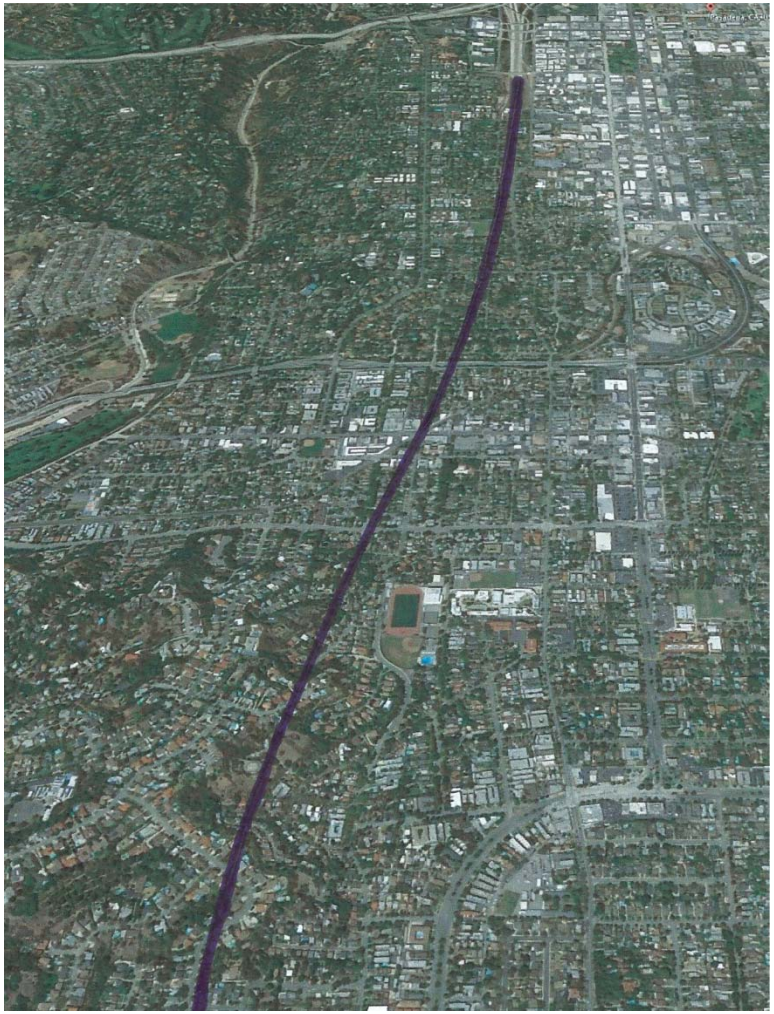
Potential Tunnel Boring Risks

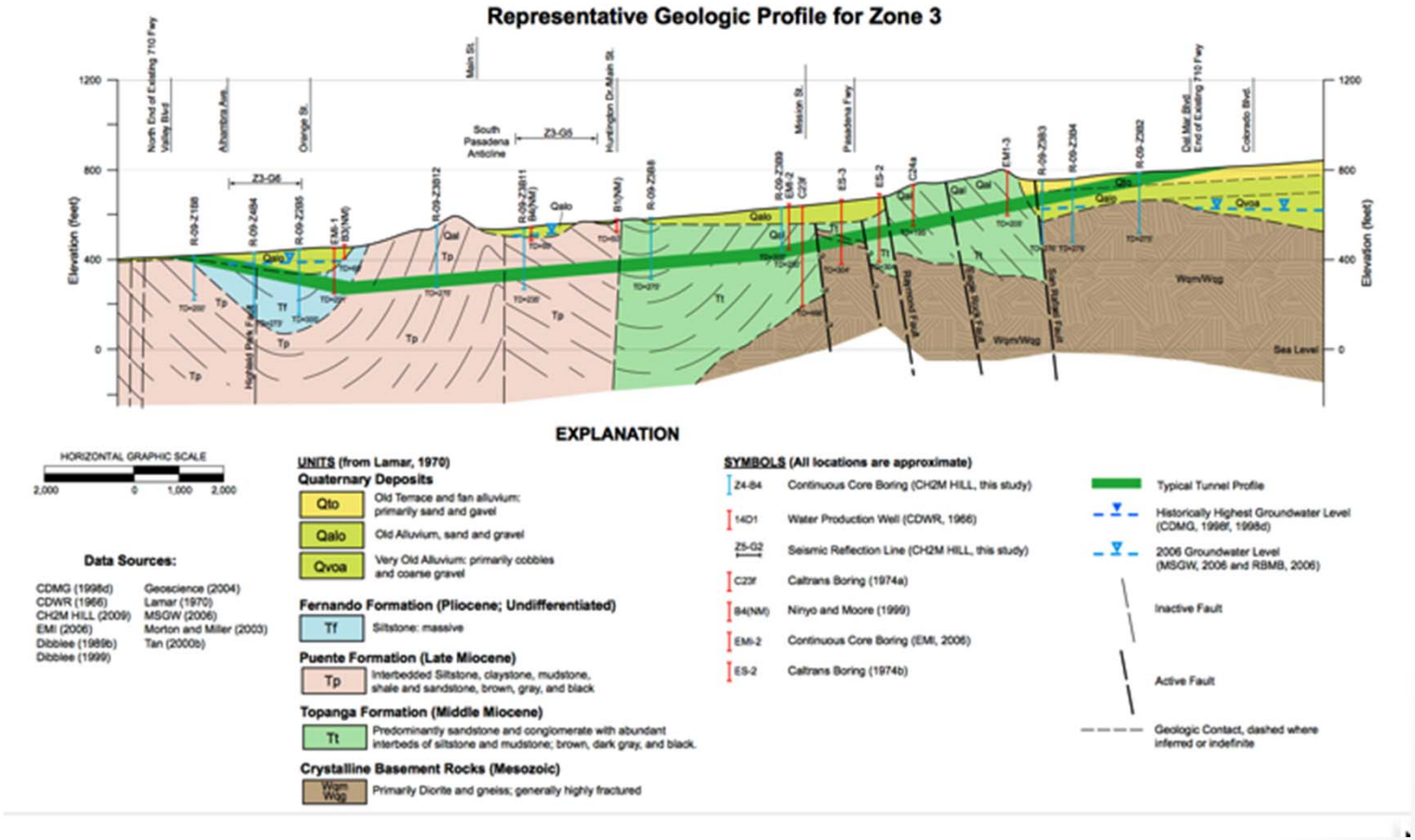
Avram D. Gold, West Pasadena Residents' Association – 710 Working Group

Possible Tunnel Configuration

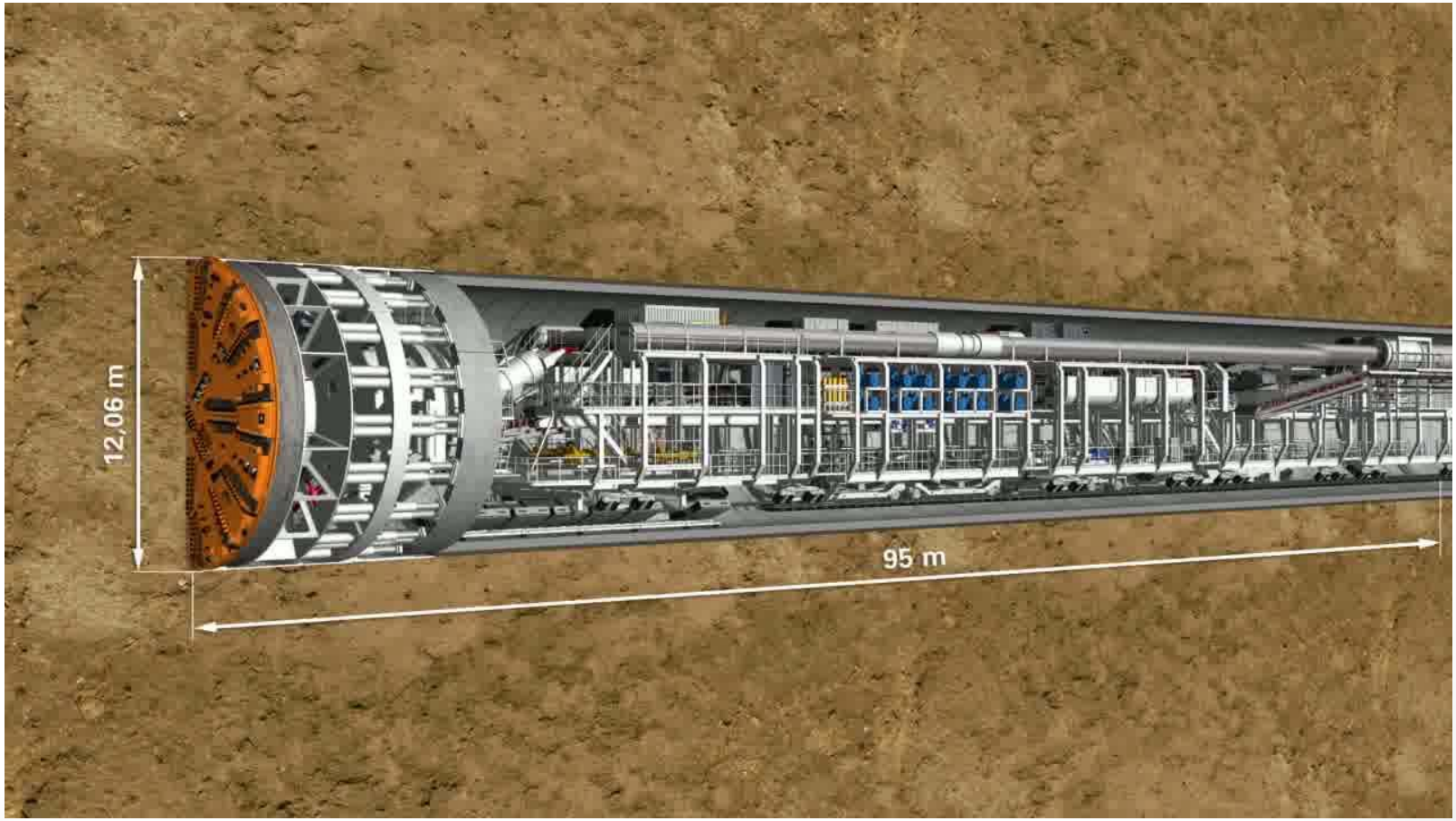
Proposed Tunnel Route



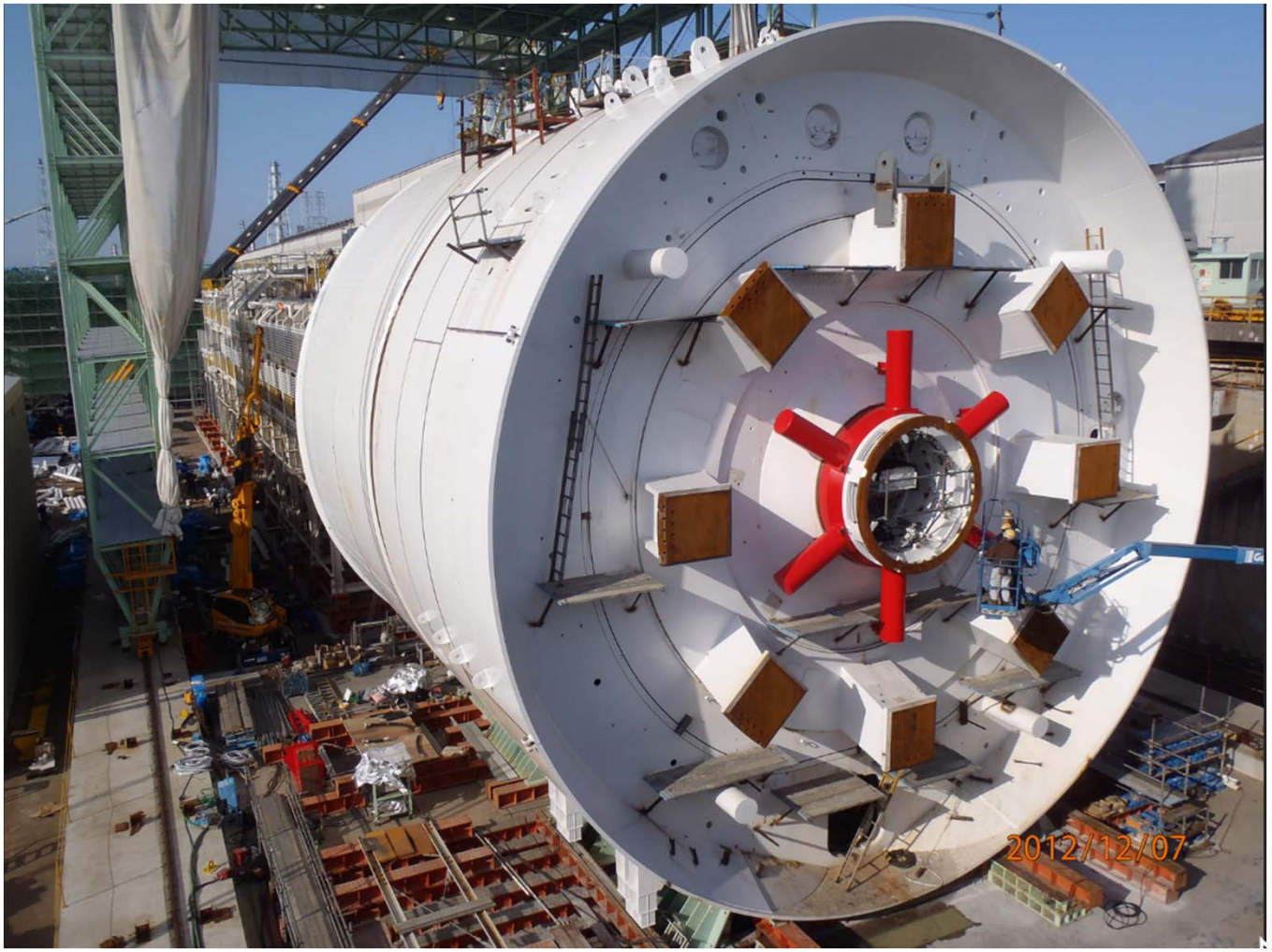
Tunnel Faults and Geology



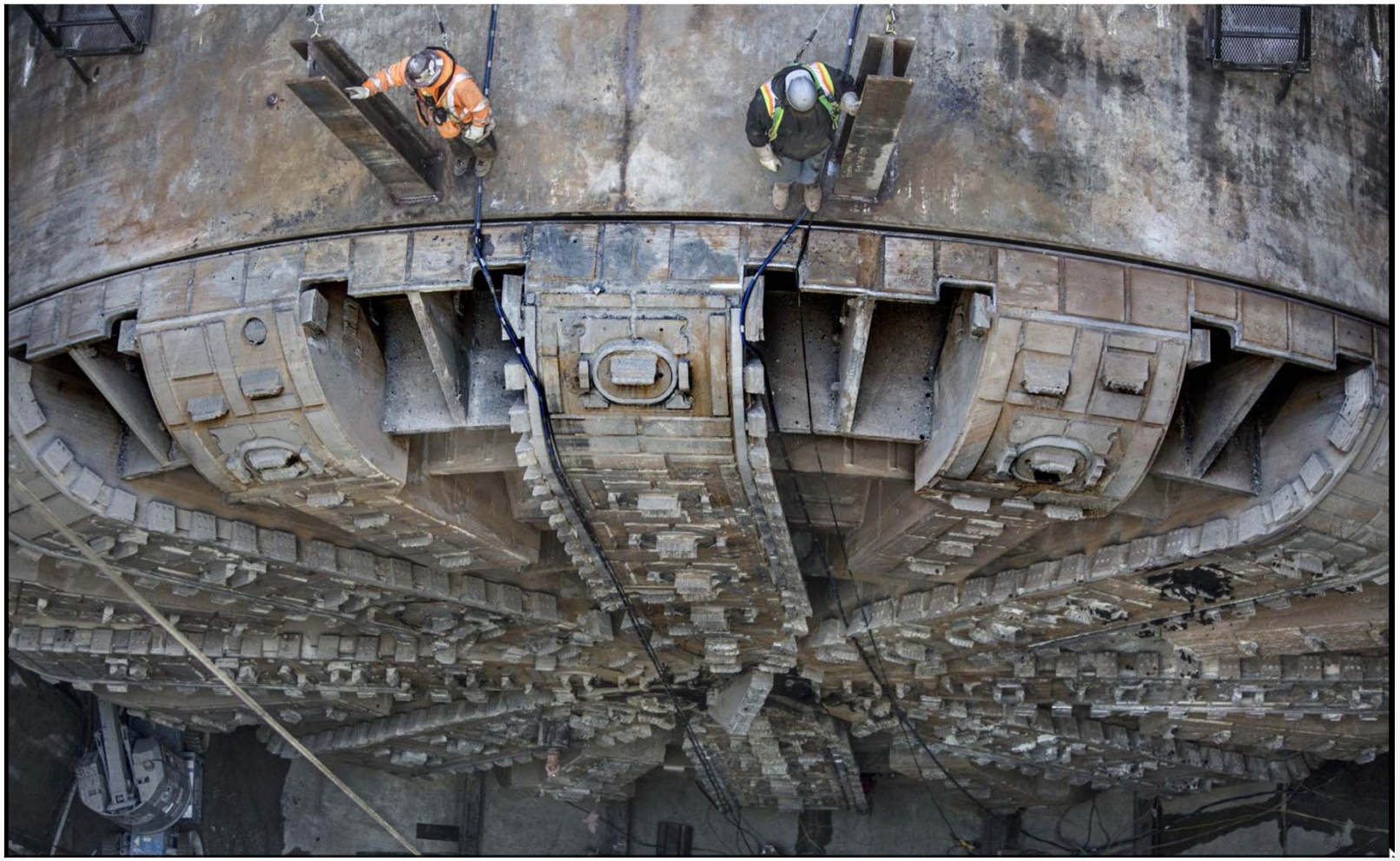
Tunnel Boring Machine (TBM)



Bertha Launch Pit



Bertha Cutting Head



Bertha Main Bearing

TBM Breakdowns

Ref #	Project Name	Tunnel Type	Tunnel Layout	Diameter	Tunnel Length	Method / TBM Type	TBM Design/ Manufacturer	Comments
1	Brightwater-Washington State[10,11,12]	Sewage	Single tube	17 feet	13 miles	Four TBMs / Slurry and EPB (both types)	Herrenknecht Germany Lovat TBM by Caterpillar USA	Two TBMs failed, the EPB was fixed, Slurry TBM had to be disassembled and its parts removed
2	Gilgel Gibe II Headrace Tunnel, Ethiopia[13,14]	Hydro Electric	Single tube	22.9 feet	16.1 miles	Two TBMs Double Shield Both Types	SELI Italy	TBM buried for two years under mud from fault 2006-2008
3	OARS - Columbus, Ohio[15,16]	Sewage	Single tube	23 feet	4.5 miles	One TBM / Duel Mode Open and Closed Shield	Obayashi Japan	Clogged in slurry mode, needed an underground rebuild, two years behind schedule
4	Crossrail – London, UK[17,18]	Subway Light Rail	Two parallel tubes	23.3feet	13 miles	Eight TBMs Two Slurry Mixshields and Six EPBs	Herrenknecht Germany	To be finished in 2018
5	Lake Mead Intake Tunnel #3 Nevada, USA[19,20]	Water Delivery	Single tube	23.55feet	3 miles	One TBM Mixshield Multimode	Herrenknecht Germany	Challenges forced the replacement of the cutter discs, all bearing seals and pinions on the bearing bull gears
6	Beles II Headrace Tunnel, Ethiopia[21]	Hydro Electric	Single tube	26.6 feet	7.45 miles	One TBM Duel Mode Double Shield EPB	SELI Italy	Tunnel face collapsed with rocks blocking cutting head 2009
7	(English) Channel Tunnel France to/from England[22,23,24]	Rail	Three parallel tubes - 3rd is a service tunnel	29 feet	31 miles	Five TBMs / Five different EPB designs	The Robbins Company USA	Three tunnels – two rail and one service and emergency. Construction escalated to an 80% cost overrun
8	Gotthard Base Tunnel Switzerland[25,26]	Rail	Two parallel tubes	Three sizes of TBMs 29 feet, 31 feet and 31.5 feet	35.4 miles	Four TBMs and SEM / Hard rock Gripper	Herrenknecht Germany	5-month TBM break down, needed a 50m access tunnel for repairs

Ref #	Project Name	Tunnel Type	Tunnel Layout	Diameter	Tunnel Length	Method / TBM Type	TBM Design/ Manufacturer	Comments
9	Tellier Tunnel Sarnia, Ontario, Canada[27,28]	Rail	Single Tube	30.34 feet	1.16 miles	One TBM EPB	Lovat Canada	Seven-month delay needing an access pit to repair broken seals and cutting head
10	Hallandsås Rail Tunnels Sweden[29,30]	Rail	Two parallel tubes	34.77 feet	3.1 miles	One TBM / Duel Mode Open and Closed Shield	Herrenknecht Germany	Needed ground freezing and pre-grouting to control high water pressures
11	A-86 East Duplex Tunnel Paris[31,32]	Only cars allowed	One tube Two - isolated decks	37.95 feet	6.2 miles	One TBM / Mixshield multimode as a Slurry or EPB	Herrenknecht Germany	Extra lane each deck for break downs – completed 2003 and then 2008
12	Hsuehshan Snow Mountain Tunnels Taiwan, China[33,34]	Auto and truck	Three parallel tubes - 3rd is a service tunnel	38.5 feet and 15.75 feet	8.1 miles	Four TBMs (two small two large) / unknown types	The Robbins Company USA	Severe flooding destroyed one TBM. It was disassembled underground and removed from the tunnel. Project took 13 years and was delayed four times.
13	Dublin Port Tunnel Ireland[35,36]	Auto and truck	Two parallel tubes	38.6 feet	1.6 miles	SEM and two TBMs / One hard-rock shielded and one open-faced backhoe	Herrenknecht Germany	The boulder clay could not support the weight of the rock TBM cutter head. Twenty-four restraining cables were needed to regain steering.
14	Miami Port Link Florida[37,38,39]	Auto and truck	Two parallel tubes	42 feet	0.73 miles	One TBM / Hybrid EPB Slurry	Herrenknecht Germany	Designed for varied hydrostatic conditions. No failures but leaks
15	Waterview Tunnel Auckland, New Zealand[40,41]	Auto and truck	Two parallel tubes	47.25 feet	1.5 miles	One TBM / EPB	Herrenknecht Nansha, China	Two equipment-related stalls totaling four weeks to replace tail seals, 2014
16	M30 Calle Madrid, Spain[42,43]	Auto and truck	Two parallel tubes	49.21 feet	34.8 miles	Seven TBMs / all EPB, SEM, Cut and Cover	Herrenknecht & Mitsubishi Heavy Industries & Duro Felguera SA	The largest TBMs as of 2005 that did not fail

Ref #	Project Name	Tunnel Type	Tunnel Layout	Diameter	Tunnel Length	Method / TBM Type	TBM Design/ Manufacturer	Comments
17	Yangtze River Tunnel Shanghai, China[44,45,46]	Auto and truck above, rail below	Two parallel tubes	50.6 feet	5.5 miles	Two TBMs / both Slurry Mixshield	Herrenknecht Germany	The largest TBMs as of 2009 that did not fail
18	Sparvo Tunnel - Sparvo, Italy[47,48,49]	Auto and truck / 2	Two parallel tubes	51 feet	1.6 miles	One TBM and SEM / EPB	Herrenknecht Germany	TBM inoperable for two months under ground 2011
19	Alaska Way Viaduct Seattle, Washington[50,51]	Auto and truck	One tube - double deck	57.5 feet	1.7 miles	One TBM / EPB	Hitachi Zosen Japan	TBM became inoperable December 2013 and is still stalled in tunnel, at least a $125M fix and rising
20	SR-710 Tunnel Alternative Los Angeles County, U.S.	Auto and truck	TBD	60 feet	4.9 miles	Two TBMs and Cut and Cover / Slurry and/or mixed mode	Yet to be contracted	Proposed TBM will be the largest ever made
21	Orlovski - St. Petersburg, Russia[52,53]	Auto and truck		63.1 feet	3280 feet	TBM ordered but never built / Slurry mix shield	Herrenknecht Germany	Project cancelled due to escalating budget

Cutting Head

TBM Repairs

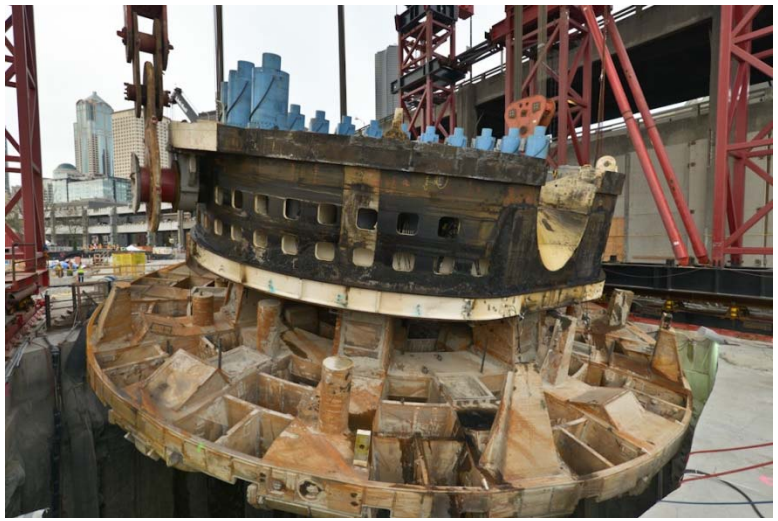
- Three ways in which TBMs can be repaired while underground:
  - From the front of the cutting head between the tunnel face and the TBM
    - Recovery tunnel is bored and/or a larger cavity is excavated
  - From behind the cutter head under pressurized or non-pressurized atmospheric conditions, assuming smaller replacement parts or local mechanical fixes can solve the problem; and/or
  - From the surface above by building a construction site with an excavation pit to lift, remove, and replace parts of the TBM

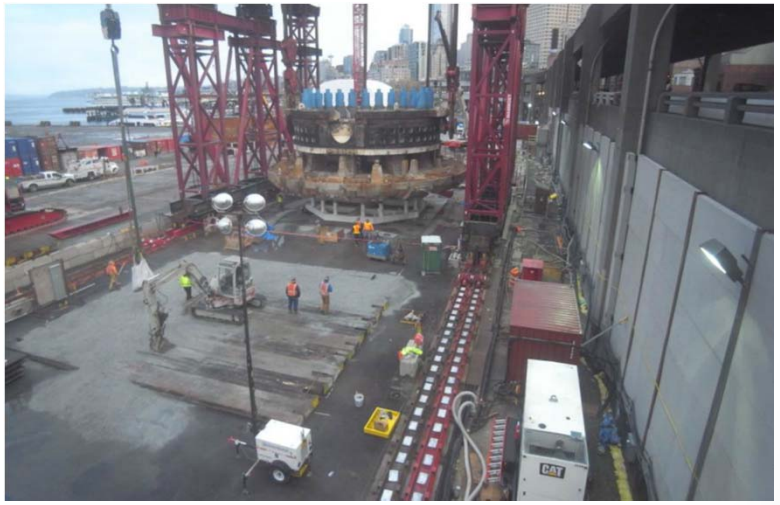
Access Pit and Crane

Feb. 13, 2015 – Aerial photo of the 120-foot-deep pit crews will use to access and repair Bertha, the SR 99 tunneling machine.
Washington State Dept of Transportation

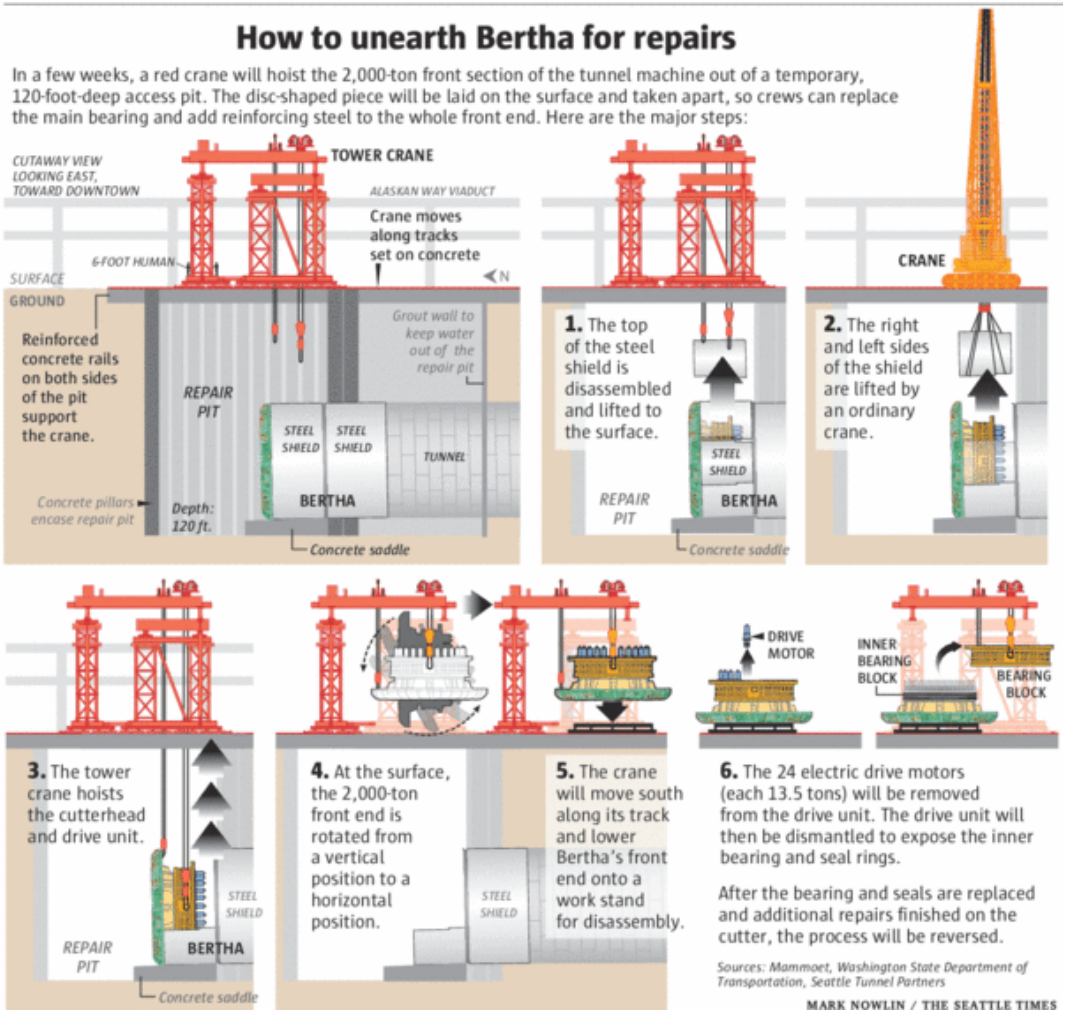
Motor Assembly

Bertha Cutting Head and Motor Assembly





Crane Lifts


How to unearth Bertha for repairs
In a few weeks, a red crane will hoist the 2,000-ton front section of the tunnel machine out of a temporary, 120-foot-deep access pit. The disc-shaped piece will be laid on the surface and taken apart, so crews can replace the main bearing and add reinforcing steel to the whole front end. Here are the major steps:
CUTAWAY VIEW LOOKING EAST, TOWARD DOWNTOWN
TOWER CRANE
ALASKAN WAY VIADUCT
Crane moves along tracks set on concrete
6-FOOT HUMAN
SURFACE
GROUND
Reinforced concrete rails on both sides of the pit support the crane.
Grout wall to keep water out of the repair pit
REPAIR PIT
STEEL SHIELD
STEEL SHIELD
TUNNEL
BERTHA
Concrete pillars encase repair pit
Depth: 120 ft.
Concrete saddle
1. The top of the steel shield is disassembled and lifted to the surface.
CRANE
2. The right and left sides of the shield are lifted by an ordinary crane.
3. The tower crane hoists the cutterhead and drive unit.
4. At the surface, the 2,000-ton front end is rotated from a vertical position to a horizontal position.
5. The crane will move south along its track and lower Bertha's front end onto a work stand for disassembly.
DRIVE MOTOR
INNER BEARING BLOCK
BEARING BLOCK
6. The 24 electric drive motors (each 13.5 tons) will be removed from the drive unit. The drive unit will then be dismantled to expose the inner bearing and seal rings.
After the bearing and seals are replaced and additional repairs finished on the cutter, the process will be reversed.
Sources: Mammoet, Washington State Department of Transportation, Seattle Tunnel Partners
MARK NOWLIN / THE SEATTLE TIMES

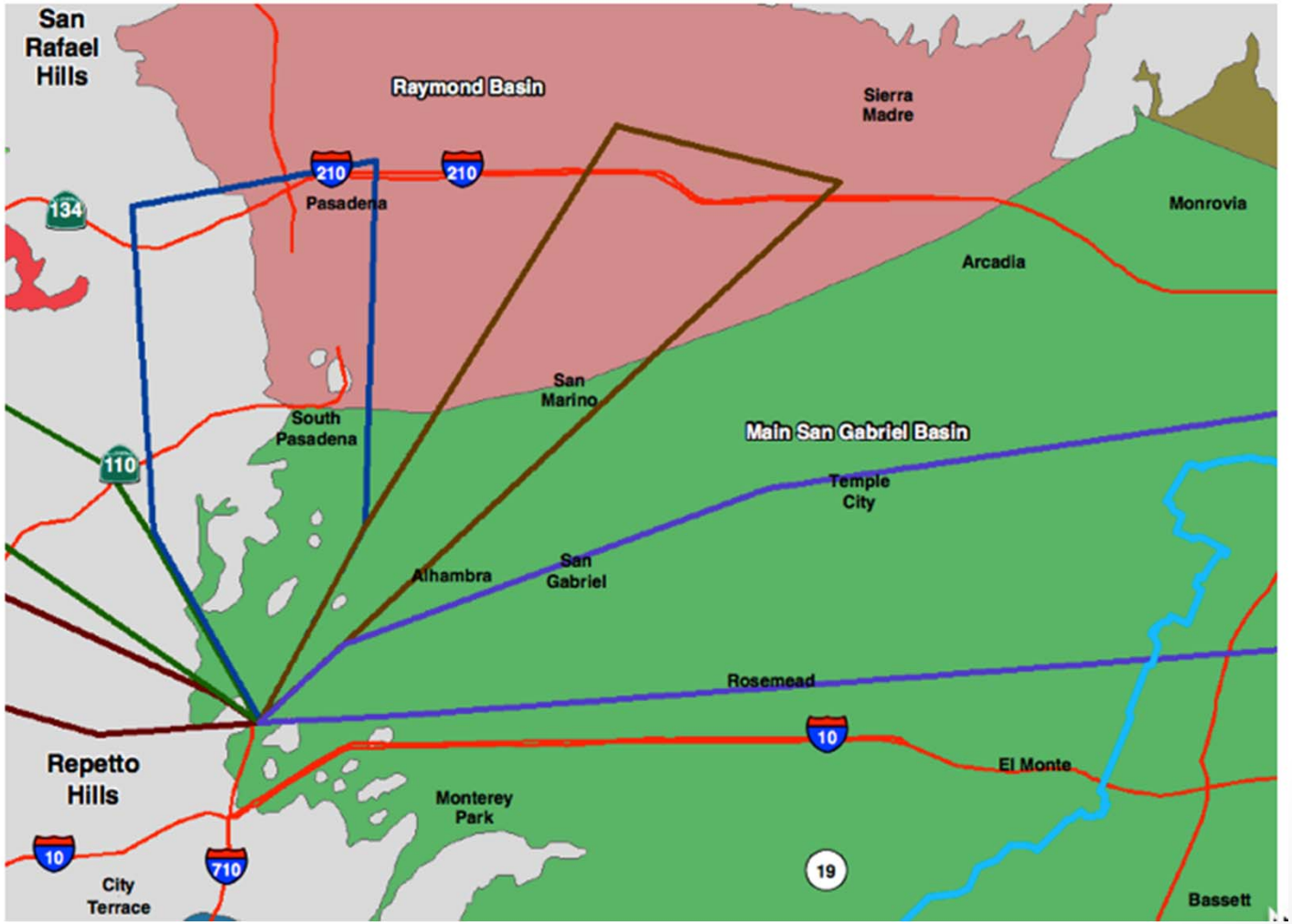
South Pasadena - Before

South Pasadena - After

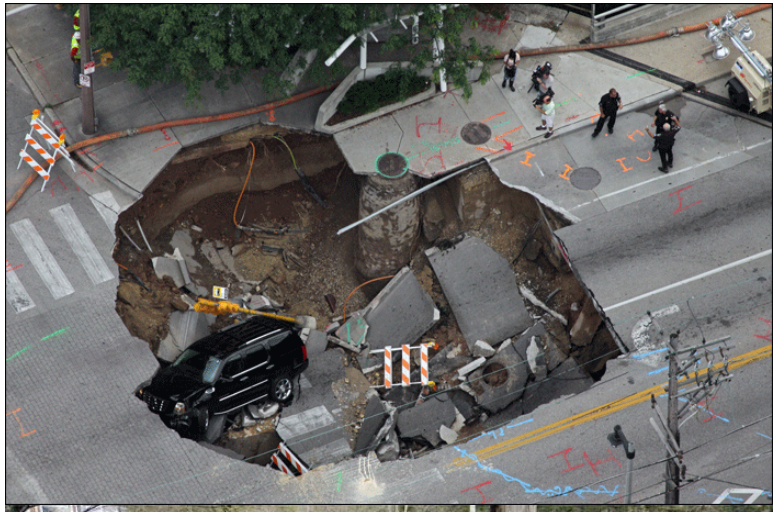
Huntington Hospital - Before

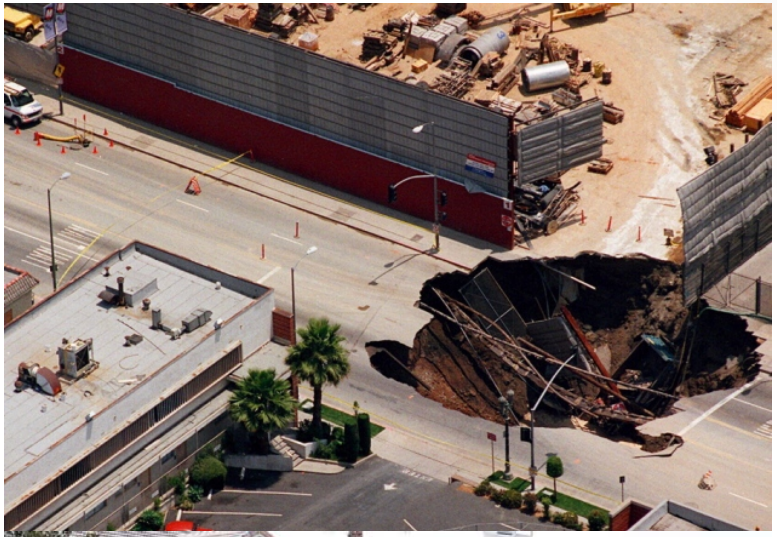
Huntington Hospital - After

Raymond and San Gabriel Basins



Sinkholes





Settlement Problem in Seattle

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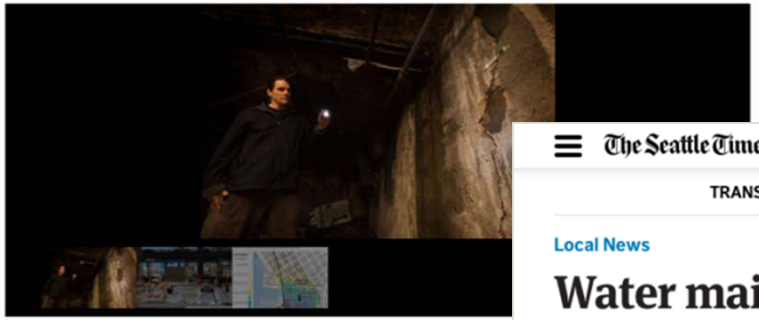
Local News

Cracks in Pioneer Square cause worries to surface

Originally published December 12, 2014 at 11:05 am | *Updated December 12, 2014 at 1:16 pm*



1 of 3 *Kevin Perkins, a cook at J&M Cafe in Seattle's Pioneer Squa*
Thursday in the basement of the building.

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TRANSPORTATION CRIME POLITICS EDUCATION EASTSIDE HEALTH OBITUARIES

Local News

Water main may be latest tunnel worry

Originally published December 15, 2014 at 10:28 pm | *Updated December 16, 2014 at 2:10 pm*

1 of 2 *State Transportation Secretary Lynn Peterson, left, briefs the Seattle City Council on the tunnel project Monday and soil settlement discovered in the...* More

Further Study Needed

- Draft EIR/EIS
  - 1.3 Purpose and Limitations: **"The preliminary design concepts presented herein are limited to the geotechnical information available to date** (CH2M Hill, 2014b). **Concepts are expected to be modified and refined as additional geotechnical information becomes available"**
- Tunnel Evaluation Report – Appendix C
  - 5.8 Preliminary Assessment of Tunnel Excavation Methods for Running Tunnels: **"… however, this is subject to change as more geotechnical data becomes available** and because the study of the range of grain sizes for each type of TBM is a developing field. For the diameters being evaluated for both tunneled alternatives; it's expected that it will be feasible for TBMs to excavate the tunnels; however, **further study as to the type of TBM to be used for each of the alignments will be evaluated in future phases of this study."**

5 Reasons the Tunnel Alternative is Risky

- There not enough geological tests for tunneling and too many underground unknowns
- SR-710 TBMs must bore through five active faults and below two depleted water tables
- Dewatering may create settlement issues, sinkholes and groundwater contamination.
- Caltrans and Metro don't know what kind of TBM design they'll need
  - Type and function is based on a complete geology survey which has yet to happen
- Most importantly, the TBMs will be the largest and the heaviest in the world and designed with untested technology
  - No TBM larger than a 50 feet diameter has worked without a significant breakdown, ours would be 60 feet