Investigation of Equipment Accidents

Gregory Brown PE ACTAR
Oregon Dept. of Transportation

WSHEMA Utah

August 28th, 2013

Preliminary Steps

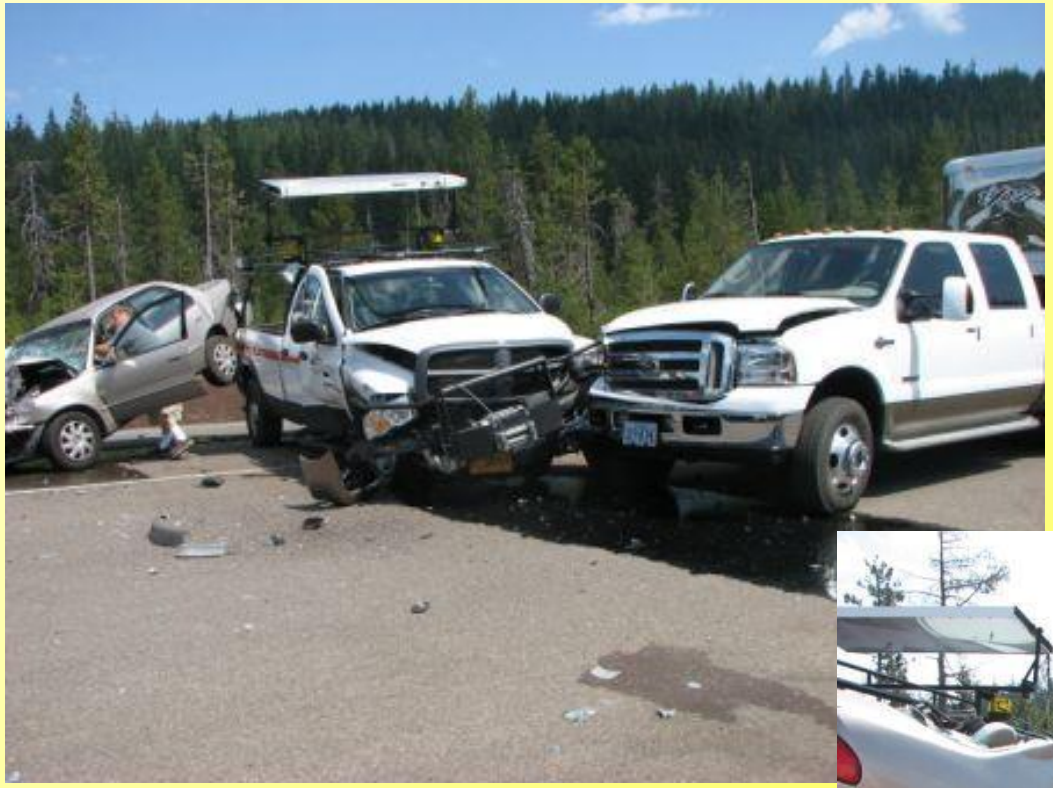
- Follow Emergency/Accident Plan
- Make Accident Scene Safe
- Notify Proper Authorities (Law Enforcement)
- Get Road Open to Traffic
- Designate a lead contact for the investigation
- Coordinate with Public Information Officer
- Start Investigation Process

Why perform an Accident Investigation?

- Reduce future accidents.
- Identify equipment defects.
- Legal litigation likely.
- Improve equipment design.
- Proposed Legislation.
- Story match the wreck?
- Accountability or Assign blame.

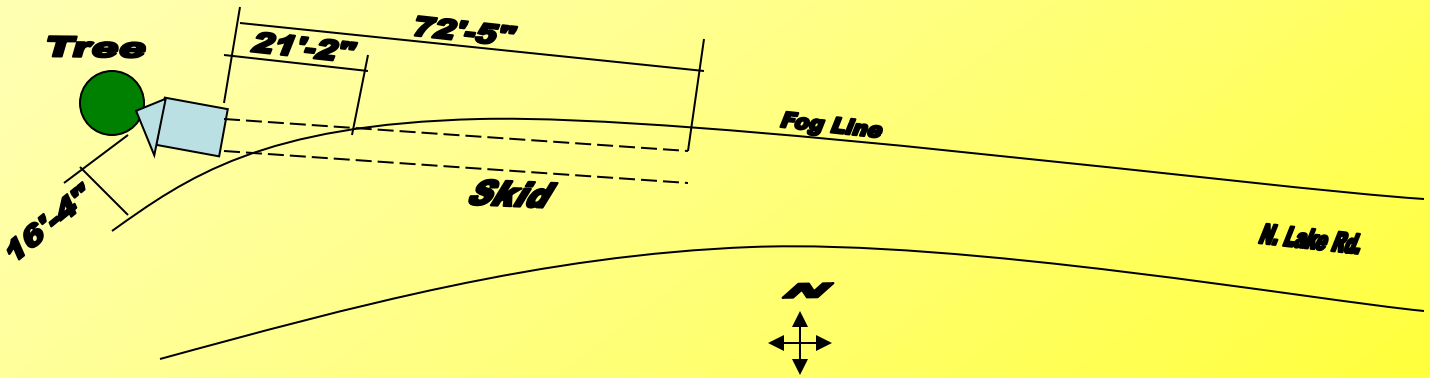
Truck got hit by a tree?

Don’t know what happened?



Equipment

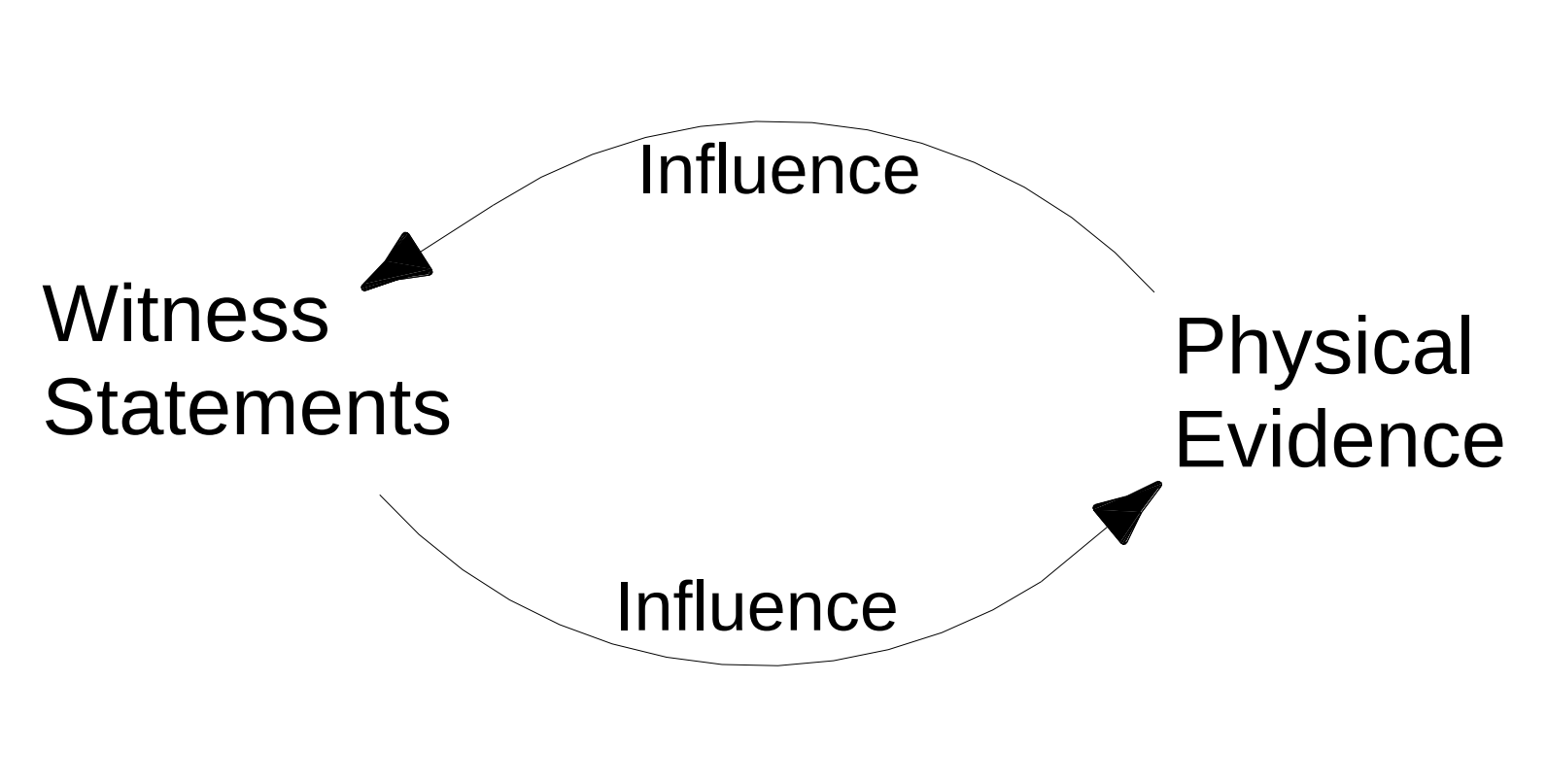
- Digital Camera.
- Measuring Tape(s).
- Survey Instrument?
- Drawing tools to construct a sketch.
- CAD/Computer Reconstruction Software.



External Resources

- State Police/County Sheriff's office
- Employee Safety Officer
- Shop Mechanic – Repair Manuals
- Engineer – Vehicle Specifications
- Incident Reports
- Dr. Reports

Evidence


Influence
Witness Statements
Physical Evidence
Influence

Interviews

Don’t Ask

- What Happened?

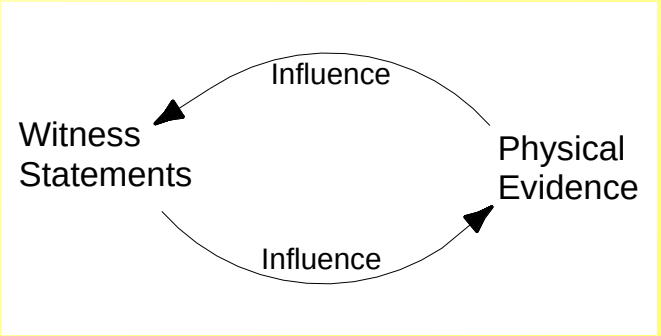
Do Ask

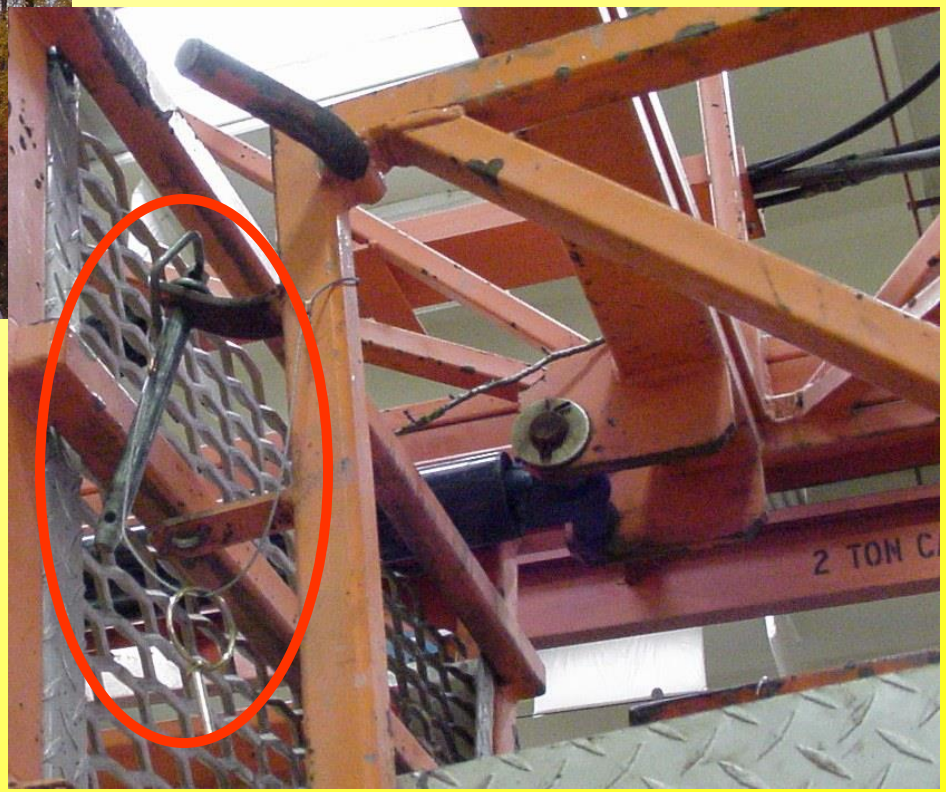
- … what did you See? Hear? Smell?
- Start before the event and extend past it.
- Have the witness walk through step by step.
- End with opinion questions, Who or what caused…

Physical Evidence

- Pictures – High Resolution
- Start far away → Move closer
- Take lots of pictures
- Show placement with fixed permanent object.
- Critical Pictures (Time Sensitive)
  - Skid Marks
  - Pavement Damage
  - Debris Field
  - Damaged road markings/guardrail
  - Damaged signs/signal equipment
  - Vehicle/Equipment???

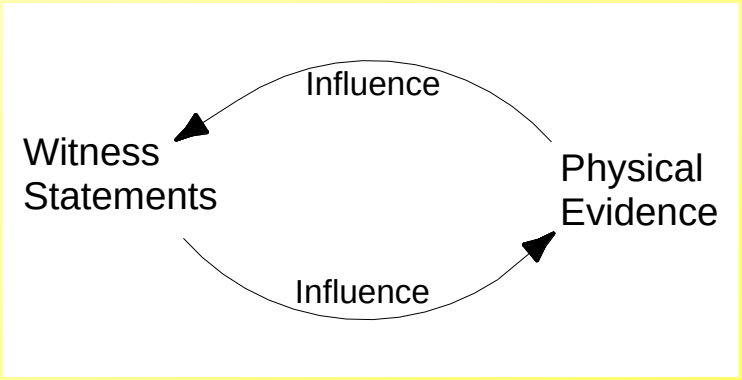
Case Study





Under Bridge Inspection Platform.

Case Study



Vehicle fire, recently installed radio.

Basic Reconstruction

- Knowns
  - Final resting place
  - Rough starting point
  - Equipment Damage

- Work Backwards
  - Use evidence
  - Establish position/time line
  - Use model to check damage against storyline

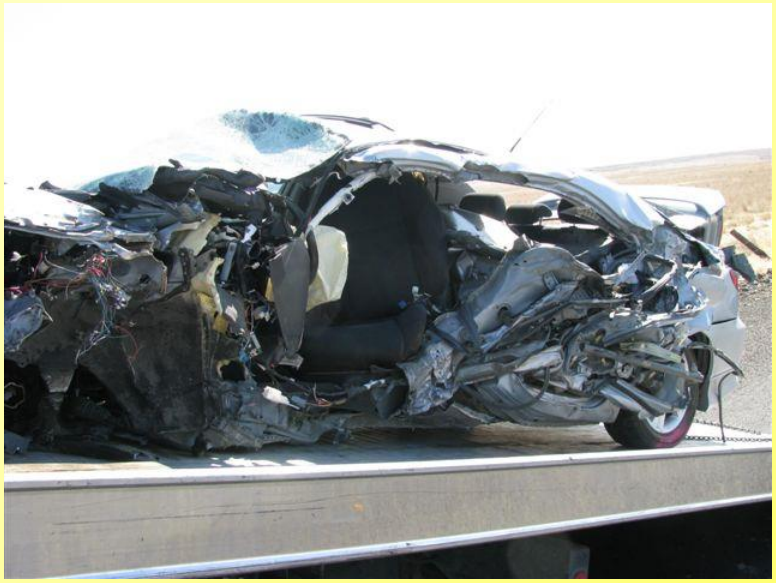
Now review reconstruction going forward and compare it with all the evidence.

Reporting the Investigation

- Personalize the Report.
- How will the information be used?
- Desired Tone?
- Evaluate Training Opportunities.
- Restore Crew Confidence.

Understanding Collisions

Energy Method (basic approach)



Newton's law of conservation of energy:

Energy can't be created or destroyed

Homeland Security Test

Kinetic Energy

Tanker Truck

Ke = ½ X m X V^2 = W X S^2 /30

Tanker Truck Weight = 100,000 lbs.

Speed = 60 MPH

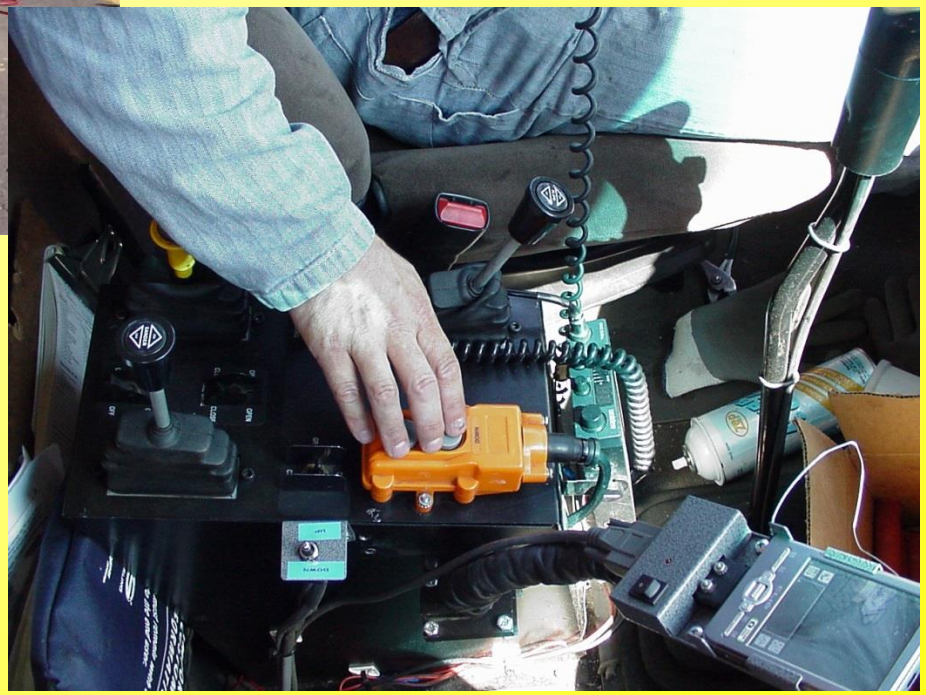
Ke = 12M ft*lbs.

vs

KE = WE (½ X m X V^2 = F X D)

Motorcycle Energy Transfer
Kinetic → Potential → Work

Controls were hard to reach?



Other Distractions?

Bucket Truck Flip

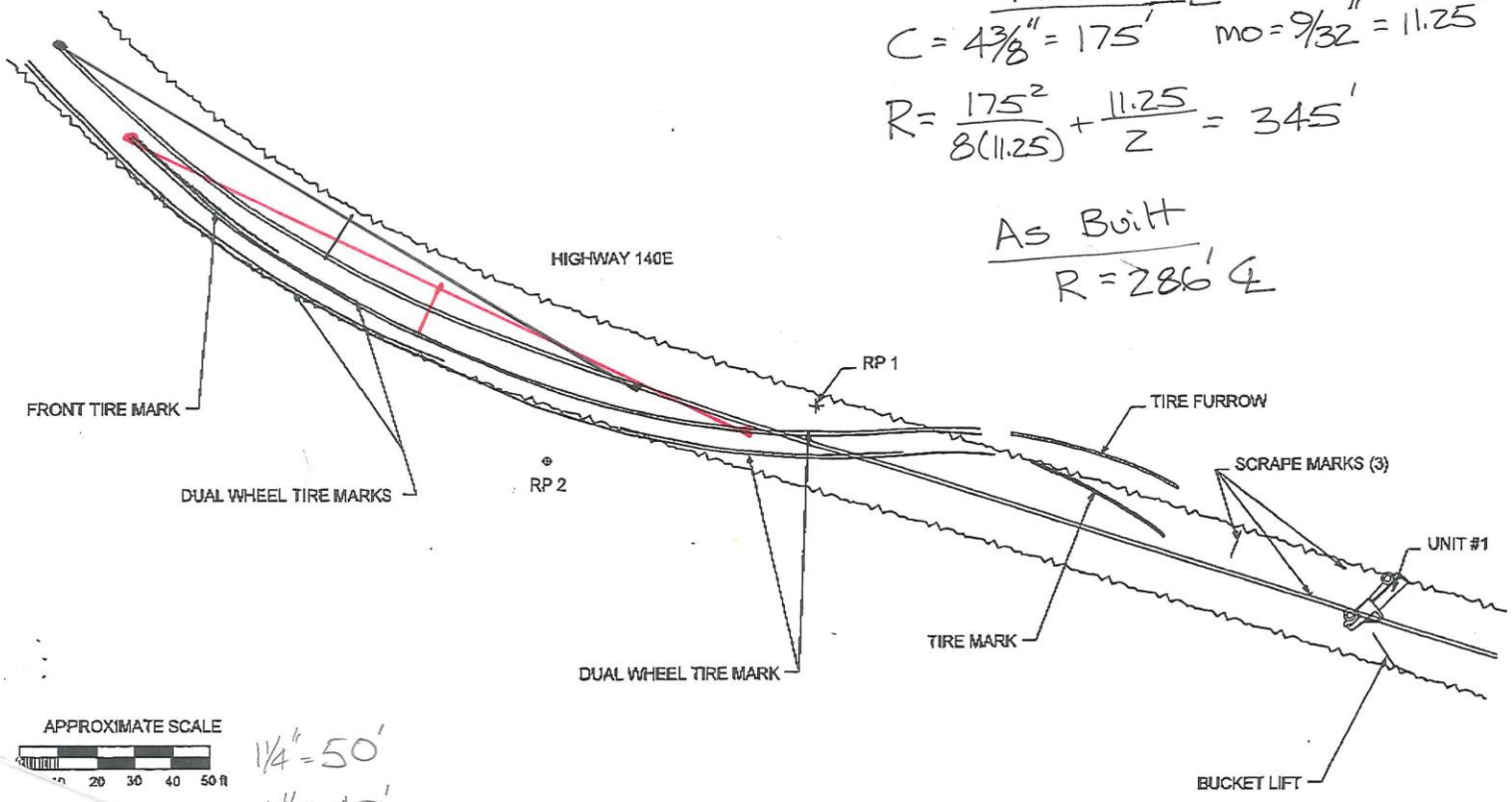
INJURY MOTOR VEHICLE CRASH
State Route 140E, MP 32
August 30, 2011
SP 11-324223

Diagram by: Trooper Aaron Boyce
Reviewed by: Sr. Trooper Jeffrey C. Willis

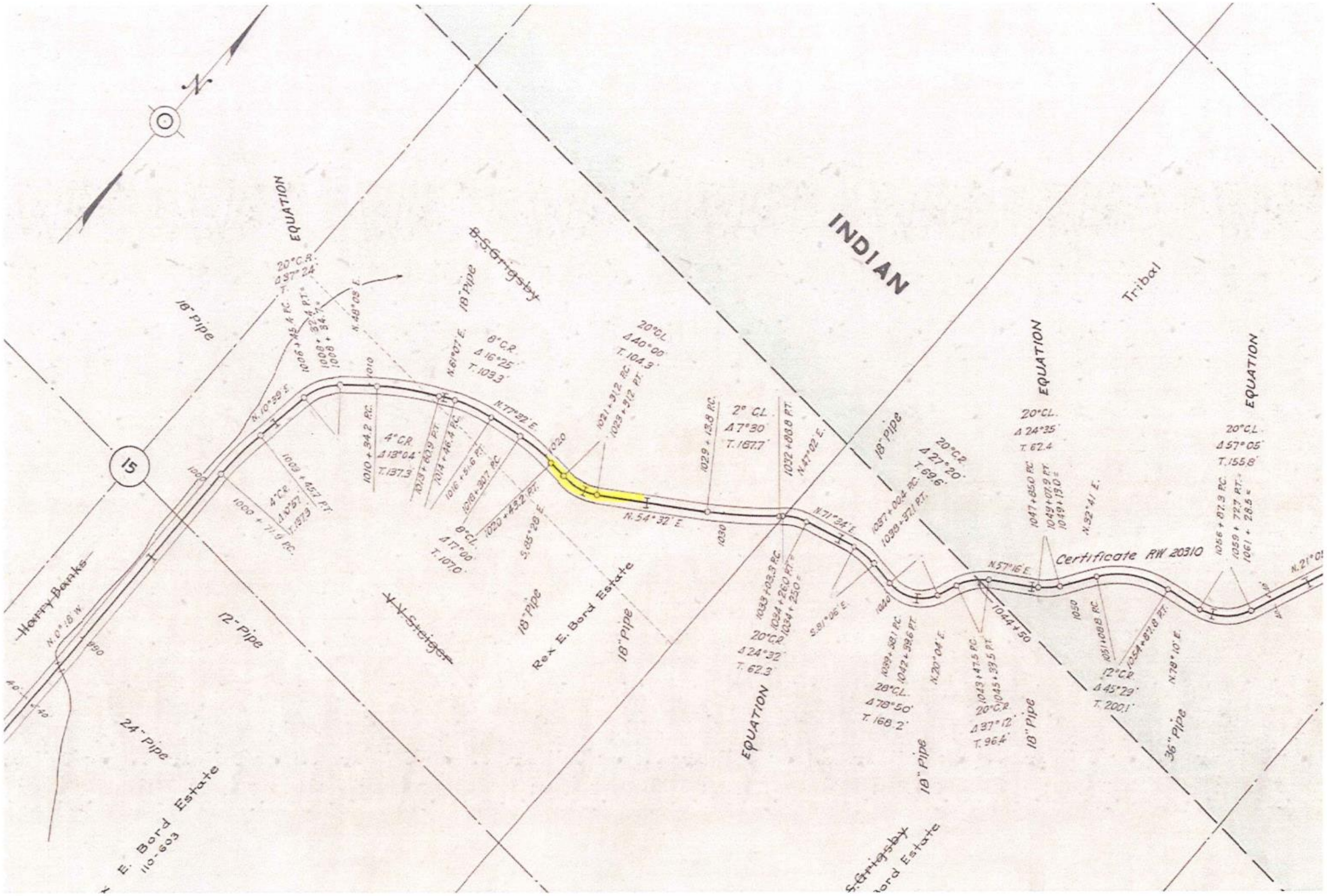
Skid (inside track)
$C = 4\frac{1}{2}'' = 180'$
$mo = 11/32'' = 13.75'$
$R = \frac{C^2}{8mo} + \frac{mo}{2} = \frac{180^2}{8(13.75)} + \frac{13.75}{2} = 301'$

Road ℄
$C = 4\frac{3}{8}'' = 175'$ $mo = 9/32'' = 11.25'$
$R = \frac{175^2}{8(11.25)} + \frac{11.25}{2} = 345'$

As Built
$R = 286'$ ℄



$1\frac{1}{4}'' = 50'$
$1'' = 40'$



N
INDIAN
Tribal
EQUATION
20°C.R.
Δ 37° 24'
18" Pipe
B.S. Grigsby
18" Pipe
6°C.R.
Δ 16° 25'
T. 103.3'
20°C.L.
Δ 40° 00'
T. 104.3'
N. 10° 39' E.
N. 61° 07' E.
N. 77° 32' E.
15
4°C.R.
Δ 13° 04'
T. 137.3'
4°C.R.
Δ 10° 57'
T. 137.3
1000 + 71.9 P.C.
1003 + 45.7 P.T.
1010 + 34.2 P.C.
1013 + 60.9 P.T.
1014 + 46.4 P.C.
1016 + 54.6 P.T.
1018 + 30.7 P.C.
1020 + 43.2 P.T.
1021 + 31.2 P.C.
1023 + 31.2 P.T.
8°C.L.
Δ 17° 00'
T. 107.0'
S. 85° 28' E.
N. 54° 32' E.
2° C.L.
Δ 7° 30'
T. 187.7'
1029 + 13.8 P.C.
1032 + 88.8 P.T.
N. 47° 02' E.
18" Pipe
20°C.R.
Δ 27° 20'
T. 69.6'
N. 71° 34' E.
20°C.L.
Δ 24° 35'
T. 62.4
20°C.L.
Δ 57° 05'
T. 155.8'
EQUATION
N. 57° 16' E.
Certificate RW 20310
N. 32° 41' E.
Harry Banks
N. 0° 18' W.
12" Pipe
V.V. Steiger
18" Pipe
Rex E. Bord Estate
18" Pipe
24" Pipe
Rex E. Bord Estate
110-603
EQUATION
20°C.R.
Δ 24° 32'
T. 62.3'
S. 81° 06' E.
28°C.L.
Δ 78° 50'
T. 168.2'
N. 20° 04' E.
18" Pipe
20°C.R.
Δ 37° 12'
T. 96.4'
1044 + 50
18" Pipe
12°C.R.
Δ 45° 29'
T. 200.1'
N. 78° 10' E.
36" Pipe
S. Grigsby
Bord Estate

Gregory Brown P.E. ODOT Fleet	K-Falls Accident (08/30/2011)	10/06/2011	1/1

Given: location @ MP 32, Hwy 140, near intersection w/ Whitetale Lane, Klamath Falls,

$f = .65$ (Fricke's "Traffic Accident Reconstruction")

Degree of Curve: 20°

Find: Minimum Travel Speed

Drawing: See ODOT "As Built" Map & OSP report & diagram

Assumptions: Dry Pavement (per OSP)
New Asphalt (per OSP)
Good Tire Condition (per vehicle inspection)
E. Bound travel (per operator statement)
Decline/Incline 2% (per ODOT digital video log)
& Super Elevation 2% (per ODOT video log)
Lane Width = 11'

Calculations:

$$R = \frac{5730'}{20°} = 286.5' \text{ @ road}$$

$\therefore$ Travel lane radius $= 286.5' + 5.5' = 292'$

$$\text{Speed} = 3.86\sqrt{R \cdot f} = 3.86\sqrt{292 \cdot .65}$$

$$= \boxed{53 \text{ M.P.H.}}$$

REGISTERED PROFESSIONAL ENGINEER
58811PE
Gregory Brown
OREGON
JULY 13, 1999
GREGORY A. BROWN

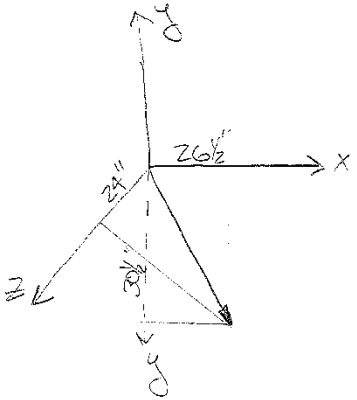
Expires: 12/31/2011

ACTAR # 1583
DPSST # 32011

Notes
1.) Used smallest radius obtained from three (3) sources. (See OSP Diagram & Calculations)

Excavator Trailer

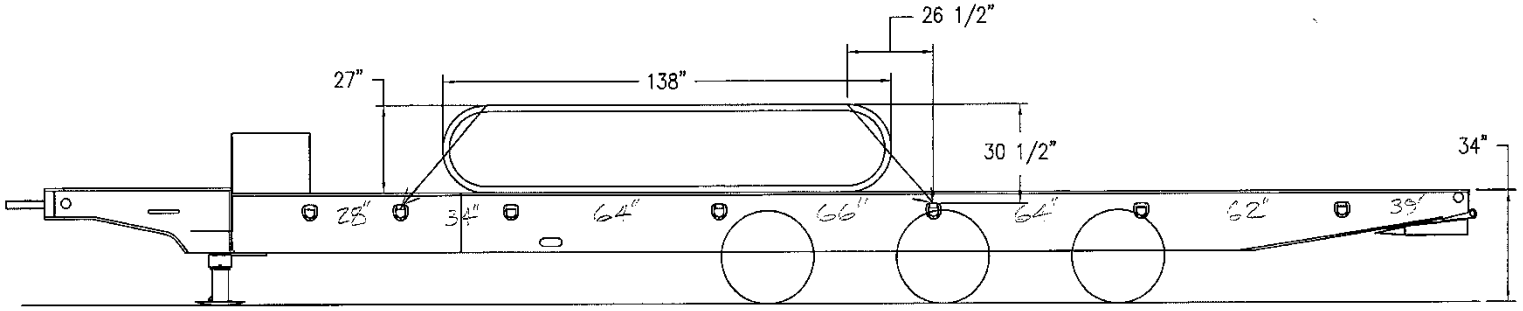
tie down



$L = \sqrt{26\frac{1}{2}^2 + 30\frac{1}{2}^2 + 24^2}$

$= 47"$

Unit vector: $(.56i + .65j + .51k)$



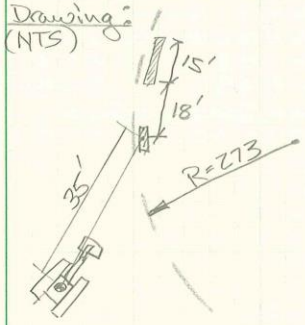
Gregory Brown P.E.	Excavator wreck	ODOT Fleet	1/1
04/27/11	Apiary Rd, Rainier OR		

Given: R = 273' (see map)
Wt = 28,000 lbs
Chain rating = 6600 lbs Tension
Chain Safety factor = 4:1
Road friction: .45*
Chain Vector: (.56i + .65j + .51k) (see tie down drawing)

Assumptions: Super elevation = Ø by observation
Grade ≤ 10% by observation
Neglect friction between excavator & trailer deck

find: Critical Speed Yaw
Chain failure speed

Drawing: (NTS)



Calculations: $V_c = 5.67\sqrt{r \cdot (1-G) \cdot f}$
$= 5.67\sqrt{273 \cdot (1-.1) \cdot .45} = 60$ fps or 41 MPH

Chain rating = R · SF
= 6600 · 4 = 26,400 lbs

Max chain pull = (26,400)(.51) = 13,464 lbs x 2 chains =
(resisting movement)
26,928 lbs

Centripetal Force of Excavator = $F = ma = \frac{28,000 \cdot V^2}{32.2 \cdot 273'} = 26,928$

$V = \sqrt{\frac{26,928 \cdot 273 \cdot 32.2}{28,000}} = 91$ Fps or 61 MPH

* lower table value used due to dirt & gravel on road from recent logging in area, as observed on 04/25/11.


CAUTION

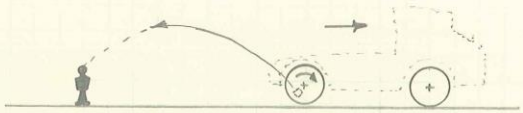

04/25/2011


04/25/2011


04/25/2011

Rock Fatality

Given:

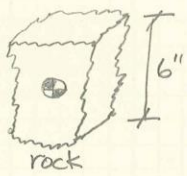


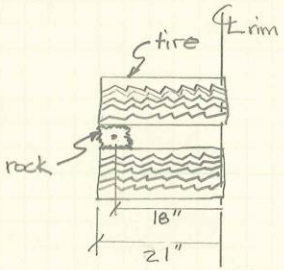
Fatal injury from rock cast off from rotating wheel.

Find: a. velocity of truck to create cast off.
b. direction when cast off occures.

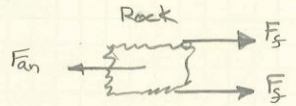
Assume: Wt rock = 20lbs
tire psi = 100 psi
rock length = 6"
tire Ø = 42"
area of rock in contact with tire = 9in²
f = .55*

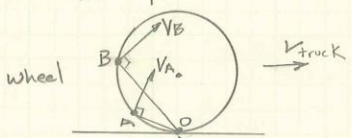
Drawing





F.B.D.





instantaneous center of zero velocity.

Calculations:

$F_f = 100psi \cdot 9in^2 \cdot .55 = 495\ lbs$

$F_{an} = 2F_f \leq 1000lbs = \frac{Wt\ an}{32.2\ ft/s^2} = \frac{20}{32.2} \cdot \frac{v^2}{r} = \frac{20}{32.2} \cdot \frac{v^2}{18"}$

$v = 170\ ft/s$ (Rock)

$v_{tire} = 21/18(170\ ft/s) = 198\ ft/s = 135\ mph$ ←

Rock can't be cast back toward rear of truck. ←

*Fricke "Accident Reconstruction"