NORTH SHORE CONNECTOR

TUNNELS AND STATION SHELL
LIGHT RAIL PROJECT

PAUL ZICK, PE
NORTH SHORE CONSTRUCTORS JV
North Shore Connector Alignment

- 7300 lf  Extension to existing 25 mile system
- 18 Contracts
- $435 Million
Funding – $435 Million

North Shore Funding Equals Economic Development

80% $348 Total Federal Dollars
($235.7 New Starts)

17% Pennsylvania $2.5

3% Allegheny County $14.5
Project Location

Future-to-Airport
North Shore Connector
Light Rail Expansion

003
006
007
004 New Gateway Station

EXISTING GATEWAY STATION

Existing Light Rail System
Project Team

• **Owner**
  - Port Authority of Allegheny County

• **Construction Manager**
  - TriGold
    • Jacobs Civil
    • HDR
    • Kwame
**Project Team**

- **Design Engineer**
  - DMJM

- **Contractor**
  - North Shore Constructors JV
    - Obayashi Corp.
    - Trumbull Corp.
What we are building

• Two Contracts

• Combined Contract Value - $156,500,000

• Time –
  – NTP                  Oct 2, 2006
  – 003 Tunnels         1243 days    Feb 26, 2010
  – 006 Station / C&C   870 days     Feb 18, 2009
Four Major Structure Types

• **Boat Section** – 340 If
  – SOE - Steel Soldier Piles and Wood Lagging

• **Cut and Cover** – 1200 If
  – SOE - Cement Deep Soil Mixing Wall (CDSM)
  – SOE – Cement Bentonite Wall (CB)

• **Top Down Construction - Station**
  – SOE - Slurry Wall

• **Bored Tunnel** – 2240 If
  – SOE - Precast Concrete Segmental Lining
Boat Section – Soldier pile and lagging

- Excavation – 0 to 35 feet
- Soldier Piles and Wood Lagging
- Above or at the water table
- Deep Wells
Boat Section - SOE - Soldier Piles & Lagging

Soldier Piles and Lagging

Grade – 7.62%

Waterproofing
Cut & Cover – SOE CDSM Walls

60’ +/-

CDSM Walls

Cut off ground water

ROCK
Cut & Cover / Launch Pit – CDSM Walls
Cut & Cover / Launch Pit - CDSM WALLS

In place soils mixed with Bentonite Slurry going down

Insert Steel Soldier Piles

Cement Slurry mixed going up
CDSM WALLS – Temporary Bridge
Excavation / Mud Slab / WP / Base Slab
Structural Concrete
Structural Concrete – Cut and Cover
Bridge to hold the Bridge

Support two Bents
Cut & Cover – Instrumentation

- Instruments
- Stain gauges
- Weather
- Tilt Meters
- Motorized Total Station
Underpinning – SR-65

Underpinning Beam

Drilled Pier

Drilled Pier
Underpinning – SR-65
North Side Station Shell
North Shore Station - Slurry Walls

Concourse
North Shore Station - Slurry Walls
North Shore Station – Slurry Walls

DESANDING

Primary Panel

Secondary Panel

Primary Panel

Primary Panel
North Side Station – Slurry walls

- Primary Panel
- Secondary Panel
- Primary Panel
- Secondary Panel
- Primary Panel
Slurry Walls - Rebar Cage
North Side Station – Top Down

ROCK
North Side Station – Pour Roof Slab
Excavate to Concourse

Backfill

Roof Slab

CONCOURSE

ROCK
Excavate to Concourse

CONCOURSE

ROCK

Soldier Piles installed by building contractor
Excavate to first row of struts

Backfill
Roof Slab

CONCOURSE

ROCK
Station Roof Slab Excavation

60 ft

40 ft

Slurry Wall
Excavate to Invert – Pour Base Slab

CONCOURSE

Backfill

Roof Slab

SLAB ANCHORS

ROCK
Construct Platform & Deck

Backfill

Roof Slab

CONCOURSE

ROCK
Ground Improvement - Jet Grouting
Launch Pit - Jet Grout

Jet Grout column construction
Drill Down
Grout bottom up
Launch Pit – Entrance Packing

Soft Eye
TBM – Move to Launch Pit
TBM – Move to Launch Pit

150 feet fully assembled
Launch Pit – TBM Launch
Launch Pit – Structure Work
Stanwix St. Receiving Pit Location

GATEWAY II

HORNE BUILDING

RECEIVING PIT
Ground Improvement - Jet Grout

- 75% Coverage
- 100% Coverage
- 100% Coverage
- 6’ Around Tunnel
Minimize Angular Distortion due to ground loss.
Bored Tunnels

TBM Tunnels – 2200 lf

Tunnel Boring Machine Launch Pit

Receiving Pit

NORTH SHORE

SOUTH SHORE
Bored Tunnel Section

Segment Lining 20’ inside diameter

PRECAST SEGMENT LINING

CAST IN PLACE INVERT
TBM Tunnels

- Slurry Pressure Balance TBM (SPBTBM)
  - Mixed Shield (Soft Ground and Rock)
  - Working Pressure 3 bar
Mining Cycle – Mine 4’ & Grout

Mine 4’

GROUT MAINTAINED BEHIND SHIELD
Mining Cycle – Install 4’ Segment Ring
Mining Cycle – Ring Complete - Mine

Mine 4’

GROUT MAINTAINED BEHIND SHIELD
Segment Grouting

- Segments
- Grout Nozzle
- Grout
TBM – SLURRY – MIX SHIELD

22'-9"
SPTBM Mixed Shield

27.1 FEET – 485 TONS
Slurry TBM – 22’- 9” dia (6.92 m)

- 24 -17 inch twin disk cutters
- 20 - Scrapers
- Bucket lips
- 3 - Wear detection devices
- 0-2.7 rpm
- Left or Right
Cutting Tools – After first tunnel

- Disk Cutters
- Scrappers
- Bucket Lips
Rock Crusher
TBM Assembly – Man Locks – 3 Bar (45 psi)

Material Lock
Cutter Head Drive

- Motors - 8 – 101 hp
- Total - 808 hp
- Variable Frequency Drive (VFD)
- 480 v AC
- 0-2.7 rpm (l or r)
- Main bearing – 8.5 ft
TBM – Rear of Middle Shield

- 5 Cylinders
- 4 Steering Groups
- 6 Cylinders
- 7 Cylinders
TBM – Rear of Middle Shield

- Propel Cylinders - 24
- Piston Diameter - 260 mm
- Rod Diameter - 220 mm
- Max Stroke - 1750 mm
- Advance force - 38227 kN (4,296 tn)
TBM Operation

Excavation Chamber

Working Chamber

Hydrostatic and Soil Pressure

Slurry In

Slurry Out
TBM – Operation Plan

SLURRY PLANT

SLURRY IN

455 hp PUMP

SLURRY OUT

2 EA - 455 hp PUMPS
Slurry Separation Plant

Plant Capacity
1000 m³/hr
Segment Erector

- Hydraulic telescopic arm type
- 6 ranges of movement
- Telescope
- Rotation
- Travel
- Independent
  - Roll & Yaw
- Controlled by joy stick
Segment Erector

- Thrust rams retracted 4’- 6”
Segment Installation

BOLT

Segment Erector
Key Segment Installation
Key Segment Installation

ERECTOR

MOVE OUT

KEY SEGMENT MOVE FORWARD
TBM Mining – Start North Side

SOUTH SHORE

NORTH SHORE

Equitable Resources

Building

Soft Ground
Fluvioglacial Material

- Gravel: 40% - 57%
- Sand: 50% - 38%
- Fines: 10% - 5%
- Cobbles: up to 2’
TBM – North River Wall

Alluvium
Fluvioglacial
Claystone
Siltstone
TBM North River Wall - Grouting

Alluvium
Fluvioglacial
Claystone
Siltstone
River Crossing

- **Allegheny River**: 25 feet
- **River Silts (Alluvial)**: 22 feet
- **Top of Rock**: FLUVIOGLACIAL
- **Silty Shale (5,400 – 11,800 psi)**: 10 feet
- **Coal**: CLAYSTONE (200 – 4,400 psi)
- **Siltstone (3,400-11,000 psi)**
River Crossing

NORTH SHORE

SOUTH SHORE

Well Horne Blg.

Equitable Resources Building

Jet Grout

Soft Ground

Mixed Face

+8.13%
TBM Guidance System – VMT

Total Station

Operator’s Display

Target

80 mm
Precast Segments – Universal Ring

Six pieces + Key

4’ – Long

20’ ID

Bolted

Two tapers 2-3/8 & 1-5/8
Segment Rebar Cages
Seg Plant – cycle 4 rings X 2/ day
Segment Finishing Line

- Rotate Segments – curve up
- Repair Surfaces
- Add Gasket
- Add Joint Packing
- Stack in reverse order of installation
Secondary Steam Curing

- 5 day Secondary Cure
- 8000 psi
Multi Purpose Vehicle (MVP)
Multi Purpose Vehicle (MVP)
Heading Segment Unloading
Heading Segment Unloading
Segment Erection
Tunnel Infrastructure

- Temporary Lighting
- 50,000 CFM Ventilation
- 13.6 KVA Main Power
- 2 - 6" Air
- 2 - 4" water
- 8" Discharge
- Walkway

12" Slurry In
12" Slurry Out
First Tunnel to Receiving Pit - July 10, 2008

Soft eye –
Fiberglass piles
First Tunnel to Receiving Pit - July 10, 2008

Containment Wall
TBM U-Turn- Rotate 180 deg
TBM U-Turn - Rotate 180 deg
TBM U-Turn- Rotate 180 deg
TBM U-Turn- Rotate 180 deg
Invert Clean Up
Invert Placement
Thank You

Questions?