PROJECT IMPLEMENTATION CONSIDERATIONS FOR THE CALIFORNIA WATERFIX
Westlands Water District
August 9, 2017
Presented by Chuck Gardner on August 22, also.

CALIFORNIA WATER FIX - OVERALL PROGRAM

- Intakes
- North Tunnels
- Intermediate Forebay
- Clifton Court Pumping Plant
- Main Tunnels
- Stockton
- Sacramento

MAIN TUNNELS

- 100 year life
- Twin bore main tunnels
- 150 ft below grade
- Concrete segmental liner
- Pressurized face Tunnel Boring Machine construction
- 45 ft excavated diameter
- 40 ft finished internal diameter

Photo Courtesy: Port of Miami Tunnel
LARGE DIAMETER
TUNNEL BORING MACHINE PROJECTS

<table>
<thead>
<tr>
<th>City</th>
<th>TBM Diameter (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port of Miami</td>
<td>42</td>
</tr>
<tr>
<td>SMART Malaysia</td>
<td>43.3</td>
</tr>
<tr>
<td>CA Waterfall</td>
<td>45</td>
</tr>
<tr>
<td>Thimble Shoals</td>
<td>45.5</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>46</td>
</tr>
<tr>
<td>TAMC East</td>
<td>47.5</td>
</tr>
<tr>
<td>Waterkloof</td>
<td>49.5</td>
</tr>
<tr>
<td>Auckland</td>
<td>50.6</td>
</tr>
<tr>
<td>Madrid</td>
<td>51.2</td>
</tr>
<tr>
<td>Wuhan Metro</td>
<td>57.5</td>
</tr>
<tr>
<td>Sparrow Italy</td>
<td>58</td>
</tr>
<tr>
<td>Seattle - 2005</td>
<td></td>
</tr>
<tr>
<td>Hong Kong TAMC</td>
<td></td>
</tr>
</tbody>
</table>

PROGRAM FACTS

- 700,000 tunnel segments
- 23 million cubic yards of excavated tunnel material
- 10-12 Tunnel Boring Machines operating simultaneously
- 195 Mega Watts of power required for Tunnel Boring Machines - need to get power to remote parts of Delta
- Existing levees protect project sites
- Limited highway access in Delta
  - Large traffic and landing sites

GEOTECHNICAL PROFILE AT TUNNEL DEPTH

Note: Over 200 borings/CPTs completed

Typical Tunnel Segments and Lined Tunnel

Seattles tunnel segments with gaskets

Hong Kong tunnel

Shafts have to be protected by levees for launch sites of TBM.
REUSABLE TUNNEL MATERIAL ("Tunnel Muck")

- Preliminary level of testing (DWR Report)
  - Sterile material
  - Suitable for engineering fill
- Stockpiles at 6-14 ft
- Existing restoration uses
  - SFPUC Bay Tunnel Bair Island
  - London Crossrail Wallasea Island

Some Delta landowners are interested in using for creek
Used in SF Bay's Bair Island
restoration project.

PROTECTING FISH

Giant sump pump

CLIFTON COURT PUMP PLANTS
PROGRAM ESTIMATES

<table>
<thead>
<tr>
<th>Amount</th>
<th>Total ($ billions)</th>
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<tbody>
<tr>
<td>PM/CM/Engineering</td>
<td>$ 1.91</td>
</tr>
<tr>
<td>Tunnels/Shafts Construction</td>
<td>$ 6.82</td>
</tr>
<tr>
<td>Remaining construction</td>
<td>$ 2.68</td>
</tr>
<tr>
<td>Land Acquisition</td>
<td>$ 0.15</td>
</tr>
<tr>
<td>Contingency (approx. 36% for tunnels/shafts and remaining construction)</td>
<td>$ 3.38</td>
</tr>
</tbody>
</table>

Program Estimate in 2014 Dollars

DCE PROGRAM SCHEDULE

<table>
<thead>
<tr>
<th>Lead staffing</th>
<th>RFQ process</th>
<th>Land Acquisition</th>
<th>Utilities</th>
<th>Pump Plant</th>
<th>Intake</th>
<th>Tunnel</th>
<th>Clifton Court</th>
<th>IF</th>
</tr>
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<tbody>
<tr>
<td>1.75</td>
<td>0.30</td>
<td>1.0</td>
<td>3.0</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
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</table>

Design Phase

<table>
<thead>
<tr>
<th>Utilities</th>
<th>Site Work</th>
<th>Tunnel</th>
<th>Clifton Court</th>
<th>Intake</th>
<th>IF</th>
<th>Pump Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>4.0</td>
<td>10.75</td>
<td>7.0</td>
<td>7.25</td>
<td>4.5</td>
<td>2.25</td>
</tr>
</tbody>
</table>

Construction Phase

<table>
<thead>
<tr>
<th>Commissioning</th>
<th>Project Duration (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>4</td>
</tr>
</tbody>
</table>

REVIEW OF OTHER MEGA-TUNNEL PROJECTS

- The Eurasia Tunnel - Turkey
- Lee Tunnel - London
- Port of Miami Tunnel - Florida
- East Side Access - New York
- Blue Plains Tunnel Project - District of Columbia
- Bay Tunnel - San Francisco
- Willamette River Combined Sewer Outfall Program - Portland
- Gotthard Base Tunnel - Swiss Alps
- SR-99 Alaskan Way Replacement - Seattle

*Projects visited by program team
THE EURASIA TUNNEL – TURKEY

- Transportation Tunnel
  40 ft Internal Diameter (ID) x 2.1 miles
- 320 ft deep
- Completed Dec 2016
  - 3 months ahead of schedule
- Challenges
  - Complex geology, seismically active zone, and high groundwater pressure

LEE TUNNEL – LONDON

- 23.6 ft ID x 4.3 mile Combined Sewer Outfall (CSO) Tunnel
- 160 ft deep
- Completed December 2015
  - On schedule
  - Within budget
- Challenges
  - Groundwater contamination, complexity of Tunnel Boring Machine launch, and spoil removal
PORT OF MIAMI TUNNEL - FLORIDA

Project Information
- (2) 39 ft ID x 4,200 ft Long Transportation Tunnels
- 120 ft deep
- Completion May 2014
  - On schedule
  - Within budget
- Challenges
  - Porous coral and limestone required grouting, restricted access above tunnel due to shipping channel

BLUE PLAINS TUNNEL PROJECT

DISTRICT OF COLUMBIA

Blue Plains Tunnel

Project Information
- 23 ft ID x 24,200 ft CSO Tunnel
- 160 ft deep
- Completed Dec 2015
  - 3 months ahead of schedule
  - Under budget
- Challenges
  - Large deep shafts, existing infrastructure above tunnel

Text at top left: To keep cruise ship traffic out of downtown

Text at bottom right: Big shafts
**BAY TUNNEL – SAN FRANCISCO**

- 5 Mile Bay Tunnel
- Retrieval Shaft
- Launch Shaft

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**WILLAMETTE RIVER COMBINED SEWER OUTFALL PROGRAM – PORTLAND**

- Swan Island PS
- Westside Tunnel
- Eastside Tunnel
- Swan Island Pump Station

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**BAY TUNNEL – SAN FRANCISCO**

*Smaller Tunnels can slow you down because of space shortage*

**Project Information**

- 15 ft ID x 5 mile water tunnel
- 110 ft deep
- Completed Oct, 2014
  - On schedule
  - Within budget
- Challenges
  - Long tunnel drive, no intermediate shafts, limited surface access, and high ground water pressure

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**WILLAMETTE RIVER TUNNELS – PORTLAND**

**Project Information**

- (1) 14 ft ID x 3.5 mile 120 ft deep and (1) 22 ft ID x 6 mile
- 150 ft deep CSO tunnels
- Cost Reimbursable Fixed Fee
- Construction Complete Feb 2012
  - 8 months ahead of schedule
- Construction value US $719 M, 9% under budget
- Challenges
  - Schedule, existing infrastructure, groundwater, Tunnel Boring Machine breakout, soil modification, and subcontract changes
GOTTHARD BASE TUNNELS – SWISS ALPS

Project Information
- (2) 30 ft ID x 35 mile rail tunnel
- Up to 6,560 ft deep
- Completed June 2016 within schedule (17 years)
- Final construction cost $12.5B within budget
- Challenge: Safety, geology
- For the 2 main tunnels and the safety, ventilation and cross cuts, a total of 95 miles tunnel has been bored

SR-99 ALASKAN WAY REPLACEMENT-SEATTLE

Project Information
- 53 ft ID x 2 mile transportation tunnel
- Construction schedule
  - Approximately 2 year delay
- Challenges
  - Equipment malfunction, existing pile foundations and other infrastructure, difficult ground
SEATTLE TUNNEL SUCCESS

Tunnel breakthrough April 4, 2017

Inside Tunnel, prior to roadway construction

QUESTIONS

LESSONS LEARNED

- Proactive risk management strategy at all stages
- Assign risk to appropriate party
- Select project delivery method to maximize project benefits
- Get construction input early
- Invest in good geotechnical program and GBR
- Must have strong owner involvement
- Co-locate project team
- Resolve Right-of-Way and property acquisition early
- Resolve utility issues early
- Identify long lead items early
- Proactively manage logistical issues
- Develop effective program communication strategy

[Handwritten note:]

acknowledges the HSR ROW challenges.
CWIF will seek 3D easement - have to find subsurface owners of mineral right.
The California WaterFix
April 2015 Construction Cost Estimate

1. 5RMK Qualifications

5RMK is a project management and planning organization providing the following services to the infrastructure and resource development industries:

- Estimating, scheduling, project planning
- Permitting, siting assessments, environmental compliance
- Program & construction management
- Claims support, defense & dispute resolution

5 retired guys from Morrison Knudsen (5 RMK)

Today's Presentation

1. 5RMK Qualifications/experience
2. Scope of program
3. Cost summary
4. Basis of estimate
5. Intakes
6. Clifton Court pump plants
7. Tunnel reaches
2. Scope of 2015 Estimate

- New class 3 estimate as defined by the Association for the Advancement of Cost Engineering International
- New scope definition based on new quantity take-offs, crew definitions, equipment selections and productivities
- Scope of the Project:
  - 2 - 3000 CFS Intakes
  - 2 - 4500 CFS Clifton Court Pump Plants
  - 1 - Intermediate Forebay
  - 1 - Clifton Court modifications, include embankments, siphons, canals and control structures
  - Tunnels with shafts and safe havens
    - 1 - 28 ft inside diameter x 2 mile long (reach 1)
    - 1 - 28 ft inside diameter x 4.8 mile long (reach 2)
    - 1 - 40 ft inside diameter x 6.8 mile long (reach 2)
    - 2 - 40 ft inside diameter x 3.1 mile long (reaches 4-7)

3. Basis of Estimate

- Based on April 1, 2015 Conceptual Engineering Report (CER)
- Detailed quantity takeoffs prepared from CER
- Wage & workmen's comp rates based on "prevailing rates" listed by California Department of Industrial Relations
- Equipment ownership and operating costs based on US Army Corps Engineers
- Vendor and subcontract costs based on independent supplier solicitations
- All costs data is in 2014 dollars
- Work shifts - surface facilities: 4 days per week, 10 hours per day
- Work shifts - tunnels: 5 days per week, (2)10 hours shifts per day
- Geotechnical data is limited - further investigations are planned
- Advance rate for 40 ft diameter tunnels - 31 ft/day
- Advance rate for 28 ft diameter tunnels - 34.5 ft/day (reach 1); 40.4 ft/day (reach 2)

Total constructed value includes:
- All craft labor costs
- Construction equipment operating and ownership cost
- All permanent material and supply cost
- Field offices, laydown and staging area development
- Personnel, material, equipment and other transport cost
- Construction supervision, administration and management

Cost does not include:
- Land Acquisition, Program Management, Construction Management, Engineering, or Contingency

7. Tunnel Reaches

[Map showing tunnel reaches 1.2.3 and 4-7]
### 3. Construction Cost

**CWF April 2015 Estimate Summary**

<table>
<thead>
<tr>
<th>Contract</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intakes 2, 3, 5</td>
<td>$1,082,880,306</td>
</tr>
<tr>
<td>Intermediate Forebay</td>
<td>$159,579,782</td>
</tr>
<tr>
<td>Clifton Court Forebay</td>
<td>$593,720,041</td>
</tr>
<tr>
<td>Clifton Court Pump Plant</td>
<td>$446,577,237</td>
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<tr>
<td>Reach 7 Tunnels</td>
<td>$1,538,449,966</td>
</tr>
<tr>
<td>Reach 6 Tunnels</td>
<td>$1,559,673,985</td>
</tr>
<tr>
<td>Reach 5 Tunnels</td>
<td>$899,619,545</td>
</tr>
<tr>
<td>Reach 4 Tunnels</td>
<td>$1,603,383,401</td>
</tr>
<tr>
<td>Reach 1, 2, &amp; 3 Tunnels</td>
<td>$1,218,681,541</td>
</tr>
<tr>
<td>Communication Network, Scada</td>
<td>$25,065,734</td>
</tr>
<tr>
<td>Access, Power Delivery &amp; Utility Relocations</td>
<td>$371,300,000</td>
</tr>
<tr>
<td><strong>Construction Total</strong></td>
<td><strong>$9,498,931,538</strong></td>
</tr>
</tbody>
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**ALDEA SERVICES**

**CALIFORNIA WATER FIX**

**RISK MANAGEMENT – DESIGN AND CONSTRUCTION**

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**ALDEA SERVICES**

**CALIFORNIA WATER FIX**

**RISK MANAGEMENT – DESIGN AND CONSTRUCTION**
US Guidelines Exist for Risk Management on Tunnel Projects

- US Risk Management practice established by this document
- Published and available online by Underground Construction Association of Society for Mining, Metallurgy, and Exploration
- Emphasizes:
  - The importance of experience in project team
  - The use of Risk Registers as a risk management tool
  - Consistent risk management approach from early planning throughout life of project


Cost of delay = $415M/yr

Three-Step Risk Management Process

1. **AVOID**
   - Change tunnel alignment to avoid structures

2. **MITIGATE**
   - Probe ahead and grout to mitigate risk from faults

3. **ALLOCATE**
   - Provide clear contractual baselines to allocate residual risk

Process of Risk Management

- **START**
  - Identify Risks
  - Assess Risks
  - Risk & Opportunity Register
  - Risk Avoided
  - Residual Risk Acceptable?
  - Risk Allocated

- **Risk Mitigated**
  - Update Risk Register

- **Implementation**
  - Identify Control Measures
  - Implement Control Measures
  - Monitor

Design and Construction Risks

<table>
<thead>
<tr>
<th>Probability Rating</th>
<th>AKA</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Probable</td>
</tr>
<tr>
<td>4</td>
<td>Likely</td>
</tr>
<tr>
<td>3</td>
<td>Possible</td>
</tr>
<tr>
<td>2</td>
<td>Unlikely</td>
</tr>
<tr>
<td>1</td>
<td>Improbable</td>
</tr>
</tbody>
</table>

Consequence vs. Likelihood Matrix
Design and Construction Risks

Risk Examples – Top Five

- Initial works delayed leading to consequent delays to main construction
- Geotechnical investigation delayed leading to delay in design completion and start of construction
- Transmission power delayed leading to delay to start of tunneling
- Differing geotechnical conditions leading to slower progress, increased cost and delay to completion of tunneling
- Substantial design change required during construction leading to delay in commissioning

\[ \text{Cost} \text{ delay} = \$415 \text{ M} \]

Program Estimate

<table>
<thead>
<tr>
<th>Item</th>
<th>SRMK Estimate (Billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Base Construction Cost</td>
<td>$9.50</td>
</tr>
<tr>
<td>Contingency</td>
<td>$3.38</td>
</tr>
<tr>
<td>Program Management/Construction Management/Engineering</td>
<td>$1.91</td>
</tr>
<tr>
<td>Land Acquisition</td>
<td>$0.15</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>$14.94</strong></td>
</tr>
</tbody>
</table>

Annual Expenditures – 2014 Dollars

- $2.5B
- $2.0B
- $1.5B
- $1.0B
- $0.5B
- $0.0B

Year: 2014 to 2030

Annual Expenditures – with Risk and Inflation Cost

- Base Cost
- Risk Cost
- Escalation

Cost (Billions)

Year: 2014 to 2030
California WaterFix Construction Cost Distribution Profile

Questions?

Estimate Summary

<table>
<thead>
<tr>
<th>Item</th>
<th>Risk with Mitigation at 75% Confidence Interval (Billions)</th>
<th>SRMK Estimate (Billions)</th>
<th>Jacobs Eng Estimate (Billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$10.66</td>
<td>$9.50</td>
<td>$8.86</td>
</tr>
<tr>
<td>Contingency</td>
<td>-</td>
<td>$3.38</td>
<td>$3.15</td>
</tr>
<tr>
<td><strong>Construction Subtotal</strong></td>
<td><strong>$10.66</strong></td>
<td><strong>$12.88</strong></td>
<td><strong>$12.01</strong></td>
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<tr>
<td>PM/CM/Eng</td>
<td>$1.91</td>
<td>$1.91</td>
<td>$1.91</td>
</tr>
<tr>
<td>Land acquisition</td>
<td>$0.15</td>
<td>$0.15</td>
<td>$0.15</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>$12.72</strong></td>
<td><strong>$14.94</strong></td>
<td><strong>$14.07</strong></td>
</tr>
</tbody>
</table>

(1) Program estimates in 2014 dollars
(2) ~36% Contingency on construction for SRMK and Jacob Engineering estimates
(3) Based on risks known at time of assessment
Next Steps

- Finalize necessary agreements
- Additional modeling of WWD supply with and without CWF
- Will look at CWF capacity staff presentation at Fresno office 9 Apr

Questions?

Additional Resources

- California DNR's CWF website
  - https://www.californiawaterfix.com/
- Metropolitan Water District's 3 white papers on CWF
- State Water Resource Control Board's CWF website
  - http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delt a/california_waterfix/
- NOAA-NMFS' website
- USFWS' website
  - https://www.fws.gov/sfbaydelta/HabitatConservation/CalWaterFix/index.ht m
Gap Funding Agreement

- Parties Involved
  - DWR
  - SWPCA
  - CVP Participant(s)

- Purpose of Agreement
  - Requires SWPCA and CVP Participant(s) to fund CWF efforts until first bond issuance

Agreement on Implementation of the Biological Opinions

- Parties Involved
  - DWR
  - Bureau of Reclamation

- Purpose of Agreement
  - Defines the roles and responsibilities of each party for the obligations created by the CWF Biological Opinions

Coordination Agreement

- Parties Involved
  - DWR
  - CVP Participants
  - Reclamation

- Purpose of Agreement
  - Describes how DWR and Reclamation will coordinate and integrate operations of the CWF into the operations of the Projects

Next Steps
CVP Participation Approach

- **Parties Involved**
  - Bureau of Reclamation
  - CVP contractors

- **Purpose of Approach**
  - Identify protections for Participants and Non-Participants
  - Describes new CWF Water allocation process

Banks will be made available to CVP CWF participants due to limits at zones.

Master Agreement

- **Parties Involved**
  - DWR
  - CVP Participants

- **Purpose of Agreement**
  - Describe CVP Participants' interest in and payment for CWF
  - Provides CVP Participants with limited access to SWP facilities for CWF Water

Construction JPA

- **Parties Involved**
  - Various SWP & CVP Participants

- **Purpose of Agreement**
  - Creates the JPA responsible for the construction of the CWF

DWR-JPA Agreement

- **Parties Involved**
  - DWR
  - Construction JPA

- **Purpose of Agreement**
  - Provides Authority to the Construction JPA for the construction of the CWF

construction JPA
WWD Possible Participation
August 9, 2017

CWP Decision Timeline

- Prior to Decision
  - Finalize terms of key agreements
- Participation Decision
  - To be made in September or early October
  - State and Federal contractors will decide whether to participate in CWF
  - Participating CVP contractors will need to identify their 'Level of Participation'
- Post-Decision actions for Participants
  - CVP contract amendments
  - Execution of construction and financing agreements
  - Finalize remaining agreements

CVP Participation Decision

- Possible 'Level of Participation'
  - 20% Participation = $3.14B capital cost and 20% of capacity interest
  - 30% Participation = $4.71B capital cost and 30% of capacity interest
  - 45% Participation = $7.07B capital cost and 45% of capacity interest
- Factors affecting water supply
  - Implementation of Biological Opinions
  - Re-initiation of Consultation on Operations
  - Adaptive Management and Real-Time Operations
  - SWRCB Decision

Prior to Decision

- CVP Participation Approach
- Master Agreement
- Construction JPA Agreement
- DWR-JPA Agreement
- Gap Funding
- BO Implementation Agreement
- Coordination Agreement
WWD Workshop 8/22

Chuck Gendar - Hallmark Group

Gendar says sedes will show fine screens no problem.

2) Storms bring large sediment though.

CG says project will cost $14.9 B in 2014 dollars, Mett says $16.7 in 2017 dollars.

Design & Construction Enterprise organized as a large corporate bureaucracy. CG says everyone will be responsible for discipline by policies and procedures with real time auditing.

When you don't have more specifics about your project tunnels project, you talk about the tunnels attempted elsewhere.

CGI acquiring subsurface mineral rights will be a significant challenge for WaterFix ROW.

Barnabe expressed frustration about the project decision being like The Twilight Zone with the state seeing itself [validation sent].