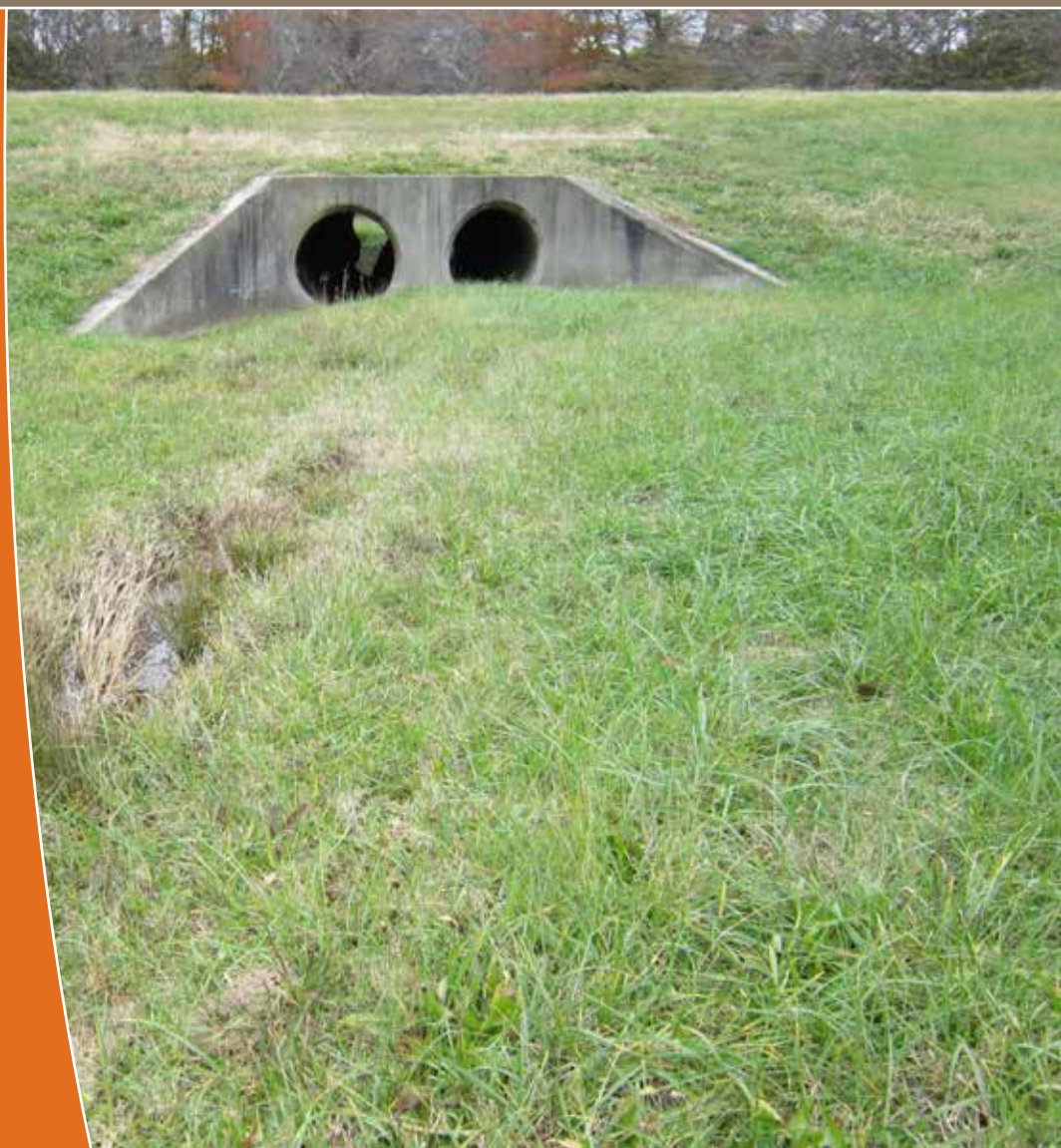
Service Life of Aluminized Type 2 Coated Steel Pipe: Predictions vs. Actual



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The last comprehensive inspection of the metal pipe test site on the Natchez Trace Parkway was documented in Report No. FHWA-RD-97-140, titled *Durability Analysis of Aluminized Type 2 Corrugated Metal Pipe* from inspections that dated October 1994 to December 1996. The American Concrete Pipe Association (ACPA) performed an inspection on November 12, 2014 and the findings are presented herein.

The pipe culverts in question are, at the time of this inspection, approximately 33 years old. This inspection consisted of visual observations of the inside (water side) of the culverts. Usually the water side of metal pipe experience earlier and greater wear than the soil side because of service conditions (including abrasion), oxygen exposure, and replenishment. The lowest water pH and resistivity for those sites as shown in the aforementioned report are 7.0 and 2609 respectively. Most are higher than 7.0 and 5000 and, therefore, not considered harsh conditions by traditional environmental criteria. It is apparent that abrasion is a factor and should be considered as such in any metal pipe durability assessment. The noted abrasion levels (bedload) are consistent with previous reports except for Mile 310.6 N which was previously reported as minor and is shown as "none" in this report.

Mile 312.4 Parallel Pipe

These 42" diameter Aluminum and Aluminized Type 2 parallel pipe have standing water and no bedload. They are experiencing minimal to minor corrosion. It is difficult to observe the condition of the invert because of the standing water. This installation is in a turnout/parking area and not on the main highway.

Mile 312.4 Single Pipe

This 18" diamter Aluminized Type 2 pipe is dry most of the time and is in good condition. This culvert is in a turnout/parking area and not on the main highway.

Mile 311.9 N

This 72" diameter Galvalume pipe is experiencing minor bedload and corrosion for approximately 40" across the invert with minor perforations. Because of terrain conditions at the inlet end, this culvert is carrying more water than the parallel pipe 311.9 S (which has been the case for almost the entire service life).

Mile 311.9 S

This 72" diameter Aluminized Type 2 pipe is experiencing minor bedload and corrosion for approximately 12" across the invert.

Mile 310.6 N

This 60" diameter Aluminized Type 2 pipe has no bedload and minor corrosion. There are perforations for approximately 18" across the invert.

Mile 310.6 S

This 60" diameter galvanized and bituminous coated pipe is experiencing minor bedload and approximately 36" of rust across the invert. For approximately the first 10' of culvert on the inlet end, approximately 24" across the invert is completely gone. Because of terrain conditions at the inlet end, this culvert is carrying much more water and bedload than the parallel pipe 310.6 N (which has been the case for almost the entire service life).


Mile 310.6 S


Mile 310.6 S

Mile 310.4*

This 54" diameter Aluminized Type 2 pipe has no bedload and the coating is gone in spots with some rust in the invert and crown. *This is mistakenly shown as 310.2 in FHWA-RD-97-140. There is not a culvert at 310.2.

Mile 310.1

This 72" diameter Aluminized Type 2 pipe is experiencing moderate abrasion and there is approximately 30" of corrosion across the invert with approximately 18" of invert fully perforated. The pipe is considerably distorted (deflected) at the 1:00 o'clock position when looking upstream.


Mile 310.1

Mile 310.0

This 72” diameter Aluminized Type 2 pipe had failed and had just undergone rehabilitation with a 50” diameter Snap-Tite liner prior to this inspection (construction clean-up still in progress at the time of this inspection).

Mile 309.5

This 30” diameter Aluminized Type 2 pipe has no bedload and the aluminum coating in the invert is fully corroded (gone). There are minor perforations along the entire barrel length.

Mile 309.4

This 42” diameter Aluminized Type 2 coated steel pipe is experiencing moderate abrasion and there is approximately 18” of corrosion across the invert with approximately 6” of invert fully perforated.


Mile 309.4


Mile 309.4

The following table contains the inspection details.

Natchez Trace
CMP Inspection November 12, 2014

Mile Marker	Type of Pipe	Pipe Gage	Dia.	Bedload	Age Years	Comments
312.4 E	Al Type 2	16	42”	None	33	Standing water, minor corrosion.
312.4 W	Aluminum	14	42”	None	33	Standing water, minor corrosion
312.4 Single	Al Type 2	16	18”	None	33	Dry, good condition.
311.9 N	Galvalume	16	72”	Minor	33	Corrosion across 40” of the invert. Also, minor perforations at invert.
311.9 S	Al Type 2	16	72”	Minor	33	Approximately 12” of corrosion across invert of pipe.
310.6 N	Al Type 2	16	60”	None	33	Minor corrosion and perforations for approximately 18” across the invert.
310.6 S	Galv. Bituminous Coated	16	60”	Minor	33	Approximately 36” rusting across invert with 24” completely gone for the first 10’ of the inlet, which appears to be from abrasion and corrosion.
310.4*	Al Type 2	16	54”	None	33	Coating gone in spots with some rust in invert and crown.
310.1	Al Type 2	16	72”	Moderate	33	Approximately 30” along width of invert corroded with 18” of that fully perforated. Pipe is considerably distorted (deflected) at the 1:00 o’clock position when looking upstream.
310.0	Al Type 2	16	72”		33	Recently rehabilitated with 50” diameter liner.
309.5	Al Type 2	16	30”	None	33	Aluminum coating in invert gone and minor perforations along the entire barrel length.
309.4	Al Type 2	16	42”	Moderate	33	Approximately 18” of corrosion across the invert with 6” of that fully perforated due to abrasion and corrosion.

* This is mistakenly shown as 310.2 in FHWA-RD-97-140. There is not a culvert at 310.2.
Aluminized Type 2 (Al Type 2)

It is not the intention of this report to enter into a long discussion of the history of charts for estimating average service life. However, a brief discussion is necessary to explain some of the different predictions shown in the following table.

Predictions per the original California Chart are not included because the pH conditions at these sites are too high and considered not corrosive. The original California Chart was based on "acidic" conditions with pH less than 5.8 (highest pH in chart is 6.0). The chart has been changed considerably over the last several years so that the results reflect a substantially longer service life even though some refer to the current charts as the "California Chart". The following shows the differences of the various prediction charts in use today.

The Corps of Engineers (COE) chart uses formulas to create the prediction curves for a galvanized coating. The formulas use a constant value of 17.24 when the pH ≤ 7.3 and a constant value of 1.84 when the pH > 7.3. A multiplier of 2.0, or larger depending on gage, is then applied to predict additional years expected for an Al Type 2 coating. The current American Iron And Steel Institute (AISI) chart uses the same formulas as used in the development of the COE chart but with higher constant values to indicate a much longer service life. The values, based on the pH, are **35.85/3.82** and the document states that Al Type 2 will last longer than galvanized (hence the plus sign "+" in the following table). The FHWA Federal Lands Highway (FLH) chart uses constant values of 22.41/2.39 for galvanized and a multiplier of 2.0 for Al Type 2. It should be noted that the estimates are **average** service life, not minimum.

Service Life Predictions (years)

Culvert	COE	AISI Current*	FHWA FLH
312.4 E (Al Type 2)	68	75+	92
312.4 W (Alum)			
312.4 Single (Al Type 2)	58	61+	78
311.9 N (Galvalume)	55	115	72
311.9 S (Al Type 2)	130	136+	170
310.6 N (Al Type 2)	80	87+	106
310.6 S (Galv. Bit. Ctd.)	37	80	47
310.4 (Al Type 2)	88	95+	116
310.1 (Al Type 2)	94	100+	126
310.0 (Al Type 2)	86	90+	114
309.5 (Al Type 2)	123	128+	160
309.4 (Al Type 2)	84	90+	112

**Modern Sewer Design*, a publication of AISI, uses the current AISI chart and a multiplier of 1.3 for Al Type 2. Therefore, the plus sign (+) could conceivably be replaced with a multiplier of 1.3.

Conclusion

The culvert at mile marker 310.0 collapsed and was lined (rehabilitated) with Snap-Tite in its 33rd year. The culverts at mile markers 310.6 South, 310.1, and 309.4, which appear to be nearing the end of their service life, will likely need repair or replacement in the near future (we recommend owner inspection for further action). Therefore, these culverts did not meet the service life predictions. Of the predictions in the above table, the COE predictions are the closest. If the multiplier of 2.0 or greater for Al Type 2 is disregarded, then the COE predictions would be a lot closer to reality. For example, the prediction for the culvert at mile marker 310.0 would be 43 years instead of 86 and it had to be lined (rehabilitated) at 33 years. Additionally, the COE prediction of 37 years for the culvert at 310.6 South, which is **Galvanized** and Bituminous Coated, is closer to reality and is experiencing approximately the same service life as the Al Type 2 culvert at mile marker 310.0 in similar environmental conditions.

Recommendations

The Ocean City Research Corp. report, *Durability Analysis of Aluminized Type 2 Corrugated Metal Pipe*, FHWA-RD-97-140, includes the following statement (in regards to the comparison of Al Type 2 to galvanized) in the Conclusions: **"Under extreme conditions, it is expected that the materials will perform in a relatively similar manner (i.e., last a long time or fail rapidly)"**. Per Report No. FHWD-RD-97-140, the conditions at this site are neutral. Some of these culverts are "extreme" in a good way and others would be considered average because of the presence of bedload. Considering the condition of the pipe versus the service life predictions, the Al Type 2 pipe performance does not warrant a multiplier over galvanized pipe. Therefore, the prediction chart used by the COE, with the constant values in the formulas of 17.24 (pH ≤ 7.3) and 1.84 (pH > 7.3), should be used by AISI and others. Additionally, the multiplier for AL Type 2 should be deleted.

Abrasion has contributed to the deterioration of some of these culverts while none are experiencing what is termed as "severe abrasion". At some point, the metal pipe industry changed the abrasion criteria for corrugated metal pipe. **Moderate** abrasion velocity used to be 5-8 fps and it is now 5-15 fps. **Severe** abrasion velocity used to be "greater than 8 fps" and it is now "greater than 15 fps". NCHRP Report 50, *Durability of Drainage Pipe*, includes the following statements: "**Doubling the velocity of a stream carrying a bedload increases its abrasive power approximately fourfold. Under the same conditions, its ability to transport rock fragments of a given size is multiplied as much as 32 times**". Therefore, the velocities for abrasion levels should be changed to the older, more conservative values of 5-8 fps for **Moderate** abrasion and "greater than 8 fps" for **Severe** abrasion. The service life predictions would be more accurate with the development of a method that incorporates abrasion, with more detail, into the present system.

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