GRAND AND MORLEY TUNNELS IN AMBOS NOGALES
DRAINAGE FEATURES AND FLOOD MAGNITUDES

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International Boundary and Water Commission
United States Section
For U.S. Department of State Meeting on April 28, 2016
View of the terrain of the Nogales Watershed in Mexico
Nogales Watershed

Drainage Area = 27.98 sq. mi.

DeConcini POE

Area of Concern
Tunnels in United States

- Grand Tunnel (Closed Conduit)
- Grand Channel (Open)
- Morley Tunnel (Closed Conduit)
- Nogales Wash (Open)
- DeConcini POE

USA
MEXICO
Grand Tunnel in Mexico

Alignment of the Grand Tunnel (Arroyo Internacional) in Mexico

 Limits where the Grand Tunnel does not have a concrete floor in Mexico

 Point where tributary tunnel joins Grand Tunnel
12 July 2008 Flood – Approximately 1,000 Feet of the Morley Tunnel collapsed in Nogales, Sonora adjacent to the pedestrian POE.
MORLEY TUNNEL COLLAPSE 12 JULY 2008 NOGALES, SONORA, MEXICO
July 12, 2008 (Day 1) Morley Tunnel Collapse in Mexico

Original Stone/Mortar Lined Walls Without Rebar
Morley Ave in Nogales, AZ
Flooding along Nogales Wash in Nogales, AZ
Flooding along Nogales Wash in Nogales, AZ
Flooding from Manhole Pressure Flow in Nogales, AZ
Damage from September 18, 2014 Flooding in Nogales, AZ
Damage from September 18, 2014 Flooding in Nogales, AZ
Flow Capacities of Tunnels

- Discharge or flow is expressed in cubic feet per second (cfs)
- 1 cfs ≈ 7.5 gallons per second [Fluid, U.S.]

The Baker (2011) report estimates capacities for maximum gravity flow throughout the tunnel.

Higher discharges cause pressure flow at tunnel entrance. Pressure flows can be higher, depending on the hydraulic head.

Maximum Gravity Flows:

- Morley Tunnel (East Tunnel) = 1925 cfs
- Grand Tunnel (West Tunnel) = 775 cfs
Flow Capacities of Tunnels vs Existing Condition Discharges

The Tetra Tech (2005) report Table 1 cites the following underground channel capacities:

- Nogales Wash (Morley) = 5,297 cfs
- Cemetery Wash (Grand) = 1,589 cfs

<table>
<thead>
<tr>
<th>Nogales Watershed Existing Condition Discharges at International Boundary (Tetra Tech, 2005)</th>
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<tr>
<td>Frequency</td>
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<td>5-Year</td>
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<td>10-Year</td>
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<td>25-Year</td>
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One Hour Discharge Volume Equivalent

The 5-year discharge would inundate 520 acres under 1 foot of water. Similarly, the 10-year and 25-year discharges would respectively inundate 682 and 993 acres under 1 foot of water.
Comparison of Existing Condition Discharges and Flow Capacities of Tunnels

Discharge (cfs)
Flow Capacities of Tunnels vs Future Condition Discharges

The Tetra Tech (2005) report Table 1 cites the following underground channel capacities.

- Nogales Wash (Morley) = 5297 cfs
- Cemetery Wash (Grand) = 1589 cfs

Future conditions are without mitigation. They represent development as occurring at a rate similar to past decades and assuming that full build-out of the watershed occurs.
Comparison of Future Condition Discharges and Flow Capacities of Tunnels
QUESTIONS?
GRAND AND MORLEY TUNNELS
IN AMBOS NOGALES

STRUCTURAL CONCERNS

by Jose A. Nuñez, P.E.

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Alignment of the Grand Tunnel (Arroyo Internacional) in Mexico

Limits where the Grand Tunnel does not have a concrete floor in Mexico

Point where tributary tunnel joins Grand Tunnel
Grand Tunnel in Mexico

No Apparent Channel Floor, July 16, 2014

Looking west from under the Bus Depot located in Mexico
Grand Tunnel in Mexico

North wall of channel paralleling international boundary in Mexico
South wall of channel paralleling international boundary in Mexico
12-inch Gap Below South Wall on July 6, 2014
Looking west on July 6, 2014. Floor is now significantly deeper on August 7, 2014. It appears that a waterfall effect is eroding the support for the walls along the channel.
Immediately adjacent to border. (see reflectors)
Immediately adjacent to border. (see reflectors)
Grand Tunnel in Mexico

Channel floor has completely eroded away; exposed bedrock is visible.

Within first 50 feet from international border.
Within first 50 feet from international border.

Channel floor has completely eroded away; exposed bedrock is visible.
Tunnels in United States

Grand Tunnel (Closed Conduit)

Grand Channel (Open)

Morley Tunnel (Closed Conduit)

Nogales Wash (Open)

Nogales Wash

DeConcini POE

USA

MEXICO
Morley Tunnel in United States

Deck of the box culvert, which is used as access road between East International Street and East Park Street.

Traffic wear and tear to concrete deck, resulting in exposed rebar on the right side corner.

Close-up view of exposed rebar on the right side corner of the culvert deck.
Morley Tunnel in United States

Floor of the Box Culvert

Abrasive particles have scoured away concrete and exposed transverse rebar.
Morley Tunnel in United States

Floor of the Box Culvert

Exposed traverse rebar

Scour has worn away concrete and exposed transverse rebar.
Morley Tunnel in United States

Floor of the Box Culvert

Detached rebar getting bent by flow in downstream direction

Abrasive particles eroded concrete and exposed transverse rebar.
Ceiling of the Box Culvert

*Ceiling deck penetrated for installation of plumbing fixtures.*
QUESTIONS?
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