Part 1

EXCAVATION AND GRADING PRACTICES PRIOR TO DEVELOPMENT OF GRADING CODES

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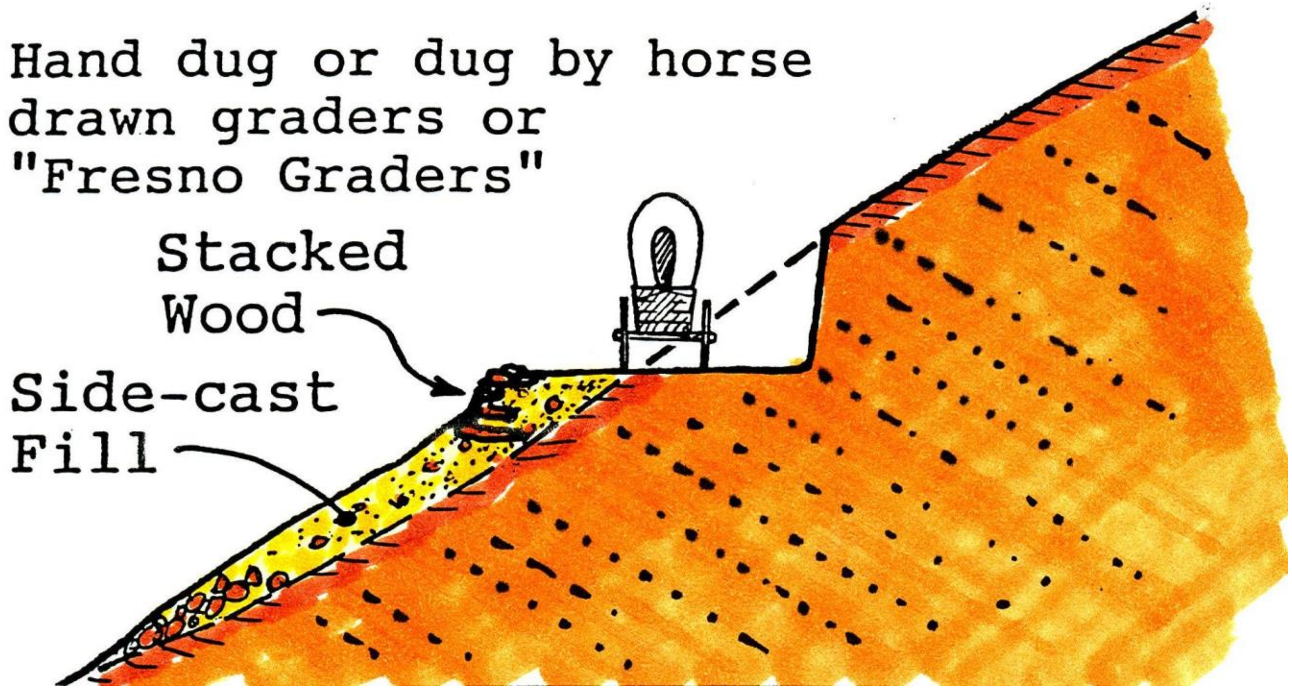
OLD ROAD CUTS AND FILLS



- Typical cut and fill techniques employed in the 19th Century. Private parties were given 20-year leases to construct and manage toll roads or bridges, so long as they maintained them.

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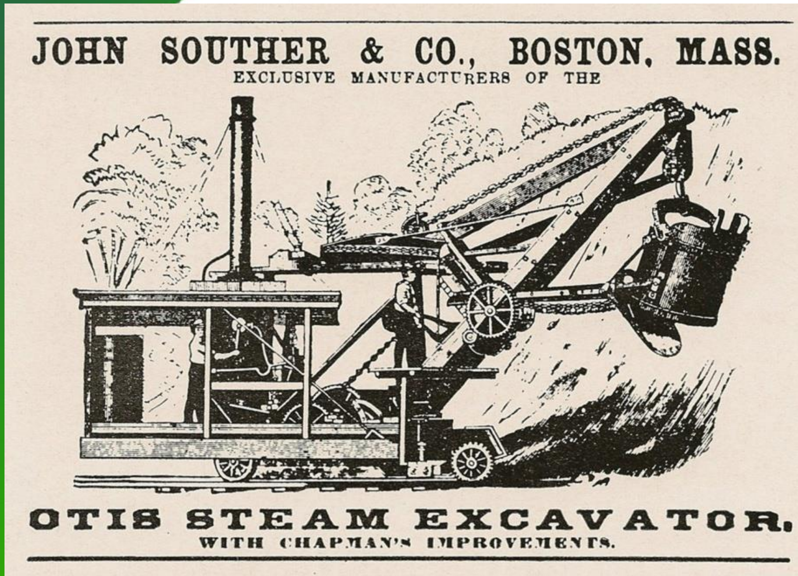
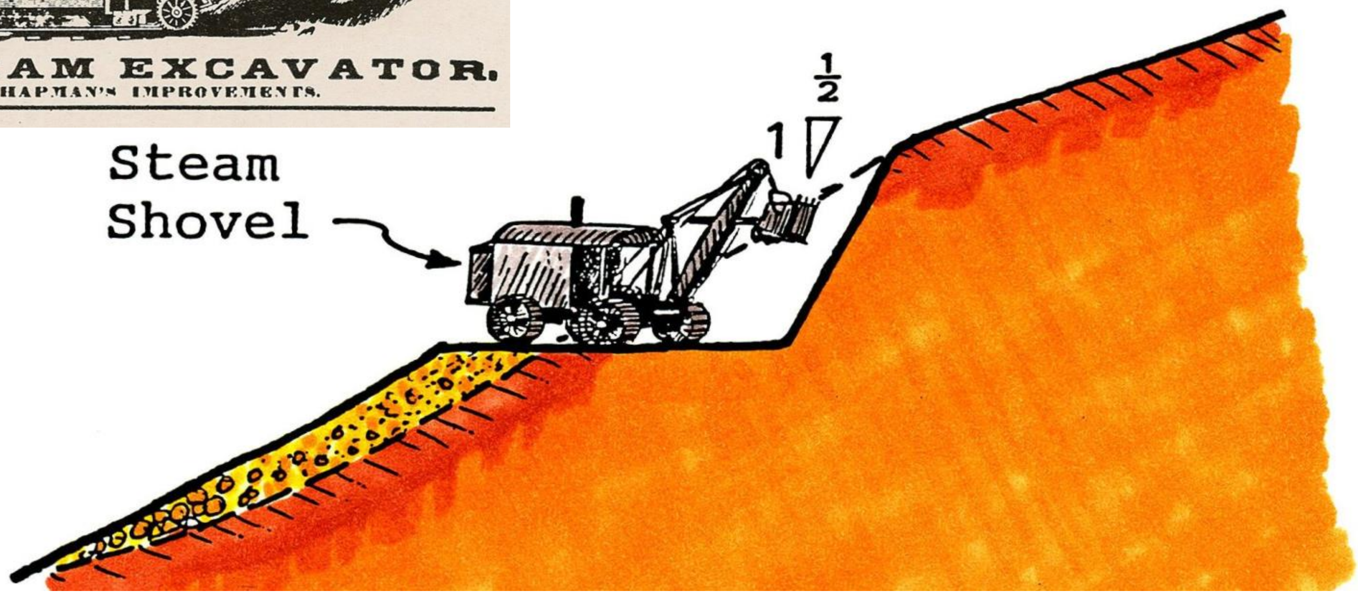
Fresno Scrappers

- Invented by Frank Dusy and Abijah McCall in 1885 in Selma, California, it was given the name “Fresno Scrapper” by James Porteous of Fresno, who adopted the design as superior that he had invented in 1882
- Pulled by four mules, Fresno Scrapers slowly overtook the grading business, spreading eastward
- By 1920 they were the most widely employed earth moving device in America, as well as the cheapest, selling for $30 to $40 apiece, depending on the model

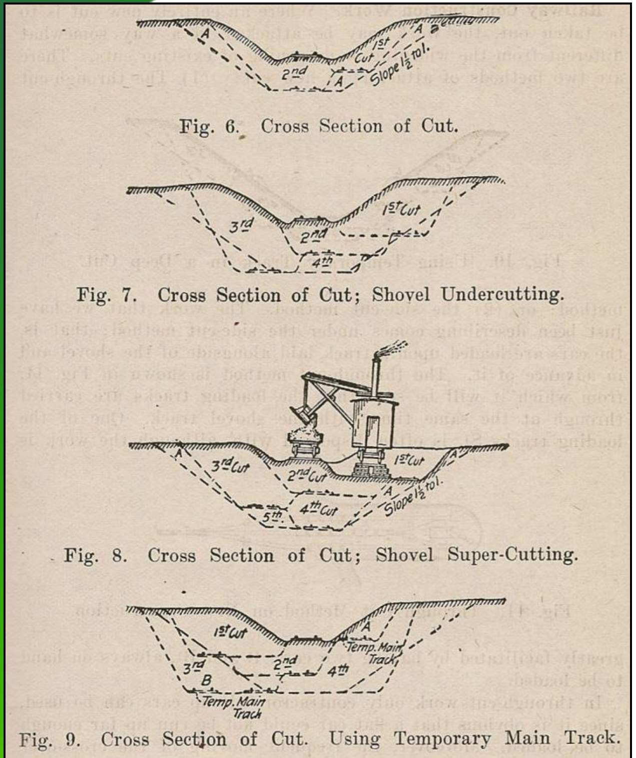


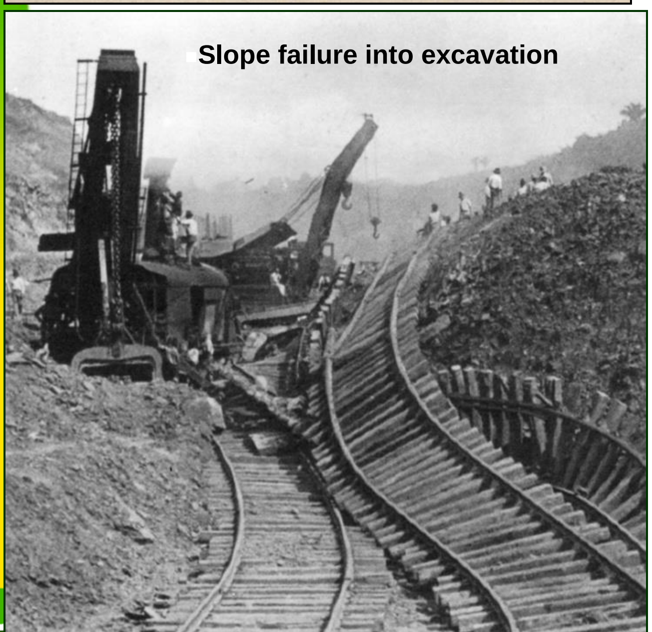
STEAM SHOVELS

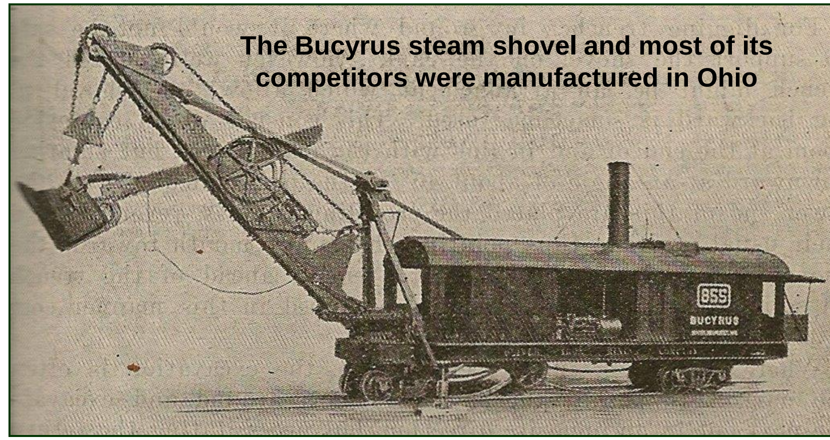


- **The steam shovel was patented in 1838, but not employed commercially until 1868, for use on the Union Pacific Railroad. From that date the major manufacturers were Otis, Osgood, Bucyrus-Erie, Harnischfeger (first gasoline powered), Koehring, P&H (first electric powered), and Lima Locomotive**.

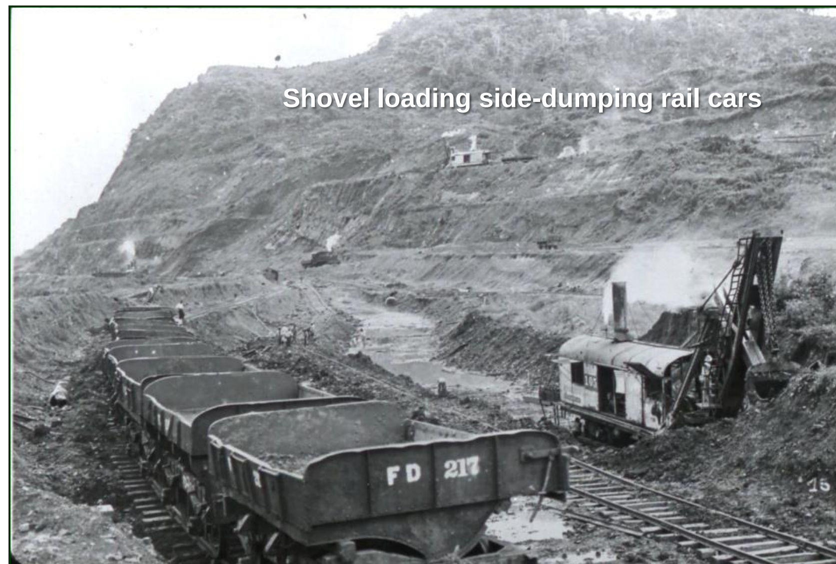
Rail-mounted Shovels




Slope failure into excavation

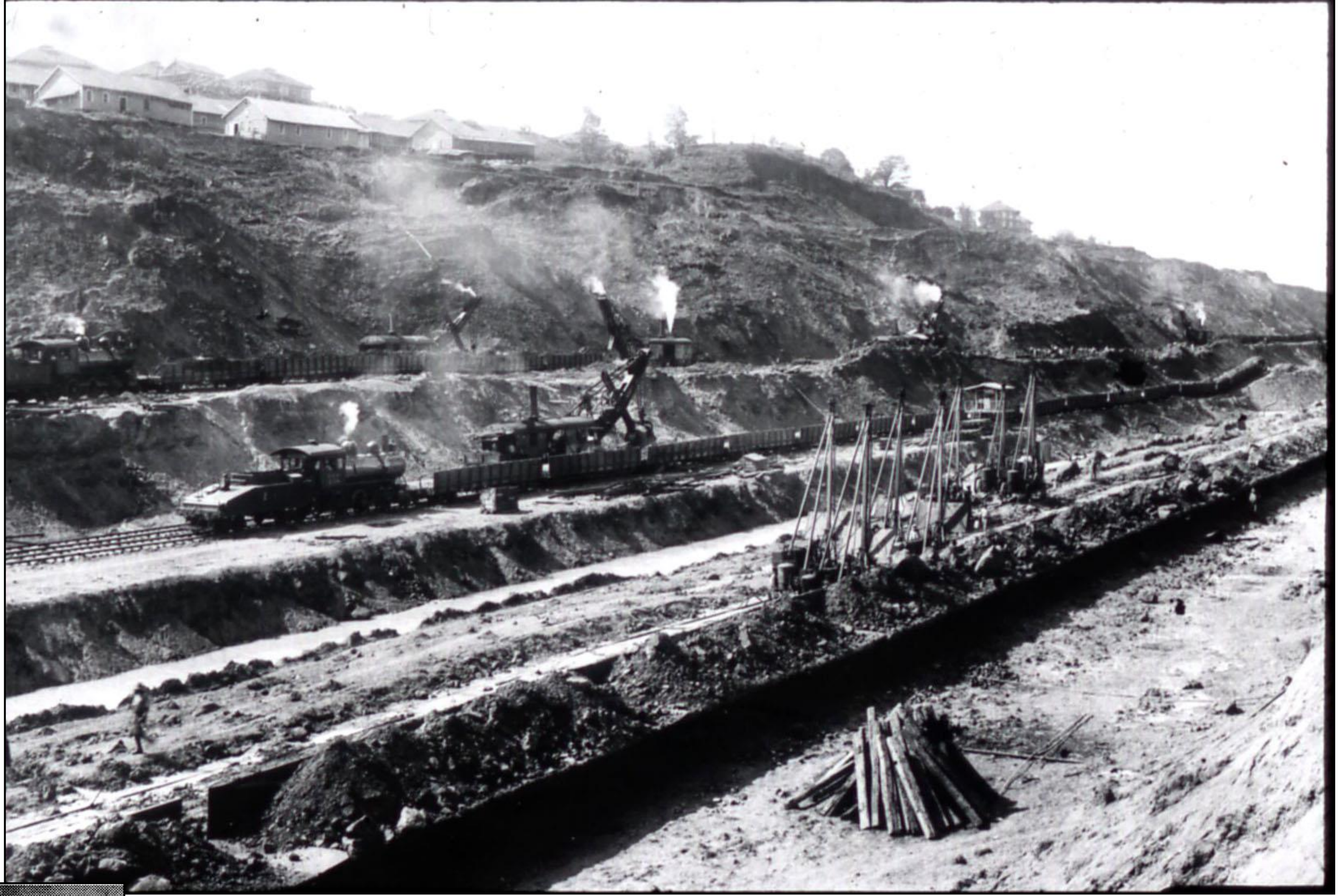


The Bucyrus steam shovel and most of its competitors were manufactured in Ohio



Shovel loading side-dumping rail cars

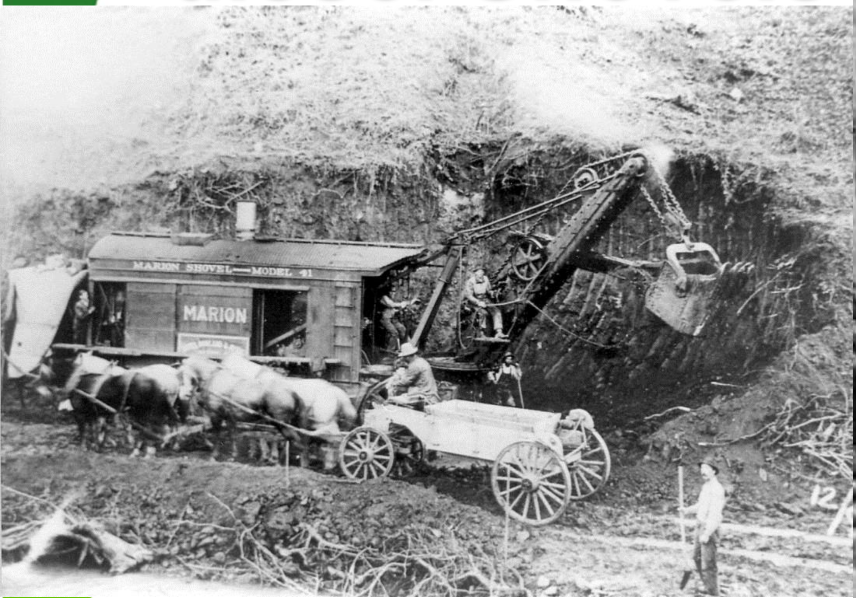
- Rail-mounted Bucyrus steam shovels reigned supreme in Panama during excavation of the canal between 1905-14



- John F. Stevens conceived the plan to construct a locked canal, using water from the Chagres River to create a vast inland lake.
- This reduced the required depth of excavations by 70 feet. The plan was favored by Teddy Roosevelt and approved by Congress on June 29, 1906.

- Looking into the gapping hole of the Panama Canal's deepest excavations, across the Continental Divide, as seen on May 17, 1913. Note 0.5:1 side slopes.
- The Americans ended up excavating 245 million yds^3, almost equal portions being dredged below water and excavated in the dry.

Gasoline and diesel Shovels



- Steam shovels had been employed for railroad construction since 1868. As automobiles began being mass produced in the early 20th Century, the demand for roads increased dramatically.
- Steam shovels were only used on the largest jobs, where rock excavation made the use of Fresno scrappers impractical.
- Left view shows excavation for San Pablo Dam in 1920, while image at right shows excavation of US Hwy 50 across Altamont Pass in 1939. Both sites are in the San Francisco East Bay.

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Tracked Shovels

- **By the early 1940s tracked shovels were the dominant tool used for heavy excavation for highways and quarries. All of these were cable-controlled until the mid-1950s.**

Increasing capacity and mobility

- By the end of the Second World War tracked shovels and mobile rock crushing plants had revolutionized the speed with which highways and airport runways could be constructed.

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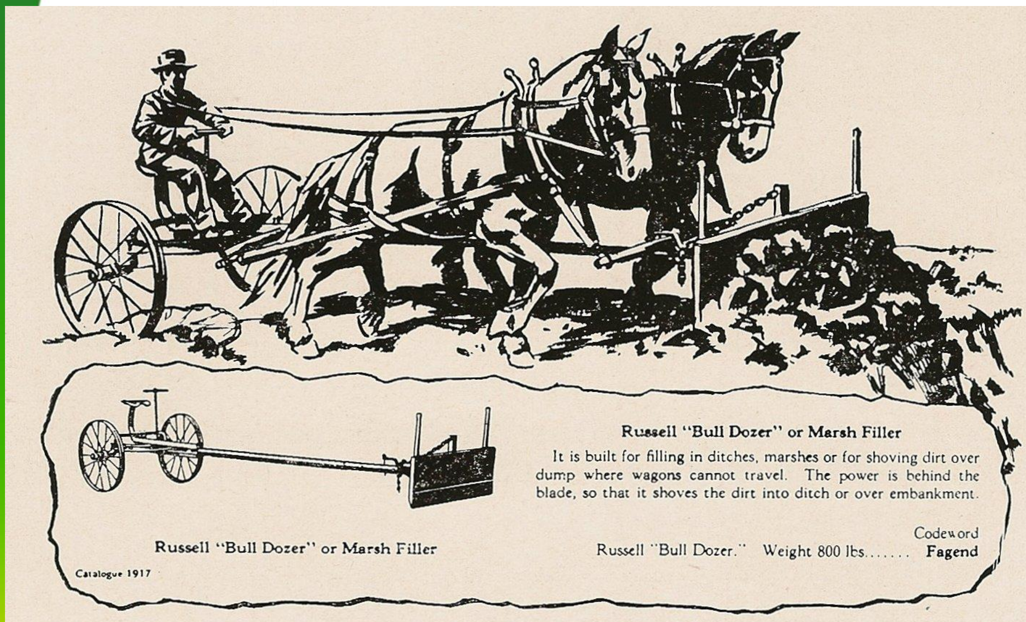
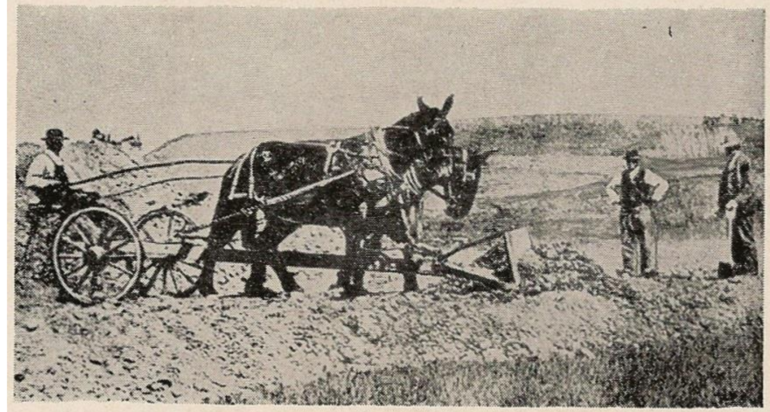
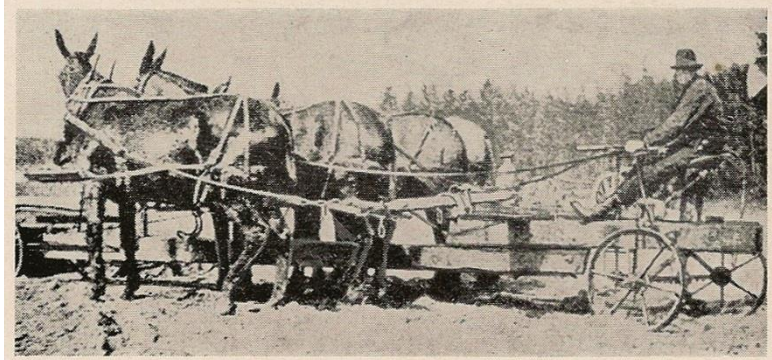
Bulldozers

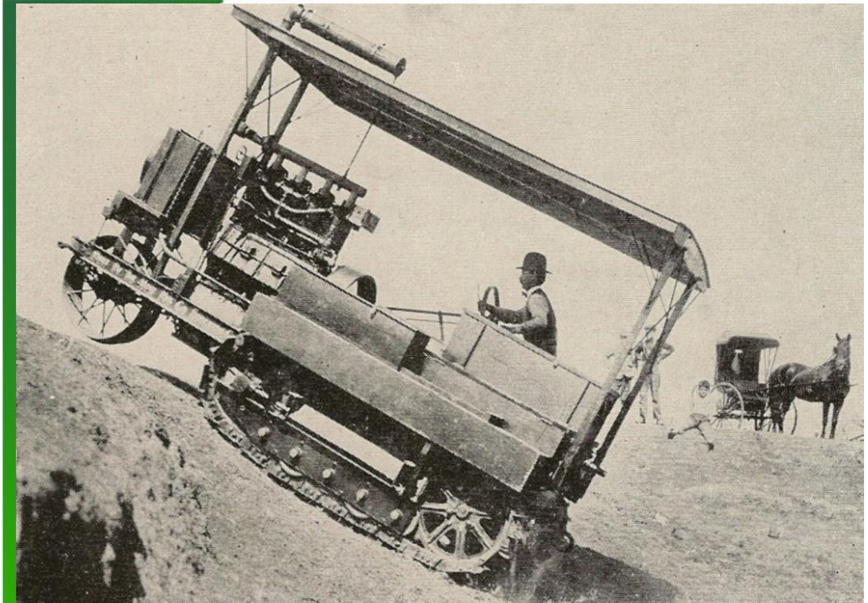




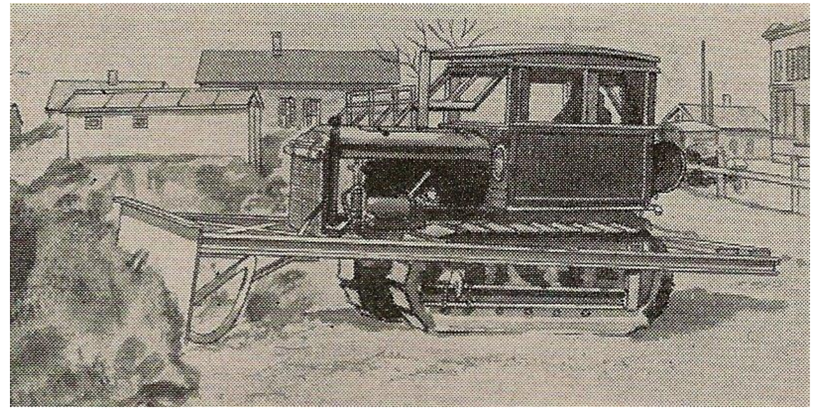


- **The Bulldozer was developed in the late 19th Century to grade railroad lines. Two bulls or horses (upper right), or up to 4 mules (lower right), could be employed to pull a wheeled caisson attached to a stiff arm connected to a flat blade, which extended out in front of the animals, as shown above. The advertisement from the Western Wheeled Scrapper Co., above left, is from 1917.**

Early Tracked Dozers



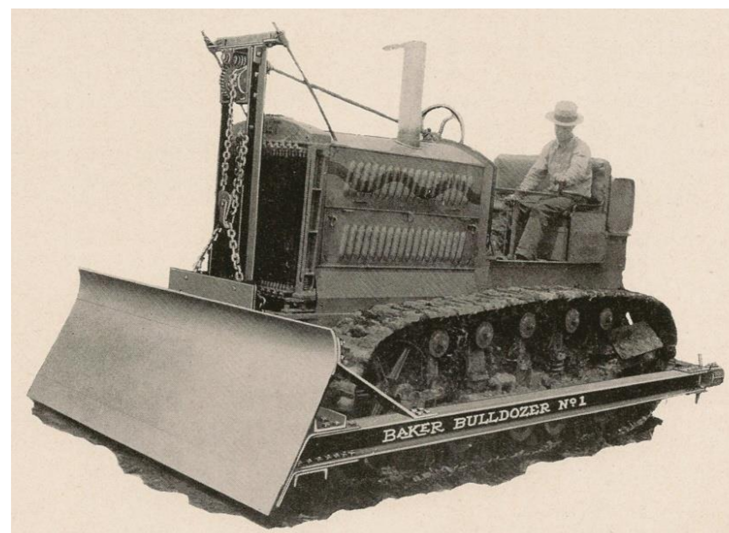
Holt's 1908 tractor climbing a slope



The LaPlant Choat tractor bulldozer appeared in 1923, but it lacked meaningful blade elevation and control

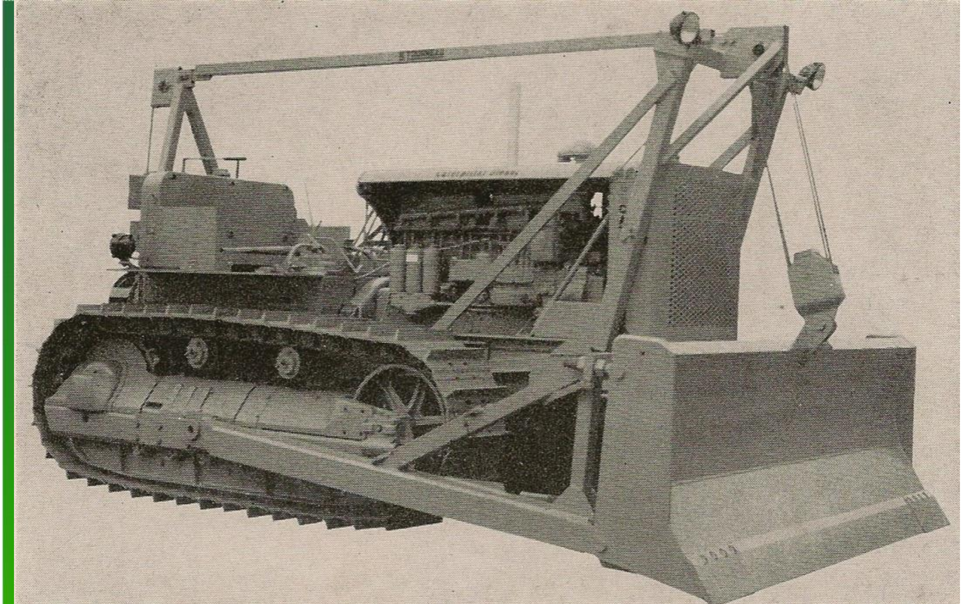
- **Between 1885-1908 Benjamin Holt of Stockton, California gradually developing a gasoline-powered self-laying tractor, like that pictured at upper left. It began simply as a means of motive power, to replace horses and mules.**

Caterpillar claims to have begun fitting tractor with dozer blades as early as 1921. This view shows a CAT 30 with an early LeTourneau dozer blade, circa 1932.



Baker Manufacturing of Springfield, Illinois' Dozer No 1, which used a chain hoist, appeared in 1927

Perfecting the tracked dozer



LeTourneau's cable and winch controlled dozer; which changed the earth moving business in 1928

Caterpillar-LeTourneau dozer with power-takeoff cable control at a dam site in Montana in 1937.

- **In 1928 LeTourneau began producing dozer blades for Caterpillar tractors, in Stockton, California**
- **At that time LeTourneau also introduced *cable and winch control* for lifting and tilting the big steel blades, which all their competitors adopted, soon thereafter.**
- **The power take-off winch (seen at lower left) using cable control became the dominant means of controlling the dozer blades until the adoption of hydraulic actuators, after the Second World War.**

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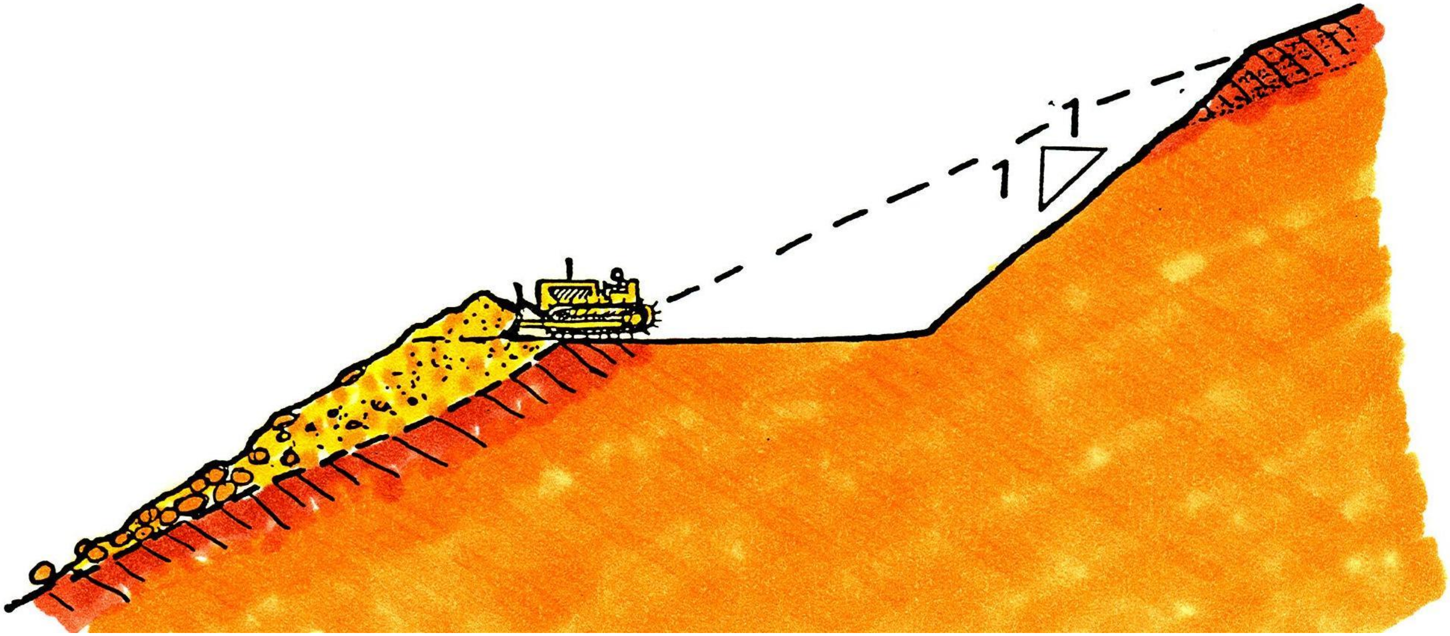
The tracked dozer allows rapid excavation and drifting

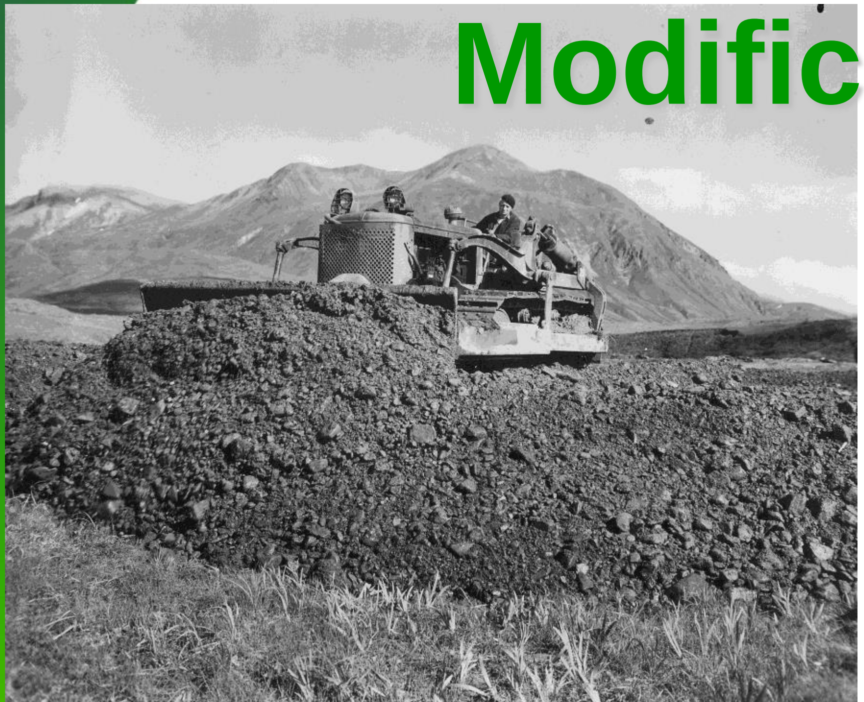


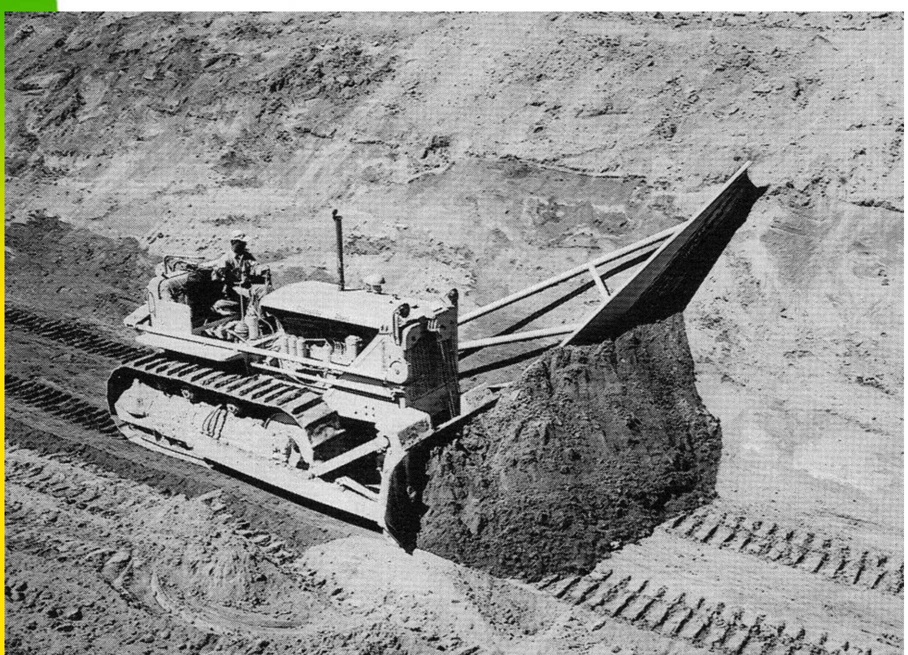
- LaTourneau pioneered the simple mechanisms that allowed dozer blades to be lifted, dropped, and angled downward, like a road grader.
- With that kind of control, tracked dozers could push, or "drift" loose earth and rock for a minimal cost, promoting an upsurge in road building activity during the 1930s and 40s.

Dozers at Hoover Dam

- **Tracked dozers played a staring role in the high-visibility Newsreels trumpeting the construction of the Boulder Canyon Project, between 1931-36**

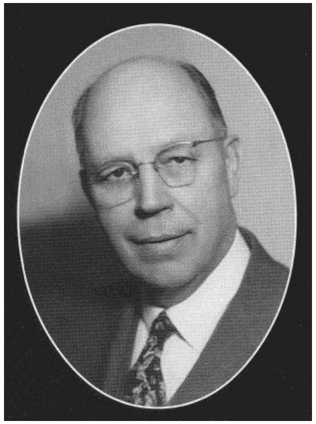
Modifications



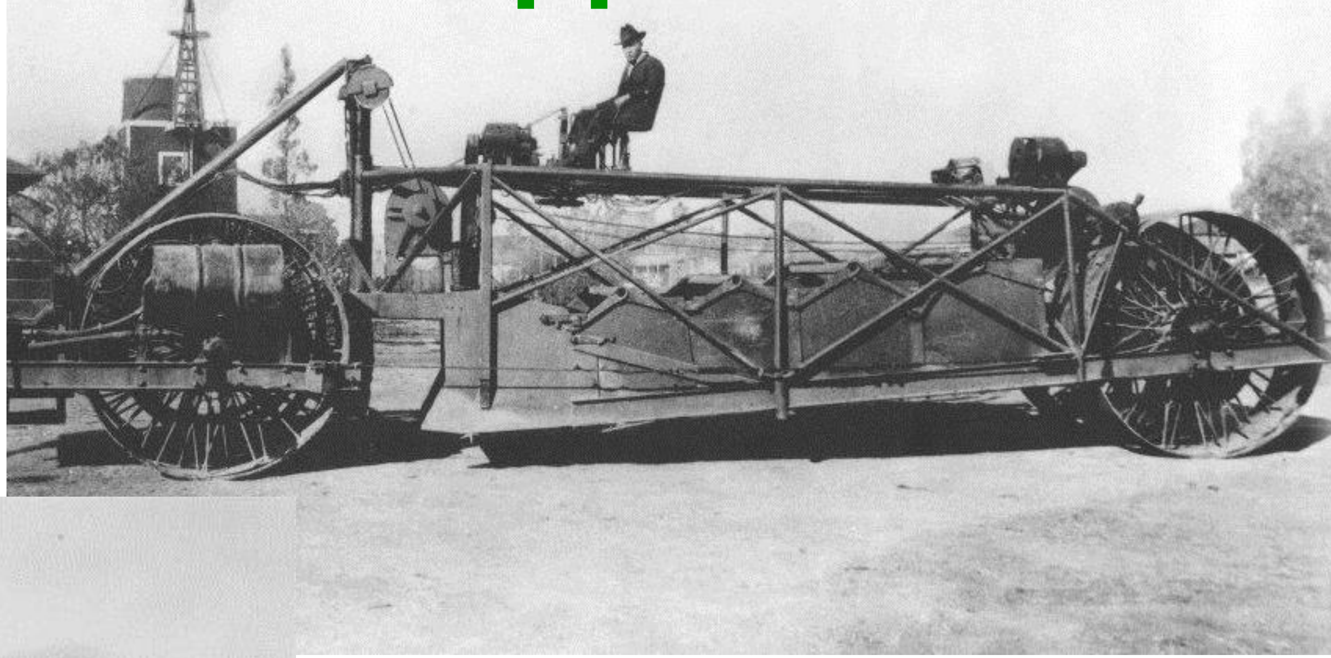


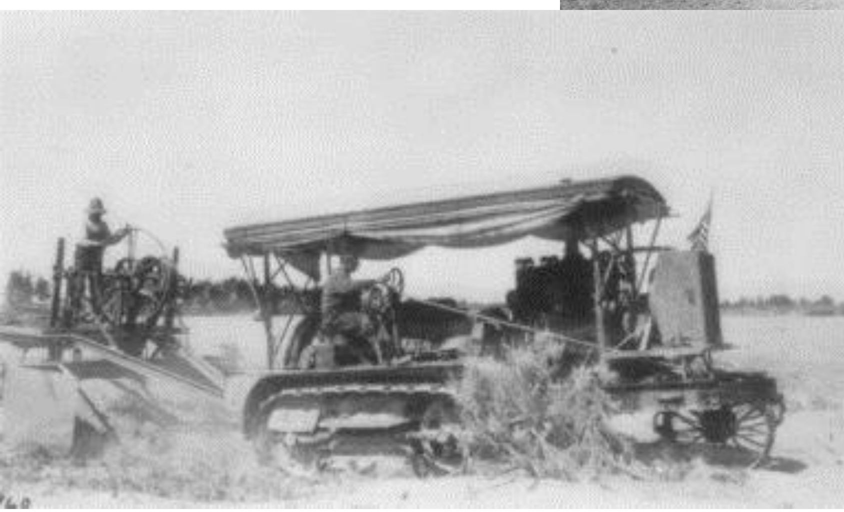
- Dozers are often modified to suit particular tasks.
- Upper left: Bucyrus Erie dozer grading an Aleutian airstrip in 1943
- Upper Right: International TD-18 dozer retrofitted with a Bucyrus-Erie dozer blade
- Lower left: Slope bar built by Peterson CAT for the Friant-Kern Canal job in 1940. These became increasingly common after the war.

Scrappers



R.G. "Bob" Letourneau (1888-1969) was a legendary figure in the earthmoving business



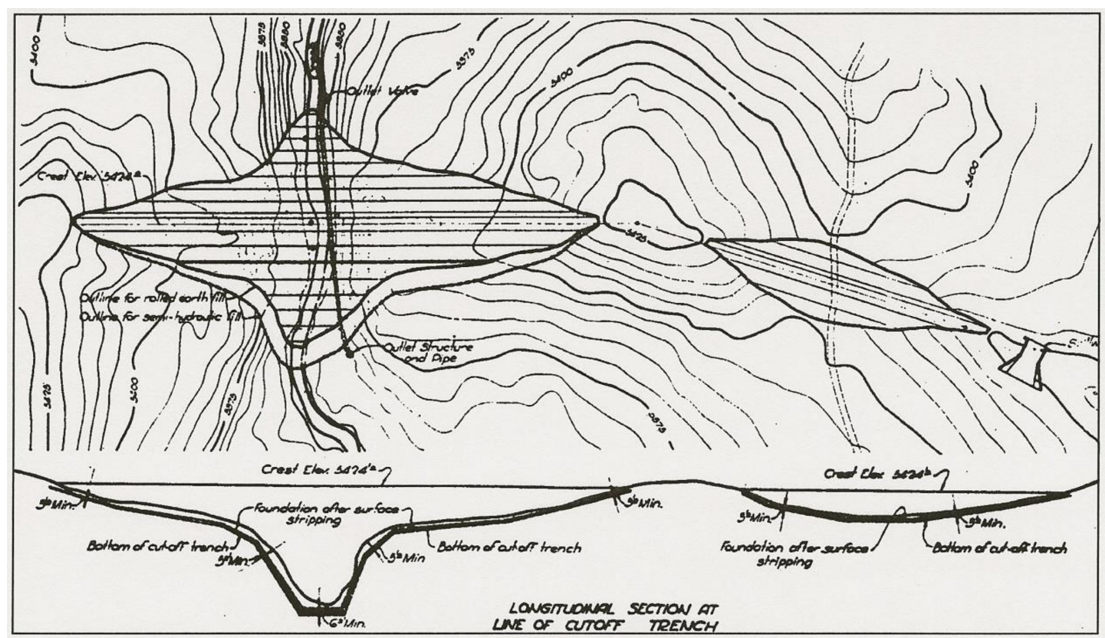


R.G. LeTourneau of Stockton, California began leveling farmer's fields in the San Joaquin Valley around 1910, using a Holt Tractor and towed scrappers of his own design, like that shown here, in 1913.

- In 1923 Letourneau invented the first self-propelled scrapper, shown above, which employed a series of five telescoping buckets that could carry 12 cubic yards of soil
- The 1923 scrapper employed all-electric drive, making it was the first machine that could excavate earth, carry it, and place it, all under its own power.

FIRST DAM BUILT WITH SCRAPPERS

- **Philbrook Dam was an 85 ft high earth fill and wing embankment built by Kaiser Construction for PG&E as a power supply reservoir in 1926, off the West Branch of the Feather River**
- **Kaiser retained R.G. Letourneau Construction Co of Stockton to move the earth with his patented telescoping scrappers, shown at left. The fill volume in both embankments was 142,000 yds^3**
- **It was the first rolled fill dam in the world constructed with mechanical scrappers**

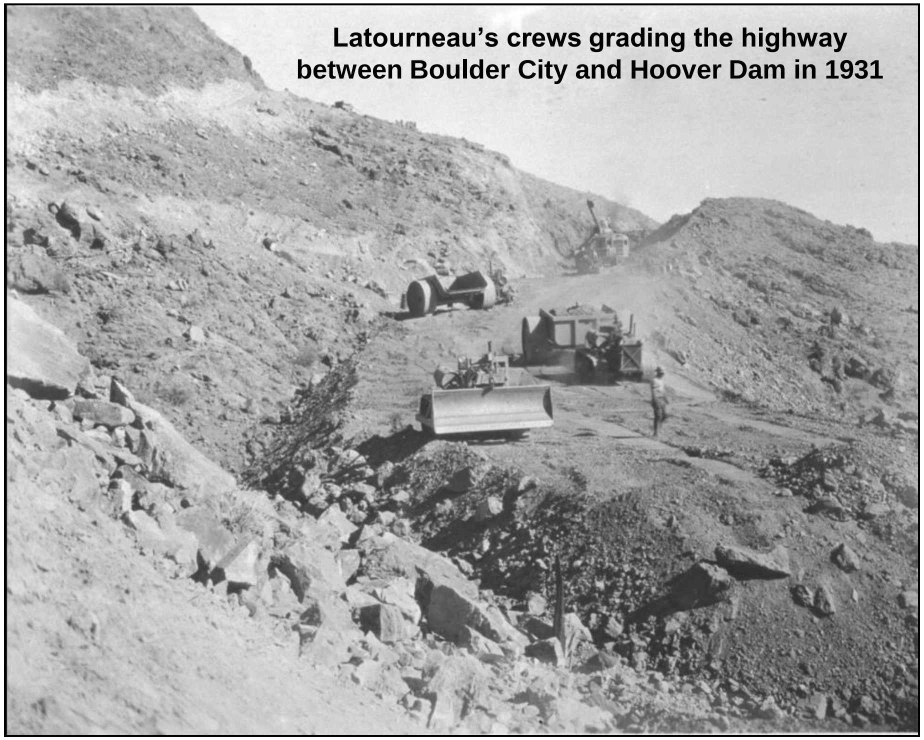


Pneumatic tires introduced in1932

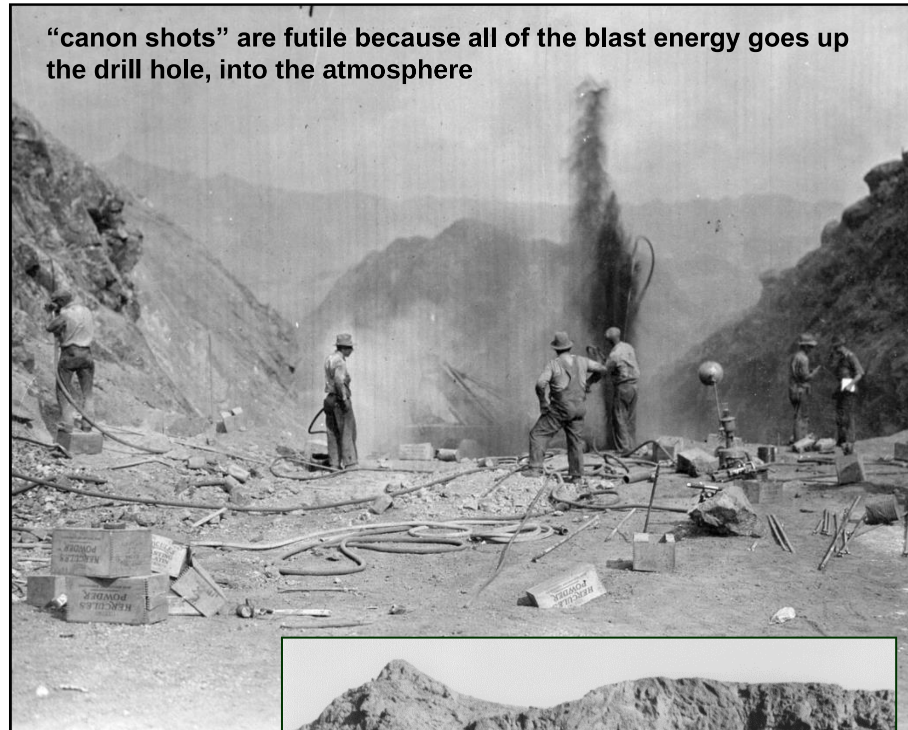
Old solid drum steel wheeled scrapper laying fill for the Bradley-San Ardo Highway in 1931

In 1932 R.G. Letourneau fitted *pneumatic tires* to some scrappers he built for a client that was grading a new state highway in the loose blow sands of the Salton Sink, in the Colorado Desert of southeastern California

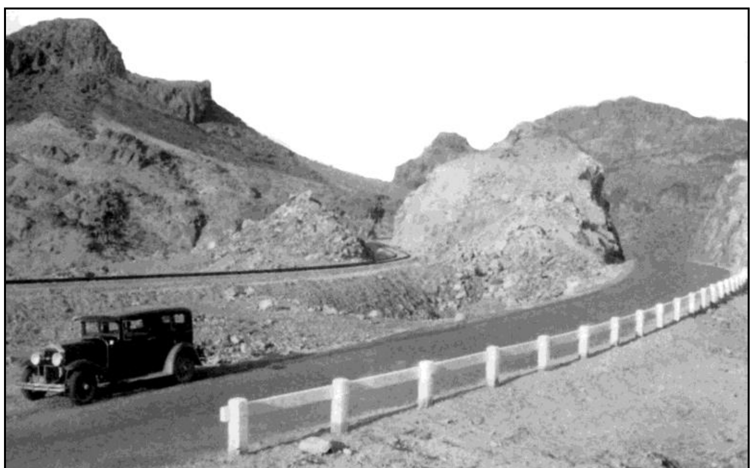
- These worked so well the entire industry shifted over to pneumatic tires over the next few years.



Latourneau's crews grading the highway between Boulder City and Hoover Dam in 1931

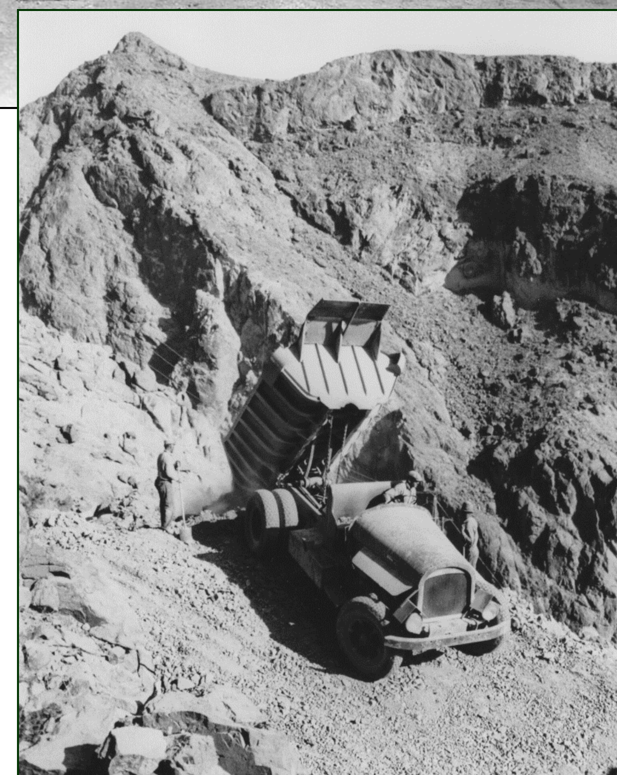


"canon shots" are futile because all of the blast energy goes up the drill hole, into the atmosphere



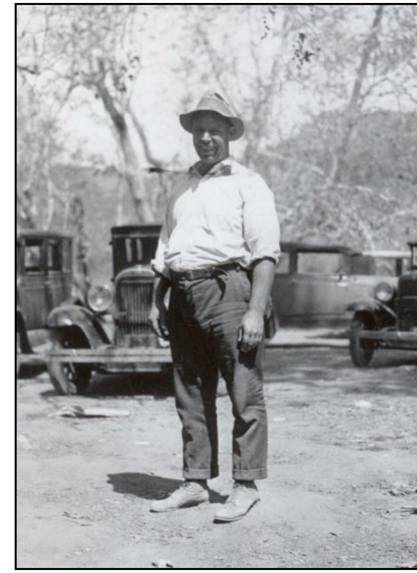
The highway as completed in January 1932. The government railroad line ran parallel to it.

In 1931-32, during construction of the main highway access to Hoover Dam, R. G. Letourneau lost $100K on a $330K contract constructing the government highway between Boulder Junction and the Hoover Dam site, because the andesite proved so difficult to excavate



- **Tracked shovels were busily engaged whittling out switchbacks for temporary construction access, and creating valuable fill wedges along the channel**

RECORD FILL PLACEMENT

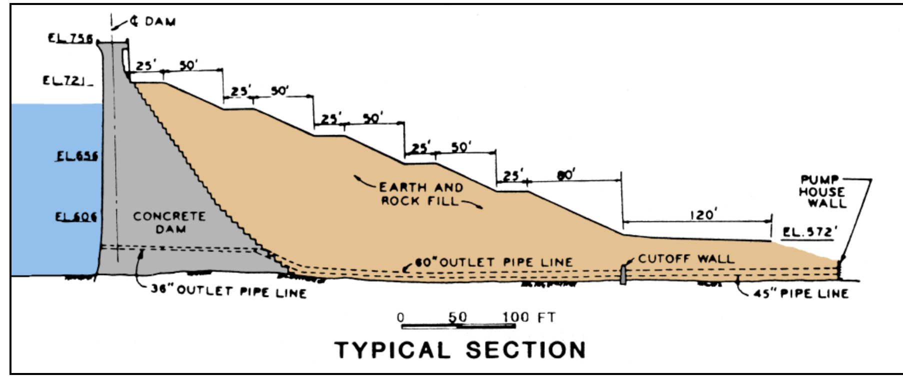


R. G. Letourneau in 1931

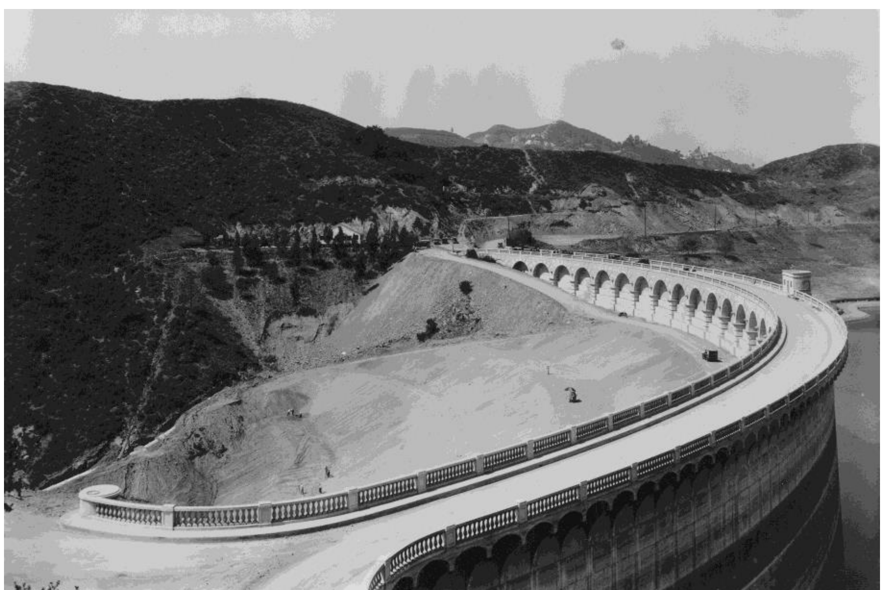
Letourneau Model A Carryall Scrapper at Santiago Dam in 1931

- In July 1931 earthmoving pioneer R. G. “Bob” Letourneau brought his 9 yd^3 capacity Model A Carryall scrappers to Orange County to grade the 136 ft high Santiago [Creek] Dam (Lake Irvine) for the Orange County Flood Control District
- Letourneau placed 400,000 yds^3 of compacted fill in the first month, setting a record for rolled fill construction
- The job was completed in the spring of 1932 with a final volume of 790,000 yds^3

LOOSE DUMPED BUTTRESS FILL



In 1933-34 the City of Los Angeles placed 330,000 yds^3 of fill against the downstream face of Mulholland Dam, making it one of the most conservative dams in the state



- In 1937 Letourneau introduced the revolutionary **Tournapull Scrapper,** shown here. It employed a clever cantilever design with an articulated U-joint, which allowed it to turn a very tight radius, with straight-away speeds of up to 25 mph
- During the Second World War Letourneau turned out 70% of the earth moving equipment used by Allied forces, from five manufacturing plants, including one in Australia.

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- The weak link in the Turnapull Scrapper was the steel 'box' that housed the drive train gears, between the engine and the two drive wheels. The punishing environment of earthwork jobs (shown above) eventually torqued these welded boxes so the gears would no longer engage. When this occurred the machine was down for good. This is why there weren't any surplus Turnapulls after the war.

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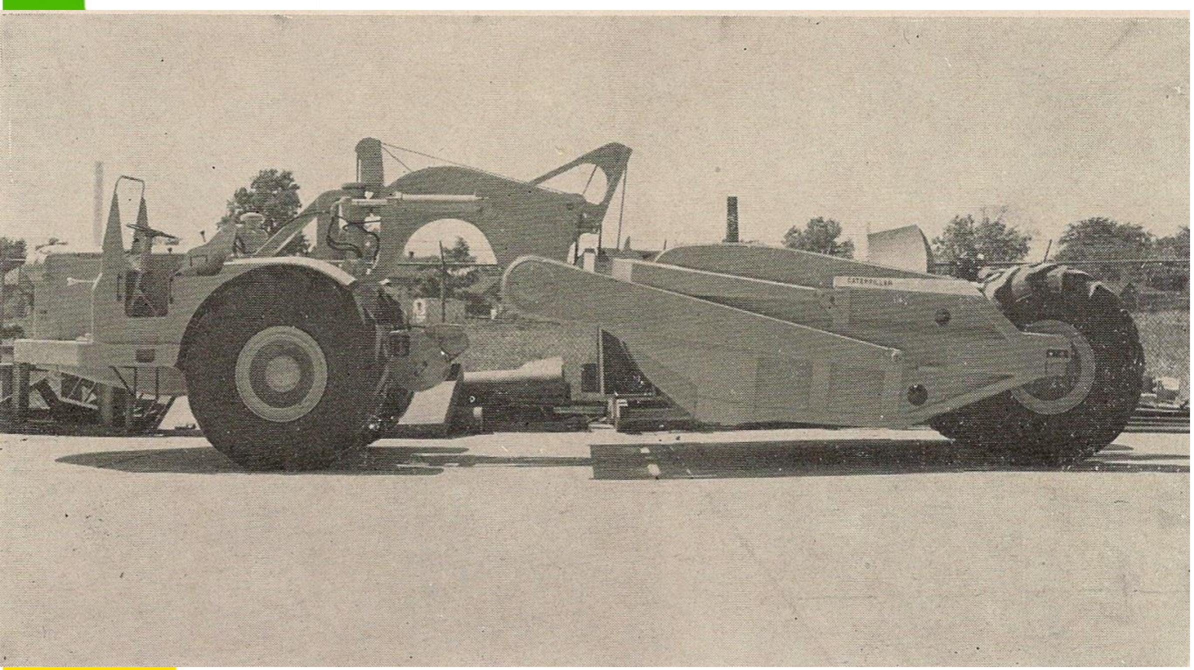
Letourneau Carryall Scrappers

- Upper left shows Letourneau Carryall scrappers working Yonton Airfield on Okinawa in July 1945.
- numerous scrapper for a decade thereafter.

Figure at left shows a Carryall being towed by an Allis-Chalmers tractor at NAD Attu in July 1943. Letourneau produced 75% of the Allied scrapers used in the Second World War

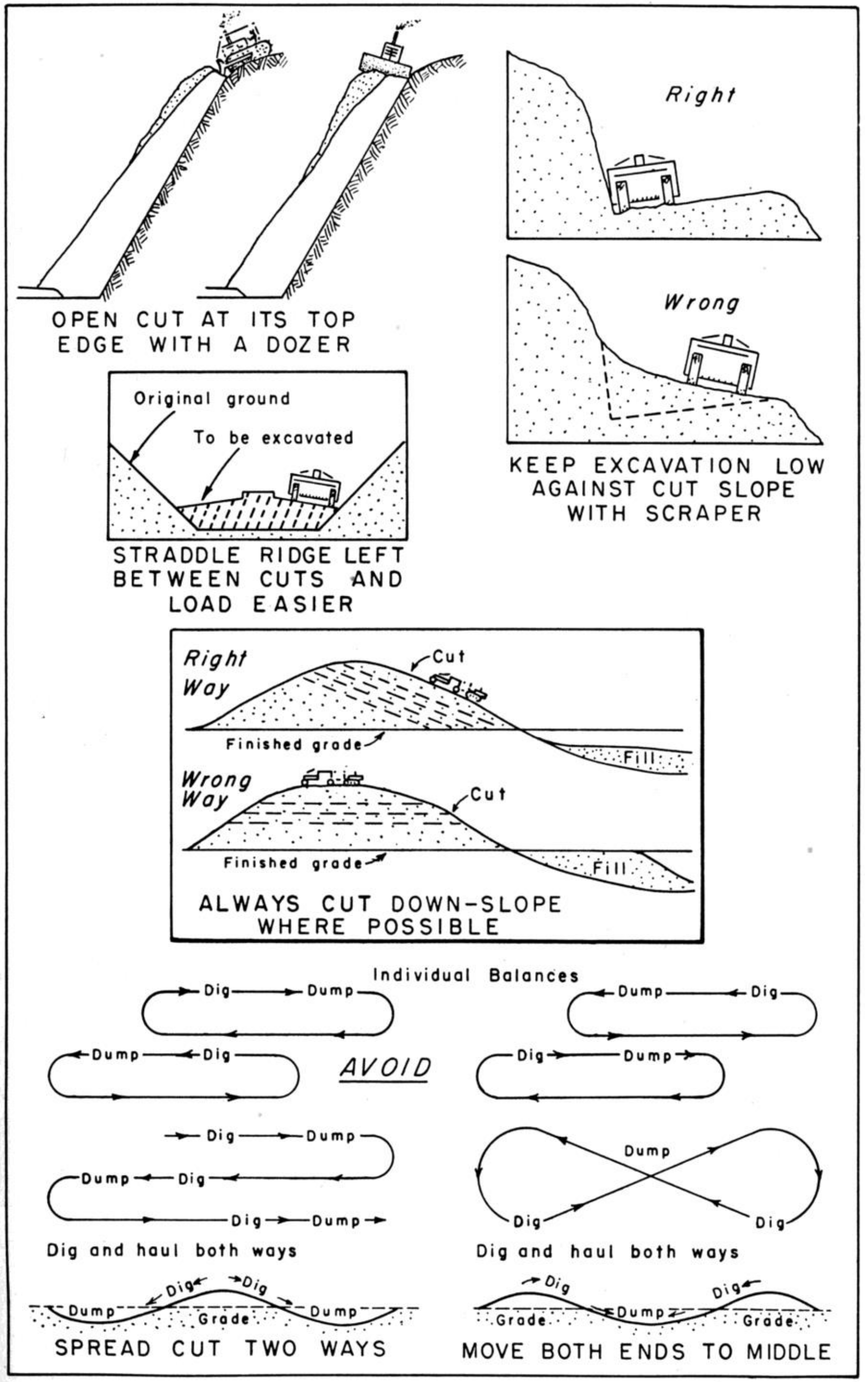
Thousands of these were sold as surplus after the war (1946-49), making them the most numerous post-war earthmoving equipment



Post-war Caterpillar Scrappers

- American experience in World War II showed the superior performance of diesel-powered equipment, borrowing on technology pioneered by the Germans.
- Upper left: CAT DW-10 tractor and No.10 scrapper, which gained great familiarity during the war.
- Lower left: CAT entered the self-propelled wheeled scrapper market that Letourneau had pioneered in 1949, with the introduction of their diesel-powered DW-21 scrapper, equipped with a 13.5 cubic yard drum.

Excavation and Grading Protocols

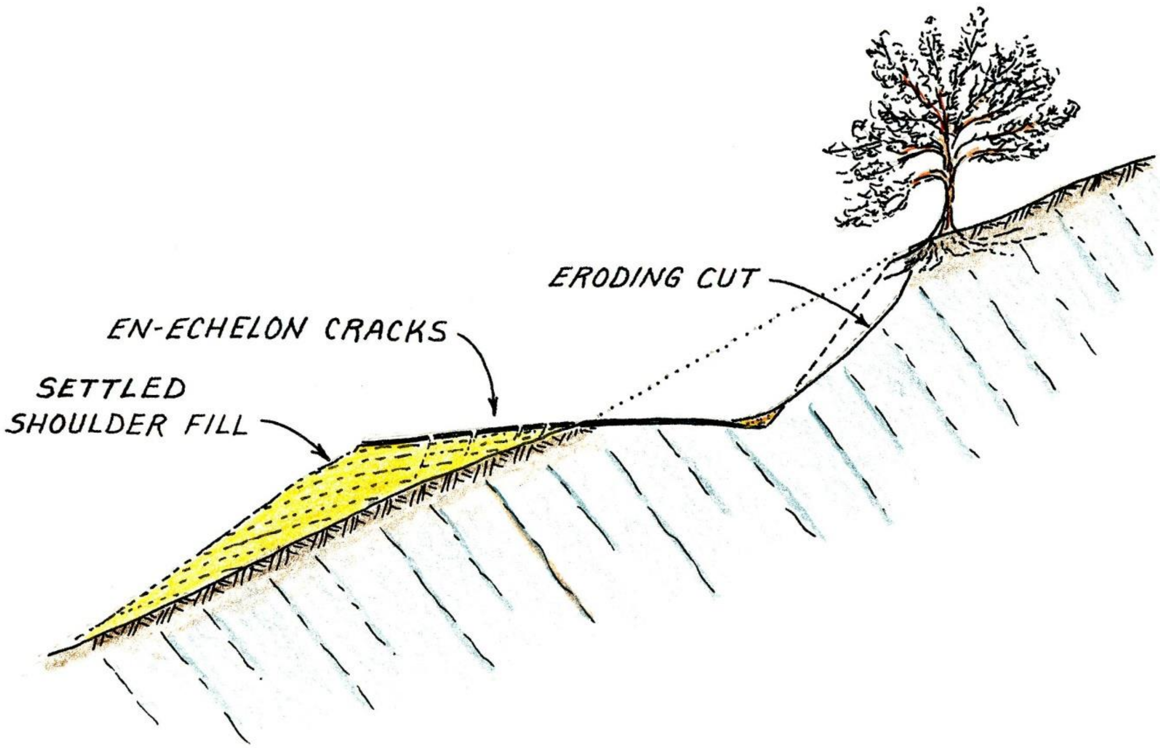


(After Park, 1942.)

FIGURE 7. Some principles of excavation using a dozer and scraper.

- **The plethora of grading and excavation work carried out in the 1930s and 40s resulted in well-established protocols for how grading jobs could best be accomplished, employing gravity whenever possible, to reduce energy expenditures.**

SLIVER FILLS



- **Prior to the adoption of grading codes, fill materials were *cast* over the hillside, so called "*side-cast fill*" or "*sliver fill*". Sliver fills tend to compress and creep downhill, promoting tensile cracking of the road's downhill shoulder and pavement cracking.**

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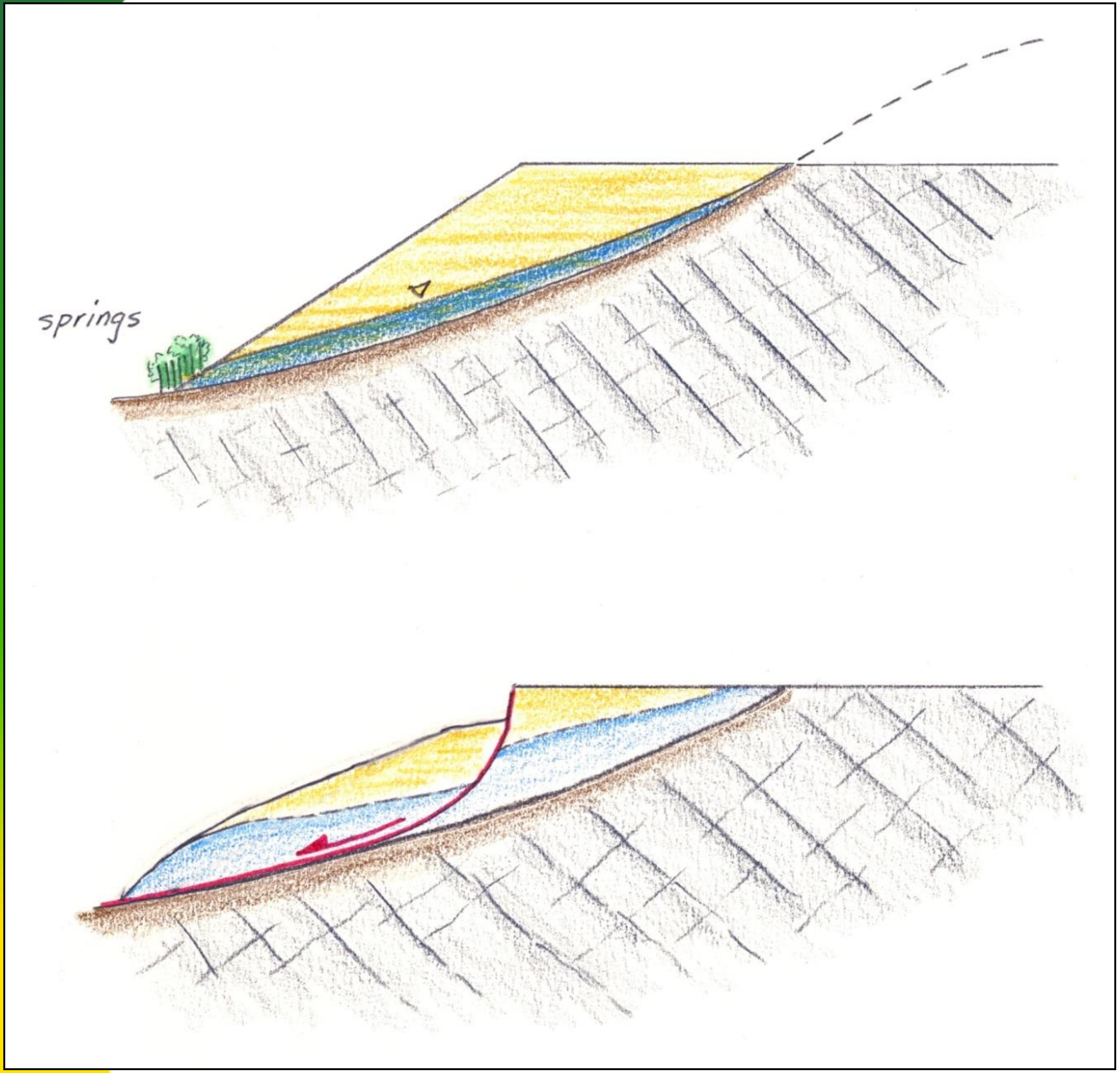
SETTLEMENT OF FILL PRISM

- Progressive settlement of the fill prism beneath the shoulder of an old road is common.
- This settlement can eventually result in a slope failure

LARGE SLIVER FILLS

- This shows the construction of sliver fill embankments along US Hwy 101 on Waldo Grade north of the Golden Gate Bridge in 1935. Sliver fills tend be stratified, with the largest rock fragments collecting towards the toe of the slope, fining upward.



- **Water tends to become trapped in sliver fills, perching on the unstripped soil horizon beneath the fill**
- **This condition often leads to moisture becoming perched within the embankment, leading to eventual slope failure**

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