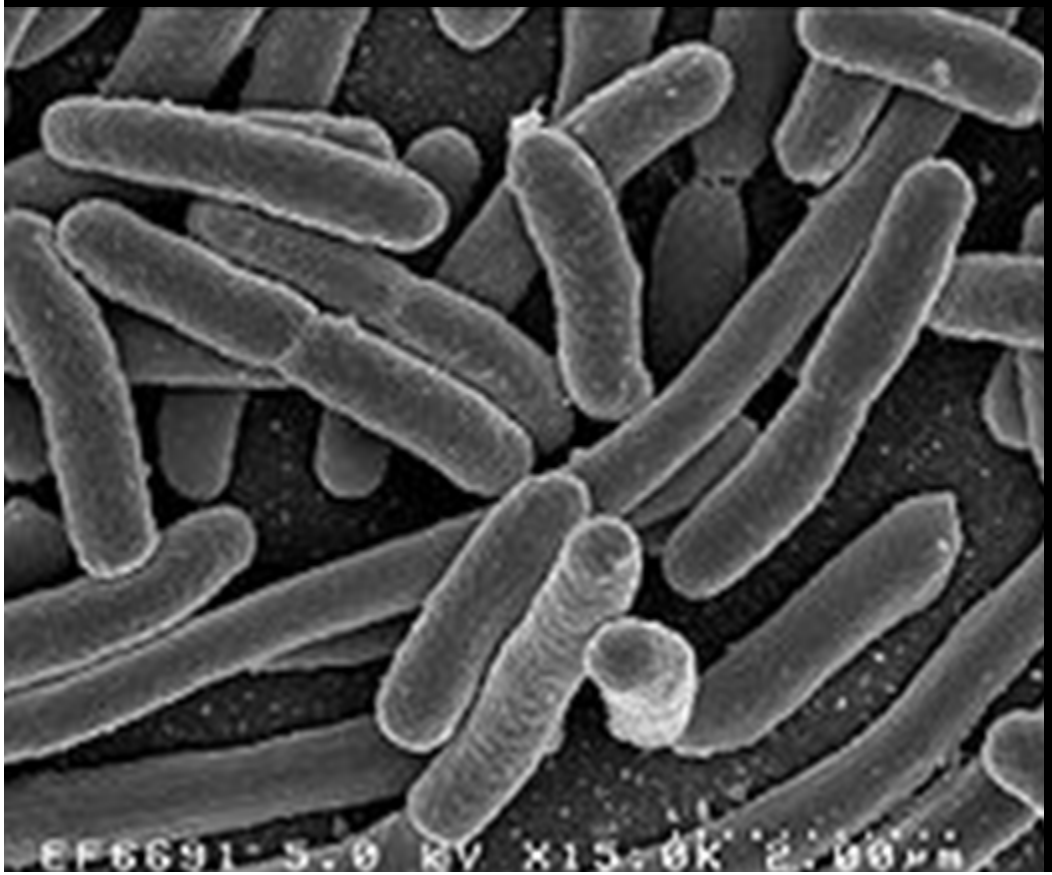
than bacteria (densities up to 10^4



Amphipods

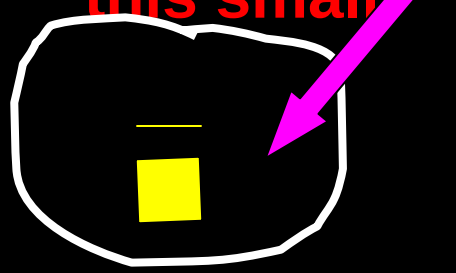
What other things live in the sediment

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.

~1 million bacteria can live in an area this thin and in an area this small



How many trillions of bacteria, opportunistic pathogens, amoebae, fungi, nematodes, amphipods, copepods, fly larvae, and all other unknown organisms are occupying the inches to several feet of sediment in a tank? The public health concern increases with the depth of sediment. What's in this sediment is not well researched!

As long as the sediment remains undisturbed, your 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 event occurs the public health concern is elevated up to the potential of a water borne disease outbreak.

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 real cost to a PWS is in the time and cost of defending itself. Milwaukee spent well over a million dollars defending itself. The law firm that brought suit against Milwaukee has developed one of the most extensive libraries in the country.

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

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."

[redacted] 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.

That dangerous combination of breaches and sediment up to 18 inches is cited in the lawsuit.

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.

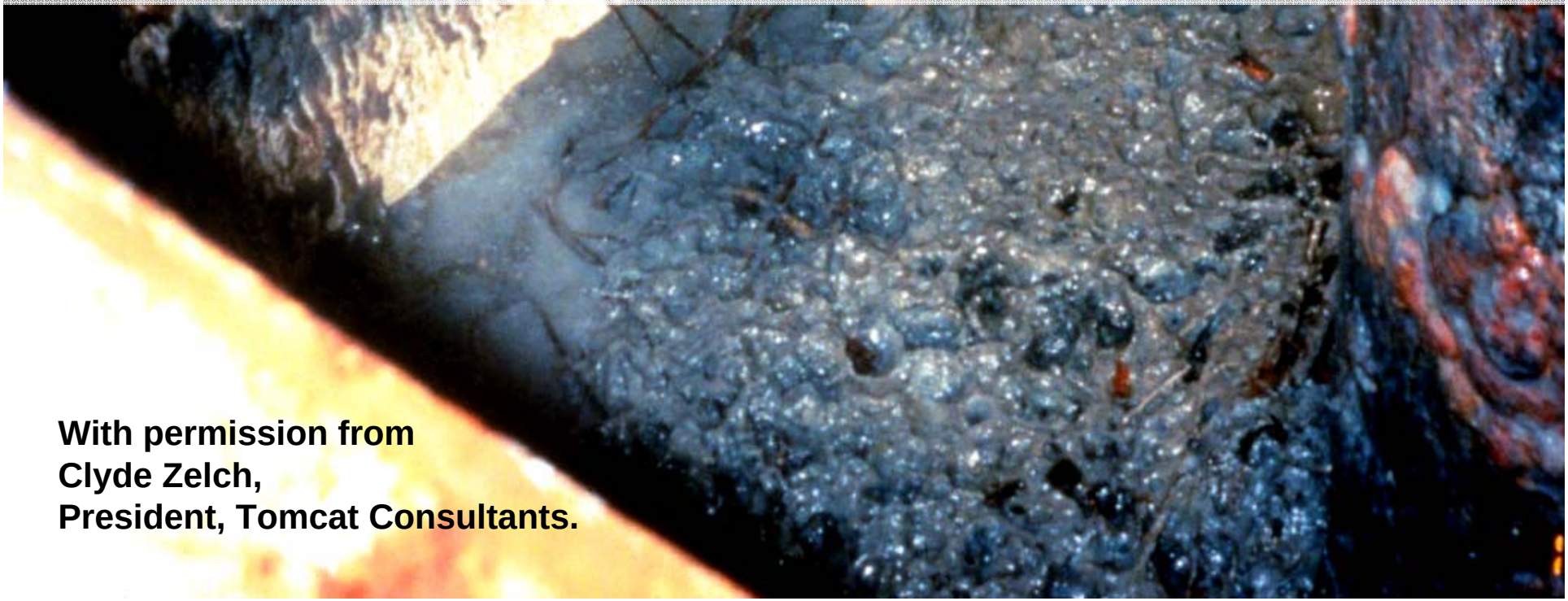
A single mouse fecal pellet contains 10^5 Salmonella.

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.

In summary, with no regulations and no clear single guidance, choose the very best practices that will eliminate down to the size of insects and the associated diseases they carry. 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.

With the Ground Water Rule now fully effective, States have the authority to enforce cleaning and inspection of tanks, if they wish, for both ground water and surface water systems.

States would need to add a frequency for cleaning and inspection that, if exceeded, would trigger a significant deficiency.

For example: EPA has given WY systems a one year warning that any system that has not cleaned and inspected its tank in the last 5 years will trigger a significant deficiency.

This would put the system on an enforceable schedule to clean and inspect its tank.

This would create a backstop and go a long way to preventing waterborne disease outbreaks from occurring for this reason.