Canal Transportation in New Jersey

Grade Level: 3-5

Objectives: Students will demonstrate their understanding of why canals were built in New Jersey in the 1830s and their impact on the economy.

Across the Curriculum:

- **Economics:** Economic impact of canals
- **Geography:** Location of canals in NJ
- **History:** Canal Comparison
- **Language Arts:** Read *A Full Hand* (Yezerski, 2002) and *Bridgetender’s Boy* (Barth, 2004)
- **Math:** Canal Comparison
- **Science:** How does a canal work? What are locks and inclined planes?

NJ Core Content Social Studies Standards:

6.1.5.CivicsPI.1: Describe ways in which people benefit from and are challenged by working together, including through government, workplaces, voluntary organizations, and families.

6.1.5.GeoPP.2: Describe how landforms, climate and weather, and availability of resources have impacted where and how people live and work in different regions of New Jersey and the United States.

6.1.5.GeoPP.3: Use geographic models to describe how human movement relates to the location of natural resources and sometimes results in conflict.

6.1.5.GeoHE.2: Cite examples of how technological advances have changed the environment in New Jersey and the United States (e.g., energy, transportation, communications).

6.1.5.GeoGl.1: Use multiple sources to evaluate the impact of the movement of people from place to place on individuals, communities, and regions.

6.1.5.GeoGl.2: Use historical maps to explain what led to the exploration of new water and land routes.

6.1.5.EconET.2: Use quantitative data to engage in cost benefit analyses of decisions that impact the individual and/or community.
6.1.5.EconET.3: Explain how scarcity and choice influence decisions made by individuals, communities, and nations.

6.1.5.EconNM.2: Use data to describe how the availability of resources in New Jersey and other regions in the United States have impacted economic opportunities.

6.1.5.EconNM.3: Describe how the development of different transportation systems impacted the economies of New Jersey and the United States.

**Common Core ELA standards:**

RI.4.9  Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

W.4.2   Write informative/explanatory texts to examine a topic and convey ideas and information clearly

W.4.7   Conduct a short research project that builds knowledge through investigation of different aspects of a topic

W.4.9   Draw evidence from informational texts to support analysis, reflection and research

SL.4.2   Paraphrase information presented in diverse media, including orally

**Resources:**


For the history of the Delaware and Raritan Canal go to [https://www.dandrcanal.com/history](https://www.dandrcanal.com/history). Also read *The Delaware and Raritan Canal* (Linda Barth, Arcadia, 2002).


For children’s literature read *A Full Hand* (Yezerski, 2002) and *Bridgetender's Boy* (Barth, 2004).

**Essential questions:**

- Why and where were canals built in the 1820s and 1830s?
- How did the development of canals impact the economies of New Jersey and the United States?
- How did canals help to transform New Jersey from an agricultural society to an industrial society?

**Warm up:**

- What is a canal?
- Has anyone visited a canal?
- How do canals work?
- What is their purpose?
Background:

Canals are man-made waterways. Canal boats were towed by mules walking along the side of the canal on a towpath. The water bore most of the weight of the load, which enabled each animal to pull far more than it could pull while traveling on land. One horse could pull less than a ton over roads but it could pull up to 30 tons of cargo loaded in a canal boat.

The **Erie Canal** was the first transportation system between the eastern seaboard (New York City) and the western interior that did not require portage (carrying the boat over land). First proposed in 1807 and constructed from 1817 to 1825, the 363-mile Erie Canal allowed boats to bring bulk goods from Lake Erie to the Hudson River at Albany/Troy, New York and then down the Hudson River to New York City. It was built at a cost of $7 million and was 40 feet wide and four feet deep, and included 83 locks. The canal significantly reduced the cost of shipping, fostered a population surge in western New York, opened regions farther west to settlement and helped make New York City the chief port in the United States. Before the Erie Canal was built, three weeks were needed to haul one ton of goods from New York City to Buffalo. The financial cost was $95 to $125 per ton. The canal reduced the time required for the journey to 8 days and the dollar cost to just $4, within 10 years of the canal's completion. The Erie Canal helped make New York City the largest and richest city in the nation.

In 1816 there were only about 100 miles of operative canals in the entire nation. The success of the Erie Canal caused a canal-building frenzy, with states borrowing millions of dollars (primarily from Europe) to build more canals. By 1850 there were about 3,800 miles of canals. The cost to ship one ton of freight for one mile via canal was as little as one penny per ton, 1/15 of the lowest cost of transporting one ton for one mile via horse and wagon at the time.

The **Morris Canal**, chartered by New Jersey in 1824, was constructed across northern New Jersey from Phillipsburg on the Delaware River to Newark, New Jersey from 1825 to 1831 and to Jersey City by 1836, a total length of 102 miles and total cost of $3.8 million. The Morris Canal had an enormous elevation change of 1674 feet and used 23 inclined planes as well as 23 locks to move the boats. The Morris Canal was 32 feet wide and four feet deep. Iron ore and coal were the primary cargo shipped by the Morris Canal. For an interactive website where you can click on and see each of the locks and planes of the Morris Canal from Jersey City to Phillipsburg go to [http://nj.gov/state/njhistorypartnership/home_page.html](http://nj.gov/state/njhistorypartnership/home_page.html).

Since it took 5 days to ship coal by canal, compared to 8 hours by rail, by the 1870s the Morris Canal had serious competition from the railroads. By the early 20th century, commercial traffic on the canal had become negligible. In 1923, the State of New Jersey took possession of the canal, and formally abandoned the canal in 1924. The canal was largely dismantled. The water was drained out, and the banks were cut. The Newark City Subway, now Newark Light Rail was built along its route. Portions of the canal were preserved, primarily at **Waterloo Village**, a restored canal town in Sussex County, which contains many features of the canal, including the remains of an inclined plane, a guard lock, a watered section of the canal, a canal store, and other period buildings. The Canal Society of New Jersey maintains a museum in the village. The inlet where the canal connected to the Hudson River is now the north edge of Liberty State Park. The North Jersey Transportation Planning Authority is leading the statewide effort to create the Morris Canal Greenway. For additional information go to [www.MorrisCanalGreenway.org](http://www.MorrisCanalGreenway.org).
The Delaware and Raritan Canal (D&R Canal) was chartered in 1830 and opened in 1834, running 44 miles across central New Jersey from Bordentown on the Delaware River to New Brunswick on the Raritan River, with a 22-mile feeder canal from Bull’s Island (near Frenchtown), along the Delaware River, to Trenton. The D&R Canal was built at a cost of $2.8 million to provide an efficient route for transporting freight between Philadelphia and New York. The D&R Canal was 24 feet wide and eight feet deep. Since the D&R Canal ran along fairly level land, it had only 14 locks. Canal boats and barges were pulled by mule teams at first. Steam-powered ships were introduced on the canal around 1843. At the same time that construction began on the canal, a railroad route through the central part of the state was also under construction. One year later, in 1831, the canal company and the railroad company merged forming "The Joint Companies." This merger provided protection against competition for both the canal and the railroad. In 1855, the Belvidere-Delaware Railroad completed the laying of track alongside the feeder canal.

The D&R Canal was one of America’s busiest navigation canals during the 1860s and 70s when it carried coal from Pennsylvania to feed the industrial boom in New York and New Jersey. During these peak years, 80% of the total cargo carried on the canal was coal. By the end of the 19th century, use of the D&R Canal declined as it was unable to compete with the power and speed of the railroads. The D&R Canal’s last year of operation at a profit was 1892. However, it stayed open through 1932 when the State of New Jersey took it over and rehabilitated it to serve as a water supply system, which it still is today. In 1974, over 60 miles of the D&R Canal and its banks were turned into a state park where people can hike, jog, bicycle, and ride horses along the path where mules used to tow boats on the canal. The D&R canal still supplies water for approximately 600,000 people and also provides a natural habitat for birds, animals, and people. For additional information go to https://www.dandrcanal.com/trails.

Procedures:/Activities:

1. **Science: How does a canal work?**

   - What are locks?
     - A lock is a device for raising and lowering boats between stretches of water of different levels on rivers and canals. A lock is like a water elevator or a bathtub: when water is added, the vessel rises; when water is let out, the vessel descends. See Handout 1 for a photo of a lock on the Delaware and Raritan Canal.

   - What are inclined planes?
     - An inclined plane is a flat supporting surface tilted at an angle, with one end higher than the other, used as an aid for raising or lowering a load. It is a simple tool that has been used for centuries. Moving an object up an inclined plane requires less force than lifting it straight up, at a cost of an increase in the distance moved. See Handout 2 for examples of inclined planes.

   - Why were locks and inclined planes important for canals?
     - Locks and inclined planes allowed a canal to take boats across land that is not flat. See the Diagram of the Morris Canal for an example.

   - How do canals work?: Watch the video at http://www.youtube.com/watch?v=fiMsYzL1ziU
2. Geography:

See Handout 3 for the path of the Delaware and Raritan (D&R) Canal and Handout 4 for the path of the Morris Canal. Have students trace both canals on a map of New Jersey (Handout 5).

Students should indicate that the D&R Canal connects from near Frenchtown down to Trenton, and then from Trenton slightly south to Bordentown and then curving north through Princeton to New Brunswick. (red lines). Students should indicate that the Morris Canal (green line) connects from Jersey City through Essex, Morris and Warren Counties to where Phillipsburg is on the Delaware River.

The map below shows the path of the Morris Canal (green) and the Delaware and Raritan canal (red) along with the few roads that existed in the 1830s.

What do the locations of the D&R and Morris Canals tell us about why these canals were built?
3. Canal comparison

- Divide the class into three groups.
- Have each group use a graphic organizer (Handout 5: Canal Comparison Chart) to compare the Erie, Delaware and Raritan and Morris Canals in terms of when they were built, where they were built, how long they were, how many locks they had, how many inclined planes, how long they were used and their current status.
- Information can be found in the background and the resources listed above.
- Jigsaw and have the groups share their findings and complete the Canal Comparison Chart.
- A completed chart should include the following:

**CANAL COMPARISON CHART**

<table>
<thead>
<tr>
<th></th>
<th>Erie Canal</th>
<th>Morris Canal</th>
<th>Delaware &amp; Raritan Canal</th>
</tr>
</thead>
<tbody>
<tr>
<td>When built</td>
<td>1817-1825</td>
<td>1825-1831</td>
<td>1830-1834</td>
</tr>
<tr>
<td>Where built</td>
<td>Buffalo, NY on Lake Erie to Albany, NY on the Hudson River</td>
<td>Phillipsburg, NJ on the Delaware River to Jersey City, NJ on Hudson Bay</td>
<td>Frenchtown, NJ on the Delaware River to Trenton, NJ and Borden, NJ to New Brunswick, NJ on the Raritan River</td>
</tr>
<tr>
<td>Cost</td>
<td>$7 million</td>
<td>$3.8 million</td>
<td>$2.8 million</td>
</tr>
<tr>
<td>Length</td>
<td>363 miles</td>
<td>102 miles</td>
<td>44 miles plus a 22 mile feeder canal</td>
</tr>
<tr>
<td>Depth</td>
<td>4 feet</td>
<td>4 feet</td>
<td>8 feet</td>
</tr>
<tr>
<td>Width</td>
<td>40 feet</td>
<td>32 feet</td>
<td>24 feet</td>
</tr>
<tr>
<td>Elevation</td>
<td>565 feet</td>
<td>1674 feet</td>
<td>58 feet</td>
</tr>
<tr>
<td>Number of Locks</td>
<td>83</td>
<td>23</td>
<td>14</td>
</tr>
<tr>
<td>Number of Inclined planes</td>
<td>0</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Dates in use</td>
<td>1825-today</td>
<td>1831-1920s but minimal use after 1870s</td>
<td>1834-1932 but minimal use after 1890s</td>
</tr>
<tr>
<td>Current status</td>
<td>Restored 1996. Used mainly for recreational watercrafts but also some commercial traffic</td>
<td>Abandoned in 1924 and largely dismantled and filled in. Historic site with a canal lock at Waterloo Village. Greenway for cycling and walking planned.</td>
<td>Provides water to approximately 600,000 people. A state park since 1974 with boating, biking and hiking trails along the canal.</td>
</tr>
</tbody>
</table>
4. **Literature connections about working on a canal.**

Have students read either *A Full Hand* by Thomas Yezerski (2002) or *Bridgetender’s Boy* by Linda Barth (2004). Both involve young boys working as mule drivers on canals. Have students report on the book they chose to read. What does the story tell us about working on a canal? Would you like to work on a canal?

5. **Research the economic impact of the canals.**

- What was the impact on New Jersey during the 1830s through 1870s, the height of the use of the canals?
- Have students gather data on the growth of towns and cities and industry in New Jersey during this period and draw conclusions about the impact of the canals.
- How did the canals help transform New Jersey from an agricultural society to an industrial society?

6. **Critical thinking activity.**

- Look at the schematic of inclined planes on the Morris Canal. Why were inclined planes necessary for the Morris Canal?

The Morris Canal was built across northern New Jersey where the land was hilly. The inclined planes allowed the boats to be carried up and down the hills in cradle cars attached to a cable. Water power was used to move the cable, which then moved the cradle car with the boat up and down the planes. This way, boats could be moved over hills and mountains.

- Why was the Delaware & Raritan (D&R) Canal more successful than the Morris Canal?

Unlike the Morris Canal, the D&R Canal ran over fairly flat land, which was easier and less costly. Also the D&R Canal was part of a Joint Company with a railroad that protected it from competition (see below).

7. **Comparison of past and present.**

- How are heavy goods, such as coal, oil, wood, furniture, metal and food products shipped today?
- What is the same and what is different regarding freight traffic today and on the canals in the 1800s?

**Assessment**

Have students explain by drawings, short essays or orally, why the Erie, Morris and Delaware & Raritan Canals were built in the early 1800s and what brought an end to the use of the canals.
Extension

- Invite a naturalist from the D&R State Park to visit your class. Call 609-924-5705 to ask for a naturalist from the D&R State Park.
- Take a walk, bicycle ride or canoe trip on the D&R Canal in New Jersey. For information about current points of interest along the D&R Canal go to https://www.dandrcanal.com/trails.
- Visit Waterloo Village in Sussex County and see the remnants of the Morris Canal.

Bicycling along the D&R Canal

Filled portion of Morris Canal in Jersey City
A lock on the Delaware and Raritan Canal
What is an inclined plane? How does it work?

- An inclined plane is a simple machine. An inclined plane is a ramp used to reduce the effort needed to raise or lower an object over a vertical height.

- It is easier to climb stairs to get to a second floor than to climb straight up a rope. It is easier to walk up a long, gentle hill than to climb up a short, steep hill.

- The following are examples of inclined planes:

  ![Loading ramp](image1)
  ![Stairs or wheelchair ramp](image2)
  ![Mountain road and threaded screw](image3)

- What are other examples?

- The ancient Egyptians used inclined planes, or ramps, to move huge blocks of stone to build the pyramids.

- Inclined planes were used as part of the Morris Canal.
To help the canal climb over the New Jersey Highlands on its way from Phillipsburg to Jersey City, the Morris Canal developed inclined planes to raise and lower its canal boats up to 100 feet at a time. Built in the 1830s and redesigned in the 1850s, these huge machines were up to 1,400 feet long and capable of moving boats loaded with 70 tons of cargo from one canal level to the next. The canal used 23 of these inclined planes and 23 lift locks to overcome an elevation change of almost 1,700 feet, an unbroken world record.

After years of service, the canal was abandoned in 1923 and much of its infrastructure was dismantled. However, at Inclined Plane 9 West the plane tender’s house, turbine chamber and tailrace tunnel are still in place making this site one of the best remaining examples of these engineering marvels.

1. THE POWER HOUSE- The stone foundation of the power house is still intact with its opening covered with iron bars. You can see the reaction turbine that once powered the plane still in place in the chamber below. Nearby are assembled pieces and parts of the machinery. Across the driveway in the plane itself marked by a double row of stones. A modern reconstruction shows how the plane rails were supported on heavy wooden timbers that provided a flexible cushion between the rail and stones.

2. THE TAILRACE- Downhill from the power house is the iron arch that frames the end of the tailrace tunnel where the water from the turbine chamber and water from bypass flume joined to flow down the tailrace channel and into the lower level of the canal at the bottom of the plane. When tows are being offered, it is possible to walk up the tailrace tunnel and into the turbine chamber. The huge reaction turbine that once powered the plane almost completely fills the room. When the plane tender opened the tub valve above, the pressure of thousands of tons of water would send the head of the turbine spinning at about 60 revolutions per minute. Water from the turbine’s four nozzles would fill the chamber and send a river surging down the tailrace tunnel.

3. THE PLANE SUMMIT- At the top of the plane the summit acted as a dam to contain the water in the upper level of the canal and divert it into the headrace flume. A double set of tracks came up the plane, over the summit and back down into the water. The 90-foot-long canal boats and cradle cars were built in two hinged sections that could flex as they crossed the summit of the plane. Plane 9 West’s double set of tracks and two cradle cars allowed boats to go up and down the plane at the same time.

THE CRADLE CARS

Canal boats were transported up and down the inclined plane on the wheeled cradle cars riding on iron rails. To facilitate loading and unloading the boats the rails extended down into the bottom of the canal at both ends of the plane. The cradle cars rolled down into the water and the boats were floated on. A brakemen supervised the loading, rode the cradle car up and down the plane, and applied a brake to keep the car under control. Both the boats and cradles were built in two sections so that they could flex as they crossed the summit of the plane.

A cradle car and canal boat on its way up the inclined planes.
THE WATER

The water to power the inclined plane was brought to the powerhouse from the upper level of the canal in a headrace flume supported on a wooden trestle and stone piers. At the powerhouse the water was dropped 47 feet to turn a reaction turbine located in a chamber below. Used water exited the turbine chamber through a tailrace tunnel and flows into the lower canal powering the next inclined plane. When the inclined plane was not in operation, water was routed through a bypass flume and channeled directly to the lower level of the canal.

WATER FLOW DIAGRAM

The headrace flume, measuring eight feet wide by five feet deep, brought water from the upper level of the canal to the powerhouse.

The Plant 9 West powerhouse is seen above while below water flows from the bypass through on the left and the tailrace tunnel on the right.

THE CABLE - The two-inch diameter wrought iron cable formed a loop traveling on idler pulleys from the cable winding drum in the powerhouse to sheave wheels located under water in the upper and lower levels of the canal. As the cable drum turned it pulled the cable and moved the cradle cars loaded with canal boats up and down the plane.
Route of the Morris Canal
Handout 5
Trace the D&R and Morris Canals on the map of New Jersey.
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