Compliments of the Drafting Room

- Conduit & Tunnel Sections -
- Los Angeles Aqueduct -

- Mr. C.H. Lee -

Water Resources Center Archives
University of California
Berkeley, California
UNLINED CANAL
Intake to Alabama Hills

Scale $\frac{3}{4} : 1$

Discharge from Centrifugal Pump

Embarkment B both berms made from material E excavated by teams and scrapers

Main Canal excavation made by Centrifugal dredge

CONSTRUCTION QUANTITIES
Per Lineal foot of Conduit Normal Section

Excavation 14.81 Cu.Yds.

HYDRAULIC PROPERTIES

Slope .0001895
Velocity 2.36
Capacity 801
Area 339.5
Wetted Perimeter 63.24
Hydraulic Radius $R$
$C$ 74.0
OWENS VALLEY CANAL
S = .0001895
STA 1120+00 TO STA 1230+00.

CONSTRUCTION QUANTITIES
Per Lineal Foot of Conduit—Normal Section

Excavation
Concrete
11.72 Cu. Yds
1.05 " " 
Hydraulic Properties

\[ S = 0.0001895 \]

\[ A = 206.6 \]

\[ WP = 38.54 \]

\[ R = 5.37 \]

\[ n = 0.014 \]

\[ C = 138.0 \]

\[ V = 4.40 \]

\[ Q = 909.0 \]

Construction Quantities

per Linial Foot "Normal Section"

Excavation 9.859 cu.yds.

Concrete 786 cu.yds.

Scale \( \frac{1}{6} " = 1 \) ft
\[ S = 0.0001895 \]
\[ A = 188.34 \text{ sq ft} \]
\[ D = 37.17 \text{ ft} \]
\[ R = 5.07 \]
\[ n = 0.014 \]
\[ c = 137.4 \]
\[ V = 4.26 \]
\[ Q = 802 \text{ s.f.} \]

Construction Quantities

per lin. ft. Normal Section

Excavation 8.58 cu. yds
Concrete lining 0.89 cu. yds

Scale \( \frac{1}{4} = 1 \text{ ft} \)
- OLANCHA CONDUIT -  

- Hydraulic Properties -  
  - Normal Section -  
  
  \[ S = 0.00015 \]  
  \[ A = 2.23.57 \]  
  \[ WP = 39.91 \]  
  \[ R = 5.60 \]  
  \[ n = 0.014 \]  
  \[ c = 139.2 \]  
  \[ V = 4.03 \]  
  \[ Q = 901 \]  

- Construction Quantities -  
  - per Linial Foot - Normal Section -  

  Excavation 10.57 Cuyds.  
  Concrete 813 Cuyds.  

Scale \( \frac{1}{8}'' = 1\text{ft} \)
### Construction Quantities

Per Linear Foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>Cu Yds</td>
<td>3.514</td>
<td>2.848</td>
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<tr>
<td>Concrete in Lining</td>
<td></td>
<td>0.945</td>
<td>0.698</td>
</tr>
<tr>
<td>Timbers</td>
<td>B.M.</td>
<td>32.0</td>
<td></td>
</tr>
<tr>
<td>Spreaders</td>
<td></td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td></td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Lagging</td>
<td></td>
<td>47.0</td>
<td></td>
</tr>
</tbody>
</table>

### Hydraulic Properties

- **Slope**: 0.0017
- **Capacity**: 434.13
- **Velocity**: 7.97
- **Area**: 54,462
- **Wetted Perimeter**: 22,499
- **Hydraulic Radius**: 2.42
- **K**: 0.014
- **C**: 124.29
GRAPEVINE DIVISION

S = 0.0017
Scale 3" = 10"

To be used where rock in crown will stand without arch.

HYDRAULIC PROPERTIES

Slope .0017
Capacity 429.0
Velocity 8.09
Area 53.11
Wetted Perimeter 21.26
Hydraulic Radius 2.5
N .014
C 124.0

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel.

Excavation 3.042 Cu.Yds
Concrete in Lining 0.65
## GRAPEVINE DIVISION

**Scale** $\frac{5}{8}'' = 1'$

### Construction Quantities

<table>
<thead>
<tr>
<th>Item</th>
<th>Timbered</th>
<th>Untimbered</th>
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<tbody>
<tr>
<td>Excavation Cu.Yds.</td>
<td>4.05</td>
<td>3.09</td>
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<tr>
<td>Concrete in Lining</td>
<td>1.01</td>
<td>0.75</td>
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<tr>
<td>Timbers B.M.</td>
<td>37.5</td>
<td>50.0</td>
</tr>
<tr>
<td>Spreaders</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Brace</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Lagging</td>
<td>53.0</td>
<td></td>
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### Hydraulic Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>0.0011</td>
</tr>
<tr>
<td>Capacity</td>
<td>432.40</td>
</tr>
<tr>
<td>Velocity</td>
<td>6.724</td>
</tr>
<tr>
<td>Area</td>
<td>64.303</td>
</tr>
<tr>
<td>Wetted Perimeter</td>
<td>24.645</td>
</tr>
<tr>
<td>Hydraulic Radius</td>
<td>2.609</td>
</tr>
<tr>
<td>N</td>
<td>0.014</td>
</tr>
<tr>
<td>C</td>
<td>125.51</td>
</tr>
</tbody>
</table>
GRAPEVINE DIVISION

\[ S = 0.001 \quad \text{Scale} \frac{\frac{1}{4}}{1} \]

Hydraulic Properties

- Slope: 0.001
- Capacity: 431.03
- Velocity: 6.714
- Area: 64.195
- Wetted Perimeter: 22.87
- Hydraulic Radius: 2.806
- \( N \): 0.014
- \( C \): 126.73

Construction Quantities

Per Linear foot of Conduit Normal Section

- Excavation: 2.99 Cu.Yds.
- Concrete in Conduit: 0.455
- . . Cover: 0.143
- Steel in Cover: 75 Pounds

Note

In no instance should the natural slope of ground on side hills cut the bottom of the Conduit.
GRAPEVINE DIVISION

Hydraulic Properties

\[ S = 0.0013 \]
\[ Q = 430 \]
\[ V = 7.23 \]
\[ A = 59.4 \]
\[ D = 23.07 \]
\[ R = 2.57 \]
\[ C = 125 \]
\[ n = 0.014 \]

Construction

Quantities

Concrete per lin. ft = 0.74

Scale \( \frac{3}{8} \text{-} 1 \text{ft} \)
GRAPEVINE DIVISION

CONDUIT SECTION

\[ S = 0.0009 \]

Hydraulic Properties

\[ S = 0.0009 \]
\[ Q = 432.5 \]
\[ V = 6.45 \]
\[ A = 67.144 \]
\[ WP = 23.51 \]
\[ HR = 2.853 \]
\[ n = 0.014 \]

Construction Quantities

Concrete in Conduit: \( \text{plinth: } 472 \)
- Cover: \( 169 \)
Excavation: \( 306 \)

Scale \( \frac{5}{8}'' = 1' \)
GRAPEVINE DIVISION.

\[ S = 0.001 \]

Scale \( \frac{\frac{1}{4}}{\frac{1}{10}} \)

Sta. 1478+50 to 1481+50

HYDRAULIC PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>0.001</td>
</tr>
<tr>
<td>Capacity</td>
<td>431.0</td>
</tr>
<tr>
<td>Velocity</td>
<td>6.71</td>
</tr>
<tr>
<td>Area</td>
<td>64.19</td>
</tr>
<tr>
<td>Wetted Perimeter</td>
<td>22.87</td>
</tr>
<tr>
<td>Hydraulic Radius ( R )</td>
<td>2.81</td>
</tr>
<tr>
<td>( C )</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>126.7</td>
</tr>
</tbody>
</table>

CONSTRUCTION QUANTITIES

Per Lineal foot of Conduit-Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>1.63 Cu. Yds.</td>
</tr>
<tr>
<td>Concrete</td>
<td>23 Pounds</td>
</tr>
<tr>
<td>Steel</td>
<td></td>
</tr>
</tbody>
</table>
GRAPEVINE DIVISION
Sand Canyon Pressure Tunnel
Concrete Portion

Hydraulic Properties
Normal Section

Slope 0.0014
Area 63.62
Wetted Perimeter 28.27
Hydraulic Radius 2.25
Velocity 6.75
Capacity 430.
n 0.014
C 122.

Construction Quantities
Per lineal Ft. of Normal Section
Excavation 3.74 Cu.Yds.
Concrete 1.30
GRAPEVINE DIVISION
Sand Canyon Pressure Tunnel
Steel Portion

Hydraulic Properties
Normal Section

Slope  .00334
Area   56.745
Wetted Perimeter 26.704
Hydraulic Radius 2.125
Velocity 7.58
Capacity 430. 90.

Construction Quantities
Per lineal Ft. of Normal Section

<table>
<thead>
<tr>
<th>Unit Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation Cu.Yds.</td>
<td>5.81</td>
</tr>
<tr>
<td>Concrete in lining</td>
<td>.61</td>
</tr>
<tr>
<td>Timbers</td>
<td>4195</td>
</tr>
<tr>
<td>Spreaders</td>
<td>6</td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>7</td>
</tr>
<tr>
<td>Lagging</td>
<td>65.7</td>
</tr>
</tbody>
</table>

2" Lagging
**FREEMAN DIVISION**

**5.0004**

**Scale 2" = 1'**

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**HYDRAULIC PROPERTIES**

- **Slope**: .0004
- **Capacity**: 429.3
- **Velocity**: 4.826
- **Area**: 88.946
- **Wetted Perimeter**: 25.734
- **Hydraulic Radius**: 3.457
- **N**: .014
- **C**: 129.8

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**CONSTRUCTION QUANTITIES**

**Per Lineal Foot of Conduit Normal Section**

- **Excavation**: 4.014 Cu.Yds
- **Concrete in Conduit**: .5022
- **Concrete in Cover**: .2033
- **Steel in Cover**: 13.75 Lbs.
FREEMAN DIVISION

TUNNEL SECTION

$S = 0.0011$

Hydraulic Properties

$S = 0.011$
$Q = 432.1$
$V = 6.715$
$A = 64.36$
$WP = 24.45$
$HR = 2.632$
$n = 0.14$
$c = 124.8$

Construction Quantities

Timbers, B.M. 34.75
Spreaders, B.M. 3.0
Shoulder Braces, B.M. 7.0
Lagging, B.M. 52.0

<table>
<thead>
<tr>
<th>Unit</th>
<th>Timbered</th>
<th>Unlined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>3.974</td>
<td>3.247</td>
</tr>
<tr>
<td>Concrete in Lining</td>
<td>1.014</td>
<td>0.745</td>
</tr>
</tbody>
</table>

Quantities per Lineal Ft. of Tunnel Normal Section.
HYDRAULIC PROPERTIES

Slope 0.0013
Capacity 430
Velocity 7.2
Area 59.71
Wetted Perimeter 23.22
Hydraulic Radius 2.565
N 0.014
C 124.7

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel Normal Section
Unit Timbered Untimbered

Excavation CuYds 3.74 3.045
Concrete in Lining 9.75 7.16
Timbers B.M. 57.25
Spreaders 5.0
Shoulder Braces 7.0
Lagging 54.0
HYDRAULIC PROPERTIES

Slope  .001  
Capacity  4.32  
Velocity  6.5  
Area  66.5  
Wetted Perimeter  24.73  
Hydraulic Radius  2.69  
N  0.014  
C  12.55  

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit Timbered</th>
<th>Un-timbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>4.065</td>
<td>3.344</td>
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<tr>
<td>Concrete in Lining</td>
<td>1.002</td>
<td>0.752</td>
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<tr>
<td>Timbers</td>
<td>37.25</td>
<td></td>
</tr>
<tr>
<td>Spreaders</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Lagging</td>
<td>54.0</td>
<td></td>
</tr>
</tbody>
</table>
HYDRAULIC PROPERTIES

Slope \(0.0004\)
Capacity \(430.0\)
Velocity \(4.77\)
Area \(90.15\)
Wetted Perimeter \(26.76\)
Hydraulic Radius \(3.37\)
\(R\) \(0.014\)
\(C\) \(130.0\)

CONSTRUCTION QUANTITIES
Per Lineal Foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Unit</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation Cu. Yds.</td>
<td>6.53</td>
<td>5.5</td>
</tr>
<tr>
<td>Concrete in Lining</td>
<td>1.30</td>
<td>1.0</td>
</tr>
<tr>
<td>Timbers B. M.</td>
<td>50.58</td>
<td></td>
</tr>
<tr>
<td>Spreaders</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>6.75</td>
<td></td>
</tr>
<tr>
<td>Lagging</td>
<td>78.0</td>
<td></td>
</tr>
</tbody>
</table>
**JAWBONE DIVISION**

\[ S = 0.0008 \quad \text{Scale} \frac{1}{4} = 1' \]

---

**HYDRAULIC PROPERTIES**

- **Slope**: 0.0008
- **Capacity**: 4.30
- **Velocity**: 6.15
- **Area**: 69.93
- **Wetted Perimeter**: 23.87
- **Hydraulic Radius**: 2.93
- **C**: 0.014
- **C**: 126.9

---

**CONSTRUCTION QUANTITIES**

Per Lineal foot of Conduit Normal Section

- **Excavation**: 3.235 Cu.Yds.
- **Concrete in Conduit**: 0.473
- **... Cover**: 1.557
- **Steel in...**: 7.76 Pounds
JAWBONE DIVISION

5 = .0008  Scale 4" = 1'

HYDRAULIC PROPERTIES

Slope .0008
Capacity 4.30
Velocity 6.15
Area 65.93
Wetted Perimeter 23.87
Hydraulic Radius 2.93

C 0.14

C 130.

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th></th>
<th>Unit Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>Cu.Yds.</td>
<td>5.025</td>
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<tr>
<td>Concrete in Lining</td>
<td></td>
<td>1.15</td>
</tr>
<tr>
<td>Timbers</td>
<td>B.M.</td>
<td>43.0</td>
</tr>
<tr>
<td>Spreaders</td>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td></td>
<td>65.0</td>
</tr>
</tbody>
</table>
JA WB ONE DIVISION
S = .0012
Scale 1" = 1'

HYDRAULIC PROPERTIES
Slope .0012
Capacity 429
Velocity 7.20
Area 59.63
Wetted Perimeter 21.89
Hydraulic Radius 2.724
C 0.014
12.55

CONSTRUCTION QUANTITIES
Per Lineal Foot of Conduit Normal Section
Excavation 2.76 Cu.Yds.
Concrete in Conduit 0.39
" Cover 0.141
Steel in Cover 722 Lbs
JAWBONE DIVISION

S = .0004
Scale $\frac{1}{4}$ = 1'

HYDRAULIC PROPERTIES

Slope: 0.0004
Capacity: 4.30
Velocity: 4.77
Area: 90.15
Wetted Perimeter: 26.76
Hydraulic Radius: 3.37
N: 0.014
C: 130.

CONSTRUCTION QUANTITIES

Per Linear Foot of Conduit Normal Section

Excavation: 4.06 Cu.Yds
Concrete in Conduit: 0.53
Cover: 0.181
Steel in Cover: 12.34 Lbs.
JAWBONE DIVISION

Scale $\frac{3}{8} = 1''$

HYDRAULIC PROPERTIES

Slope
Capacity
Velocity
Area
Wetted Perimeter
Hydraulic Radius
R
C

CONSTRUCTION QUANTITIES
Per Lineal foot of Conduit Normal Section

Excavation
Concrete in Conduit
" Cover
Steel in Cover

2.957 Cu.Yds.
0.443
0.138
7.153 Lbs.
JAWBONE DIVISION

S = .0013
Scale 2" = 1'

2-1/2" Sq. Twisted Rods 9'-0" Long

Water Surface

HYDRAULIC PROPERTIES

Slope .0013
Capacity 4.30
Velocity 7.35
Area 58.2
Wetted Perimeter 21.65
Hydraulic Radius 2.655
H 2.014
C 12.50

CONSTRUCTION QUANTITIES

Per Linear foot of Conduit Normal Section

Excavation 2.745 Cu.Yds.
Concrete in Conduit .426
Concrete Cover .1308
Steel in Cover 6.81 Lbs.
HYDRAULIC PROPERTIES

Slope \( 0.000723 \)
Capacity \( 431 \text{ Sec. Ft.} \)
Velocity \( 5.72 \text{ Ft. Per. Sec.} \)
Area \( 75.39 \text{ Sq. Ft.} \)
Wetted Perimeter \( 26.79 \text{ Ft.} \)
Hydraulic Radius \( 2.81 \)
\( n \) \( 0.014 \)
\( c \) \( 126.8 \)

CONSTRUCTION QUANTITIES
Per lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>Cu.Yds.</td>
<td>4.515</td>
<td>3.702</td>
</tr>
<tr>
<td>Concrete in Lining</td>
<td>&quot; &quot;</td>
<td>1.068</td>
<td>0.773</td>
</tr>
<tr>
<td>Timbers</td>
<td>B. M.</td>
<td>40.00</td>
<td></td>
</tr>
<tr>
<td>Spreaders</td>
<td>&quot; &quot;</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>&quot; &quot;</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Lagging</td>
<td>&quot; &quot;</td>
<td>60.0</td>
<td></td>
</tr>
</tbody>
</table>
HYDRAULIC PROPERTIES

Slope 0.00035
Capacity 4.31
Velocity 4.59
Area 93.95
Wetted Perimeter 26.65
Hydraulic Radius 3.53
H 0.014
C 130.7

CONSTRUCTION QUANTITIES
Per Lined Foot of Conduit Normal Section

Excavation 4.23 Cu.Yds
Concrete in Conduit 5.36
" Cover 2.033
Steel in Cover 13.75 Lbs.
Hydraulic Properties

$Q = 433$ Sec ft.
$S = 0.00035$
$n = 0.014$
$A = 92.0$ Sq ft.
$D = 24.9$ ft.
$R = 3.7$
$C = 1.31$
$V = 4.7$ ft.

Construction Quantities.

per Lin ft. Normal Section

Excavation 4.21 Cus. ft.

Concrete in Conduit = 0.55
" " Cover = 0.231
Steel = 15.641 Lb.
ANTEOLOPE DIVISION
Scale 4' = 1'

HYDRAULIC PROPERTIES

Slope
Capacity
Velocity
Area
Welled Perimeter
Hydraulic Radius
N
C

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel

Pay Line

Unit Timbered Untimbered

Excavation CuYds 5.12 4.22
Concrete in Lining 1.13 .81
Timbers B.M. 42.5
Spreader 5.0
Shoulder Braces 7.0
Lagging 6.0.
HYDRAULIC PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>.0005</td>
</tr>
<tr>
<td>Capacity</td>
<td>429.5</td>
</tr>
<tr>
<td>Velocity</td>
<td>5.14</td>
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<tr>
<td>Area</td>
<td>83.52</td>
</tr>
<tr>
<td>Wetted Perimeter</td>
<td>26.06</td>
</tr>
<tr>
<td>Hydraulic Radius</td>
<td>3.20</td>
</tr>
<tr>
<td>N</td>
<td>0.014</td>
</tr>
<tr>
<td>C</td>
<td>128.5</td>
</tr>
</tbody>
</table>

CONSTRUCTION QUANTITIES
Per Lineal foot of Conduit Normal Section

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>3.8 Cu.Yds</td>
</tr>
<tr>
<td>Concrete in Lining</td>
<td>0.508</td>
</tr>
<tr>
<td>&quot; &quot; Cover</td>
<td>0.16</td>
</tr>
</tbody>
</table>
| Steel in              | 9.63 Lbs.
ANT ELOPE
S = .00035

DIVISION
Scale $\frac{1}{4}" = 1'$

HYDRAULIC PROPERTIES

- Slope: .00035
- Capacity: 431.
- Velocity: 4.59
- Area: 93.95
- Wetted Perimeter: 26.65
- Hydraulic Radius: 0.35
- $n$: 0.14
- $C$: 130.7

CONSTRUCTION QUANTITIES
Per Lineal foot of Conduit Normal Section

- Excavation: 4.23 Cu.Yds.
- Concrete in Conduit: .536
- Cover: 20.33
- Steel in Cover: 13.75 Lbs.
ANT ELOPE DIVISION
Scale ¼"=1.

2-5/8 Twisted Rods 12'6" Long
Water Surface

HYDRAULIC PROPERTIES

Slope
Capacity
Velocity
Area
Wetted Perimeter
Hydraulic Radius
n
C

0.0005
4.30
5.28
81.44
24.33
3.35
0.014
129.2

CONSTRUCTION QUANTITIES
Per Lineal foot of Conduit Normal Section.

Excavation
Concrete in Conduit
" Cover
Steel in Cover

3.703 Cu.Yds.
.475 "
.2033 "
13.75 Lbs.
ANTELOPE DIVISION
S. = 0.00035  Scale ¼" - 1'
Revised - See *25A

HYDRAULIC PROPERTIES

Slope 0.00035
Capacity 430.6
Velocity 4.566
Area 94.33
Wetted Perimeter 26.76
Hydraulic Radius 3.52
N. 0.014
C. 130.0

CONSTRUCTION QUANTITIES

For lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Unit</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation Cu. Yds.</td>
<td>6.61</td>
<td>5.65</td>
</tr>
<tr>
<td>Concrete in Lining &quot;</td>
<td>1.28</td>
<td>1.00</td>
</tr>
<tr>
<td>Timbers B. M.</td>
<td>43.00</td>
<td></td>
</tr>
<tr>
<td>Spredders</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>7.00</td>
<td></td>
</tr>
<tr>
<td>Lagging</td>
<td>76.00</td>
<td></td>
</tr>
</tbody>
</table>

25
HYDRAULIC PROPERTIES

Slope \(= 0.00035\)
Capacity 433.0
Velocity 4.51
Area 96.366
Wetted Perimeter 27.74
Hydraulic Radius 3.47
\(H\) 0.014
\(C\) 129.5

CONSTRUCTION QUANTITIES
Per Lineal Foot of Tunnel

Normal Section
Timbered Untimbered
Cubic Yds. Cubic Yds.
Excavation 641 5.88
Concrete in Lining 1.298 0.972
Timbers 54 BM

Spreadsers 4
Shoulder Braces 6
Lagging 69
ANT ELOPE DIVISION

CONDUIT SECTION

Hydraulic Properties

Normal Section

S = 0.0018
A = 53.15
Wp = 22.165
HR = 2.399
V = 8.122
Q = 431.7
n = 0.014
C = 123.6

Construction Quantities

per Linear Foot Normal Section

TIMBERED UN TIMBERED

Excavation 3.449 2.792
Concrete in Lining 9354 691
Lagging 47' BM
Shoulder B. 7'
Spreaders 5'
Timbers 32'
ELIZABETH TUNNEL

S = 0.001
Scale 4' = 1'-0"

HYDRAULIC PROPERTIES

Tunnel Slope 0.001
Hydraulic Gradient 0.003282
Capacity 1000
Velocity 11.426
Area 87.523
Wetted Perimeter 34.09
Hydraulic Radius 2.5675
N 0.014
C 124.5

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>CuYds 4.90</td>
<td>4.05</td>
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<td>Concrete in Lining</td>
<td>&quot;  1.185</td>
<td>1.805</td>
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<tr>
<td>Timbers</td>
<td>B.M. 43</td>
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</tr>
<tr>
<td>Spreaders</td>
<td>&quot;  5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>&quot;  7.0</td>
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<tr>
<td>Lagging</td>
<td>&quot;  60</td>
<td></td>
</tr>
</tbody>
</table>

26A
ELIZABETH TUNNEL

Scale \( \frac{1}{4} = 1' \)

Hydraulic Properties

- Slope: 0.001
- Capacity: 90.02
- Velocity: 34.86
- Area: 2.58
- Wetted Perimeter: 0.014
- Hydraulic Radius: 0.014

CONSTRUCTION QUANTITIES

Per Lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th></th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation CuYds</td>
<td>5.02</td>
<td>4.18</td>
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<td>Concrete in Lining</td>
<td>1.105</td>
<td>0.84</td>
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<td>43</td>
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<td>Spreaders</td>
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<tr>
<td>Shoulder Braces</td>
<td>7.0</td>
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</tr>
<tr>
<td>Lagging</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>
HYDRAULIC PROPERTIES

Const. Slope .002
Hyd. " .0017
Capacity 1000
Velocity 9.98
Area 100.23
Wetted Perimeter 36.54
Hydraulic Radius 2.74
N .012
C 146.5

CONSTRUCTION QUANTITIES

Per Linear Foot of Tunnel Normal Section

Timbered Untimbered
Excavation 5.60 4.63
Concrete in Lining 1.25 0.926
Timbers 49 B.M.
Spreaders 5
Shoulder Braces 8
Lagging 70
SAN FRANCISCO DIVISION
PRESSURE TUNNEL

HYDRAULIC PROPERTIES

Hyd. Slope 0.0013
Const. " 0.002
Capacity 1000
Velocity 9.08
Area 110.14
Wetted Perimeter 38.29
Hydraulic Radius 2.88
n 0.012
C 148

CONSTRUCTION QUANTITIES
Per Lineal Ft of Tunnel Section.

Timbered Untimbered
Excavation 6.12 5.19
Concrete in Lining 1.27 0.35
Timbers 49 BM
Spreader 6 "
Shoulder Braces 8 "
Lagging 71 "

Scale 4" = 1'-0"
SAUGUS DIVISION
$=0.00047$  Scale $\frac{\frac{1}{4}}{1'}$

HYDRAULIC PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Slope</td>
<td>0.00047</td>
</tr>
<tr>
<td>Capacity</td>
<td>4.20</td>
</tr>
<tr>
<td>Velocity</td>
<td>4.78</td>
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<tr>
<td>Area</td>
<td>87.95</td>
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<tr>
<td>Wetted Perimeter</td>
<td>29.31</td>
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<tr>
<td>Hydraulic Radius $H$</td>
<td>3.0</td>
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<tr>
<td>$C$</td>
<td>0.014</td>
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<tr>
<td></td>
<td>127.4</td>
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CONSTRUCTION QUANTITIES
Per Linear Foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Timbered</th>
<th>Untimbered</th>
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<tbody>
<tr>
<td>Excavation</td>
<td>5.12</td>
<td>4.22</td>
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<tr>
<td>Concrete in Lining</td>
<td>1.13</td>
<td>0.81</td>
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<tr>
<td>Timbers</td>
<td>42.5</td>
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</tr>
<tr>
<td>Spreaders</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td>7.0</td>
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</tr>
<tr>
<td>Lagging</td>
<td>60.</td>
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</tr>
</tbody>
</table>
SAUGUS DIVISION
S=0.00047
Scale \( \frac{\frac{1}{4}'}{1'} \)

**HYDRAULIC PROPERTIES**

- Slope: 0.00047
- Capacity: 416
- Velocity: 4.98
- Area: 83.52
- Wetted Perimeter: 26.06
- Hydraulic Radius: 3.20
- N: 0.14
- C: 128.5

**CONSTRUCTION QUANTITIES**

Per Lineal foot of Conduit Normal Section

- Excavation: 38 Cu.Yds.
- Concrete in Conduit: 0.508
- " Cover: 0.16
- Steel in Cover: 9.63 Lbs.
**Saugus Division**

S = 0.00047  
Scale $\frac{1}{4}" = 1'$

---

**Hydraulic Properties**

- **Slope**: 0.00047
- **Capacity**: 416
- **Velocity**: 4.925
- **Area**: 84.28
- **Wetted Perimeter**: 26.75
- **Hydraulic Radius**: 3.15
- **C**: 0.014

---

**Construction Quantities**

Per lineal foot of tunnel normal section

<table>
<thead>
<tr>
<th>Item</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>5.8</td>
<td>4.78</td>
</tr>
<tr>
<td>Concrete in Lining</td>
<td>1.24</td>
<td>.88</td>
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<tr>
<td>Timbers</td>
<td>4.8</td>
<td></td>
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<tr>
<td>Spreaders</td>
<td>6.0</td>
<td></td>
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<tr>
<td>Shoulder Braces</td>
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<tr>
<td>Lagging</td>
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</tr>
</tbody>
</table>

---

29
Saugus Division

Slope: 0.001
Capacity: 1000
Velocity: 7.81
Area: 127.87
Wetted Perimeter: 35.60
Hydraulic Radius: 3.59
C: 0.014
130.3

Hydraulic Properties

Construction Quantities Per Linear Foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Unit</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>6.7</td>
<td>5.93</td>
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<td>1.314</td>
<td>1.029</td>
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<tr>
<td>Timbered</td>
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<tr>
<td>Spreaders</td>
<td>.6</td>
<td></td>
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<tr>
<td>Shoulder Braces</td>
<td>7.0</td>
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<tr>
<td>Logging</td>
<td>.70</td>
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</tbody>
</table>

30
SAUGUS DIVISION
S = 0.0005 Scale 1/4" = 1'

HYDRAULIC PROPERTIES
Slope
Capacity
Velocity
Area
Wetted Perimeter
Hydraulic Radius

C

CONSTRUCTION QUANTITIES
Per Lineal foot of Tunnel Normal Section

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Timbered</th>
<th>Untimbered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>Cu.Yds.</td>
<td>5.0</td>
<td>4.12</td>
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<tr>
<td>Concrete in Lining</td>
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<td>1.11</td>
<td>0.80</td>
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<td>Timbers</td>
<td>B.M.</td>
<td>42.5</td>
<td>8.0</td>
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<td>Spreaders</td>
<td></td>
<td>5.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Shoulder Braces</td>
<td></td>
<td>7.0</td>
<td>60.</td>
</tr>
<tr>
<td>Lagging</td>
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<td></td>
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</tbody>
</table>

32
STANDARD REINFORCED CONCRETE SIPHON

HYDRAULIC PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>78.54</td>
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<tr>
<td>Wetted Perimeter</td>
<td>31.416</td>
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<tr>
<td>Hydraulic Radius</td>
<td>2.50</td>
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<tr>
<td>Velocity</td>
<td>5.88</td>
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<tr>
<td>Capacity</td>
<td>463</td>
</tr>
<tr>
<td>n</td>
<td>0.014</td>
</tr>
<tr>
<td>C</td>
<td>124</td>
</tr>
</tbody>
</table>

CONSTRUCTION QUANTITIES
Concrete 1.24 Cu. Yds Per Lin. Ft.

LONGITUDINAL REINFORCEMENT
17-3/4" Diam. Rods, 36'-11" Long Lapped 3'-2"
Spaced About 2 Ft. C-C

TRANSVERSE REINFORCEMENT SPACED 4" C-C

<table>
<thead>
<tr>
<th>Head</th>
<th>Rods</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 ft.</td>
<td>3/8&quot;</td>
<td>35'-4&quot;</td>
</tr>
<tr>
<td>30 &quot;</td>
<td>3/8&quot;</td>
<td>35'-10&quot;</td>
</tr>
<tr>
<td>45 &quot;</td>
<td>3/8&quot;</td>
<td>36'-5&quot;</td>
</tr>
<tr>
<td>70 &quot;</td>
<td>3/8&quot;</td>
<td>36'-11&quot;</td>
</tr>
</tbody>
</table>

Note: Sub Grade, or bottom of trench is 12 inches below grade, as noted on profile. Grade is taken as finished line of concrete in bottom of pipe.
STANDARD FLAT SLABS FOR CONDUIT.

12' 5 3/8"
11' 5 3/8"
6" 5 3/8"

Wire Fabric

5/8" Twisted Rods 12' 3" long Normal rod spacing 18" apart
4 ft. Top Cut " 9"
6 ft. or more Top Cut 6"

Conduits:
Pose Valley Division 5 = 0.0004
Freeman Division 5 = 0.0004
Mojave Division 5 = 0.00035
Antelope Division 5 = 0.00035
Antelope Division 5 = 0.0005

Scale 1/2" = 1'-0"

Construction Quantities:
Concrete 0.2641 Cu. Yds.
Steel Normal Spacing 10.845 #
9" 21.690 #
6" 32.536 #

May 1, 1911.