Source: TCEQ Status Report (Oct 2018)
Impairment History

• 1990 – North Bosque identified as problem watershed
• 1992 – Listed as impaired on 303(d) List
• 1996 – Bosque River Advisory Committee formed
• 1998 – TMDL development initiated for excessive algae associated with high nutrients
• 2001 – TMDLs for phosphorus approved
• 2002 – Implementation Plan approved
North Bosque TMDL

Narrative Criteria - excessive aquatic plant growth due to elevated nutrients
Limiting Nutrient - Phosphorus

Instream & Laboratory Bioassays
Relationship between P & Algal Growth Rate

Monod Function

$$RGR = \frac{(0.94 \times PO_4-P)}{(0.024 + PO_4-P)}$$
North Bosque River TMDL

- Approved by EPA December 2001
- Mandates about a 50% reduction in soluble reactive phosphorus (SRP)
- Target concentrations of $\text{PO}_4^-$-P about 0.03 mg/L as the river flows into Lake Waco

(Target concentrations vary with Index Site from 0.448 mg/L below Stephenville to 0.028 mg/L at Valley Mills)
North Bosque Monitoring Stations

Index Stations circled in Red
## North Bosque River TMDL Reduction Goals

**Table 6. Average Annual-Average Soluble Phosphorus Concentration**

<table>
<thead>
<tr>
<th></th>
<th>Above Stephenville</th>
<th>Below Stephenville</th>
<th>Above Meridian</th>
<th>Clifton</th>
<th>Valley Mills</th>
</tr>
</thead>
<tbody>
<tr>
<td>From ‘Existing’ scenario (ppb)</td>
<td>203.3</td>
<td>1,143.2</td>
<td>117.0</td>
<td>52.2</td>
<td>41.3</td>
</tr>
<tr>
<td>From ‘TMDL-e’ scenario (ppb)</td>
<td>114.2</td>
<td>448.1</td>
<td>54.5</td>
<td>30.3</td>
<td>27.5</td>
</tr>
<tr>
<td>% reduction</td>
<td>43.83 %</td>
<td>60.80 %</td>
<td>53.42 %</td>
<td>41.95 %</td>
<td>33.41 %</td>
</tr>
</tbody>
</table>

The decimal places shown in this table are artifacts of the estimation process, and should not be considered significant.
North Bosque River TMDL

Identified two major sources of SRP

- Wastewater Treatment Facilities
- Dairy Waste Application Fields
### Phosphorus Sources

#### Table 3. Estimated Percent of Total Gross Annual Load by Source Type

<table>
<thead>
<tr>
<th>Source</th>
<th>Above Stephenville</th>
<th>Below Stephenville</th>
<th>Above Meridian</th>
<th>Clifton</th>
<th>Valley Mills</th>
</tr>
</thead>
<tbody>
<tr>
<td>urban runoff</td>
<td>2 %</td>
<td>6 %</td>
<td>6 %</td>
<td>6 %</td>
<td>6 %</td>
</tr>
<tr>
<td>row crop</td>
<td>0 %</td>
<td>0 %</td>
<td>2 %</td>
<td>4 %</td>
<td>5 %</td>
</tr>
<tr>
<td>non-row crop</td>
<td>2 %</td>
<td>2 %</td>
<td>2 %</td>
<td>1 %</td>
<td>1 %</td>
</tr>
<tr>
<td>pasture</td>
<td>9 %</td>
<td>5 %</td>
<td>7 %</td>
<td>8 %</td>
<td>9 %</td>
</tr>
<tr>
<td>wood/range</td>
<td>7 %</td>
<td>5 %</td>
<td>18 %</td>
<td>22 %</td>
<td>24 %</td>
</tr>
<tr>
<td>WWTP</td>
<td>0 %</td>
<td>28 %</td>
<td>10 %</td>
<td>9 %</td>
<td>10 %</td>
</tr>
<tr>
<td>WAF</td>
<td>80 %</td>
<td>54 %</td>
<td>55 %</td>
<td>50 %</td>
<td>45 %</td>
</tr>
<tr>
<td>Column totals (%)</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>
### Implementation Practices

<table>
<thead>
<tr>
<th>WWTF Discharges</th>
<th>Dairy Operations (CAFOs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Phosphorus Discharge Limits focused on two largest municipalities (Stephenville &amp; Clifton)</td>
<td>• Nutrient Management Planning</td>
</tr>
<tr>
<td>• Monitoring of Phosphorus at all WWTFs within Watershed</td>
<td>• Soil Testing for Phosphorus</td>
</tr>
<tr>
<td></td>
<td>• Use of Composting as Alternative to direct Land Application</td>
</tr>
</tbody>
</table>

• Use of Composting as Alternative to direct Land Application
Municipal WWTFs

Two Largest Required P Control

- **Stephenville** (1.5 MGD) implemented biological & chemical P control fall 2005
- **Clifton** (0.3 MGD) implemented chemical P control spring 2005

Decrease in Total-P in Effluent:
- Pre-Treatment often > 3mg/L
- Post-Treatment generally < 1 mg/L
North Bosque River Dairy Operations
Dairy Waste Application Fields

Comprehensive Nutrient Management Plans (CNMPs) -

• Required by new Concentrated Animal Feeding Operations (CAFOs) regulations – permitted facilities

Water Quality Management Plans (WQMP) -

• Voluntary for AFOs
Dairy Manure Export Support Project - TSSWCB

Composted Manure Incentive Project - TCEQ
Changes in Land Use

<table>
<thead>
<tr>
<th>Category</th>
<th>2000 Acres</th>
<th>2017 Acres</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>24,554</td>
<td>13,741</td>
<td>-44%</td>
</tr>
<tr>
<td>Historical</td>
<td>2,142</td>
<td>18,812</td>
<td>778%</td>
</tr>
<tr>
<td>Total</td>
<td>26,696</td>
<td>32,553</td>
<td>22%</td>
</tr>
</tbody>
</table>

Map represents conditions as of fall 2017

WAF = waste application field
Trends -
Is water quality improving?
## Phosphorus Trends

### North Bosque River Index Stations (+1)

<table>
<thead>
<tr>
<th>TIAER</th>
<th>TCEQ</th>
<th>Location</th>
<th>Period</th>
<th>SRP</th>
<th>Total P</th>
</tr>
</thead>
<tbody>
<tr>
<td>BO020</td>
<td>17226</td>
<td>Above Stephenville</td>
<td>1997-2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO040</td>
<td>11963</td>
<td>Below Stephenville</td>
<td>1994-2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO070</td>
<td>11963*</td>
<td>Near Hico</td>
<td>1993-2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO083</td>
<td>18003**</td>
<td>Near Iredell</td>
<td>2003-2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO090</td>
<td>11956</td>
<td>Near Clifton</td>
<td>1996-2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BO095</td>
<td>11954</td>
<td>Near Valley Mills</td>
<td>1996-2017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not a designated Index Station

** Limited flow data at station 18003
Flow-Adjusted ln(PO$_4$-P), mg/L

Water Quality Trends - BO040 below Stephenville

3σ Limits

UCL

$\bar{M} = 0$

LCL

Subgroup Index (year)

Subgroup Sizes: Min n = 11  Max n = 12  Box width varies with n
Flow-Adjusted ln(PO$_4$-P), mg/L

Water Quality Trends - BO095 near Valley Mills

Subgroup Index (year)

Subgroup Sizes: Min n = 11   Max n = 12   Box width varies with n
Have we met target goals?

Not entirely but getting close
Station 11956 located near Clifton

* Provisional Data
Station 11958/18003 located near Iredell
Station 11963 located below Stephenville
Station 17226 located above Stephenville

* 2018 Provisional Data
Is Water Quality Improving?

Yes!

Changes in treatment by WWTFs & land management are having an impact
Why is it taking so long?

Changes in land management impacted by variations in

- Timing and location of practices
- Residual impacts (soil & sediments)
- Long-term weather patterns
Acknowledgements

Funding for Monitoring -

- **TCEQ** - Texas Commission on Environmental Quality
- **TSSWCB** - Texas State Soil & Water Conservation Board
- **USDA-NRCS** - Natural Resources Conservation Service
- **EPA** - Environmental Protection Agency
- **BRA** - Brazos River Authority
- **TIAER** – Texas Institute for Applied Environmental Research