In [1]:

```
# importing required librabries
import pandas as pd
import seaborn as sns
import matplotlib .pyplot as plt
import numpy as np
import matplotlib.dates as mdates
import warnings
warnings.filterwarnings("ignore")
plt.style.use("fivethirtyeight")
import matplotlib.style as style# Import necessary libraries
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from statsmodels.tsa.seasonal import seasonal_decompose
```

In [2]:

```
data = pd.read_csv('train_data.csv')
data.head()
```

Out[2]:

	ID	date	Item Id	Item Name	ad_spend	anarix_id	units	unit_price
0	2022-04-12_B09KDTS4DC	2022-04-12	B09KDTS4DC	NapQueen Elizabeth 8" Gel Memory Foam Mattress...	NaN	NAPQUEEN	0.0	0.0
1	2022-04-12_B09MR2MLZH	2022-04-12	B09MR2MLZH	NapQueen 12 Inch Bamboo Charcoal Queen Size Me...	NaN	NAPQUEEN	0.0	0.0
2	2022-04-12_B09KSYL73R	2022-04-12	B09KSYL73R	NapQueen Elsa 8" Innerspring Mattress, Twin XL	NaN	NAPQUEEN	0.0	0.0
3	2022-04-12_B09KT5HMNY	2022-04-12	B09KT5HMNY	NapQueen Elsa 6" Innerspring Mattress, Twin	NaN	NAPQUEEN	0.0	0.0
4	2022-04-12_B09KTF8ZDQ	2022-04-12	B09KTF8ZDQ	NapQueen Elsa 6" Innerspring Mattress, Twin XL	NaN	NAPQUEEN	0.0	0.0

In [3]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 101490 entries, 0 to 101489
Data columns (total 8 columns):
 #   Column      Non-Null Count   Dtype  
---  ------      --------------   -----  
 0   ID          101490 non-null  object 
 1   date        101490 non-null  object 
 2   Item Id     101488 non-null  object 
 3   Item Name   99658 non-null   object 
 4   ad_spend    77303 non-null   float64
```

```
 5   anarix_id   101490 non-null  object
 6   units       83592 non-null   float64
 7   unit_price  101490 non-null  float64
dtypes: float64(3), object(5)
memory usage: 6.2+ MB
```

In [4]:
```
data['date'] = pd.to_datetime(data['date'])
data.isnull().sum()
```

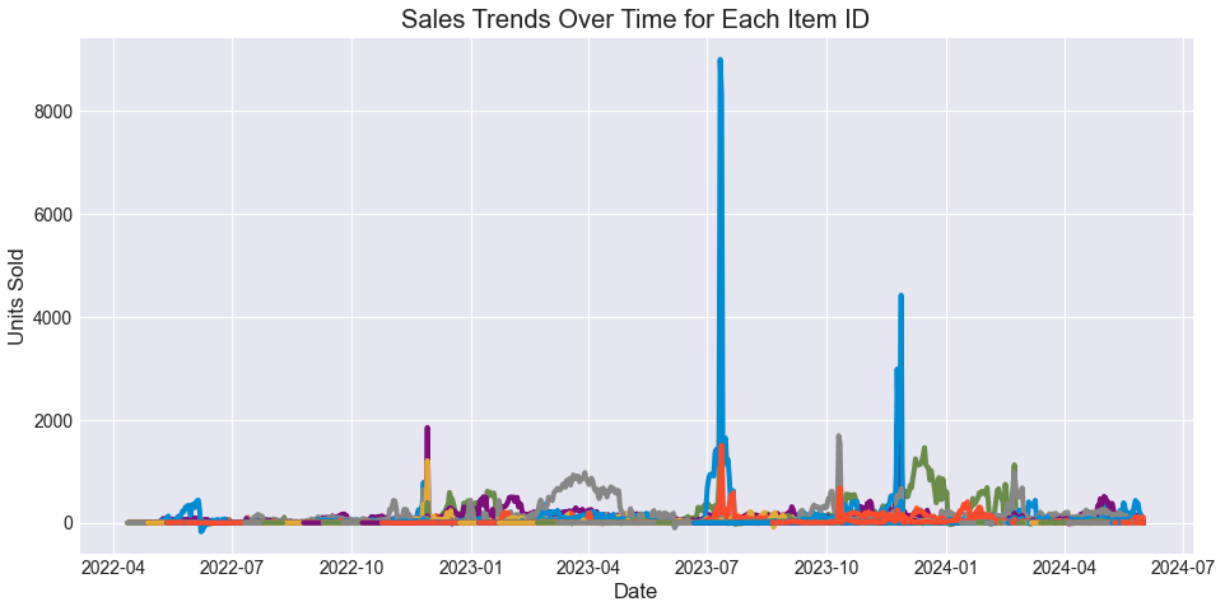
Out[4]:
```
ID               0
date             0
Item Id          2
Item Name     1832
ad_spend     24187
anarix_id        0
units        17898
unit_price       0
dtype: int64
```

In [6]:
```
data.index
```

Out[6]:
```
RangeIndex(start=0, stop=101490, step=1)
```

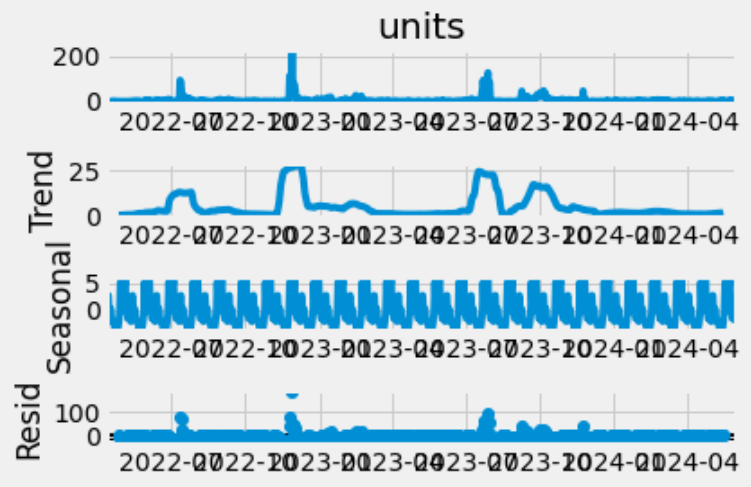
EDA

In [37]:
```
unique_item_ids = data['Item Id'].unique()

plt.figure(figsize=(14, 7))
for item_id in unique_item_ids:
    item_data = data[data['Item Id'] == item_id]
    plt.plot(item_data['date'], item_data['units'], label=f'Item {item_id}')
plt.title('Sales Trends Over Time for Each Item ID')
plt.xlabel('Date')
plt.ylabel('Units Sold')

plt.show()
```



In [14]:
```
item_data = data[data['Item Id'] == unique_item_ids[0]]
item_data.set_index('date', inplace=True)
item data = item data.resample('D').sum()
```

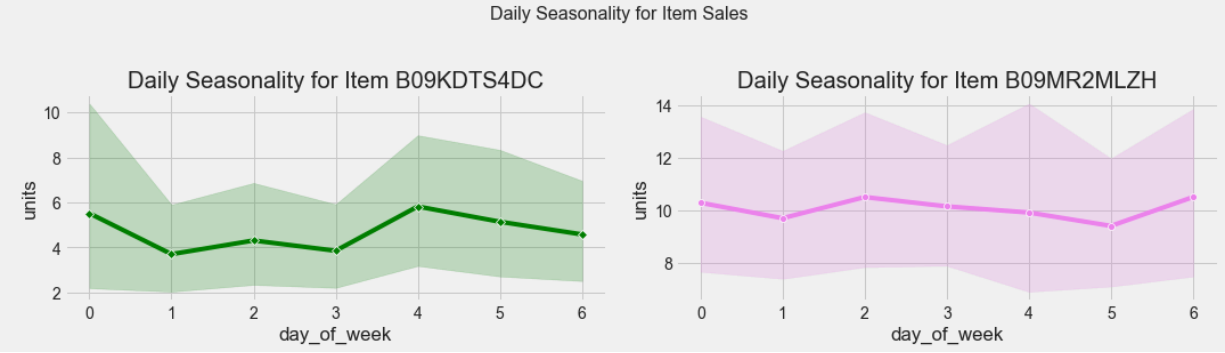
```
result = seasonal_decompose(item_data['units'].dropna(), model='additive', period=30)
result.plot()
plt.show()
```

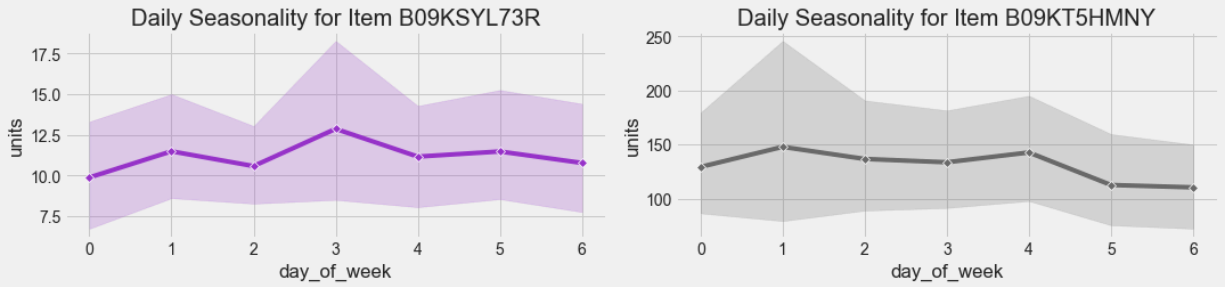


Daily Seasonality

In [38]:

```
data['date'] = pd.to_datetime(data['date'])
# Extract day of the week for daily seasonality analysis
data['day_of_week'] = data['date'].dt.dayofweek

plt.style.use("fivethirtyeight")

fig, axs = plt.subplots(nrows=2, ncols=2, sharey=False, figsize=(15, 8))
fig.suptitle("Daily Seasonality for Item Sales", fontsize=16)

item_ids = data['Item Id'].unique()[:4]  # Assuming there are at least 4 unique item IDs

sns.lineplot(data=data[data['Item Id'] == item_ids[0]], x='day_of_week', y='units', ax=axs[0
axs[0, 0].set_title(f'Daily Seasonality for Item {item_ids[0]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[1]], x='day_of_week', y='units', ax=axs[0
axs[0, 1].set_title(f'Daily Seasonality for Item {item_ids[1]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[2]], x='day_of_week', y='units', ax=axs[1
axs[1, 0].set_title(f'Daily Seasonality for Item {item_ids[2]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[3]], x='day_of_week', y='units', ax=axs[1
axs[1, 1].set_title(f'Daily Seasonality for Item {item_ids[3]}')

sns.set_style("darkgrid")

fig.tight_layout(rect=[0, 0, 1, 0.96])  # Adjust layout to make room for the title
plt.show()
```

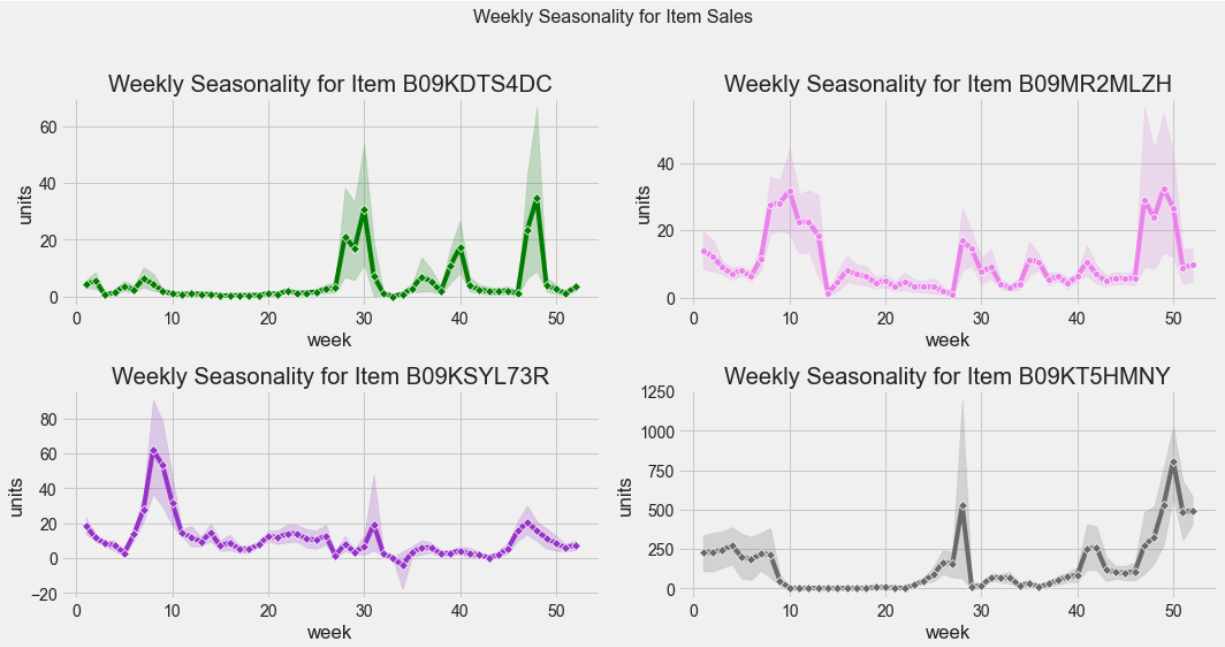




Weekly Seasonality

In [41]:

```
data['date'] = pd.to_datetime(data['date'])
data['week'] = data['date'].dt.isocalendar().week

plt.style.use("fivethirtyeight")

fig, axs = plt.subplots(nrows=2, ncols=2, sharey=False, figsize=(15, 8))
fig.suptitle("Weekly Seasonality for Item Sales", fontsize=16)

item_ids = data['Item Id'].unique()[:4]  # Assuming there are at least 4 unique item IDs

sns.lineplot(data=data[data['Item Id'] == item_ids[0]], x='week', y='units', ax=axs[0, 0], m
axs[0, 0].set_title(f'Weekly Seasonality for Item {item_ids[0]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[1]], x='week', y='units', ax=axs[0, 1], m
axs[0, 1].set_title(f'Weekly Seasonality for Item {item_ids[1]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[2]], x='week', y='units', ax=axs[1, 0], m
axs[1, 0].set_title(f'Weekly Seasonality for Item {item_ids[2]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[3]], x='week', y='units', ax=axs[1, 1], m
axs[1, 1].set_title(f'Weekly Seasonality for Item {item_ids[3]}')

sns.set_style("darkgrid")


fig.tight_layout(rect=[0, 0, 1, 0.96])  # Adjust layout to make room for the title
plt.show()
```



Monthly Seasonality

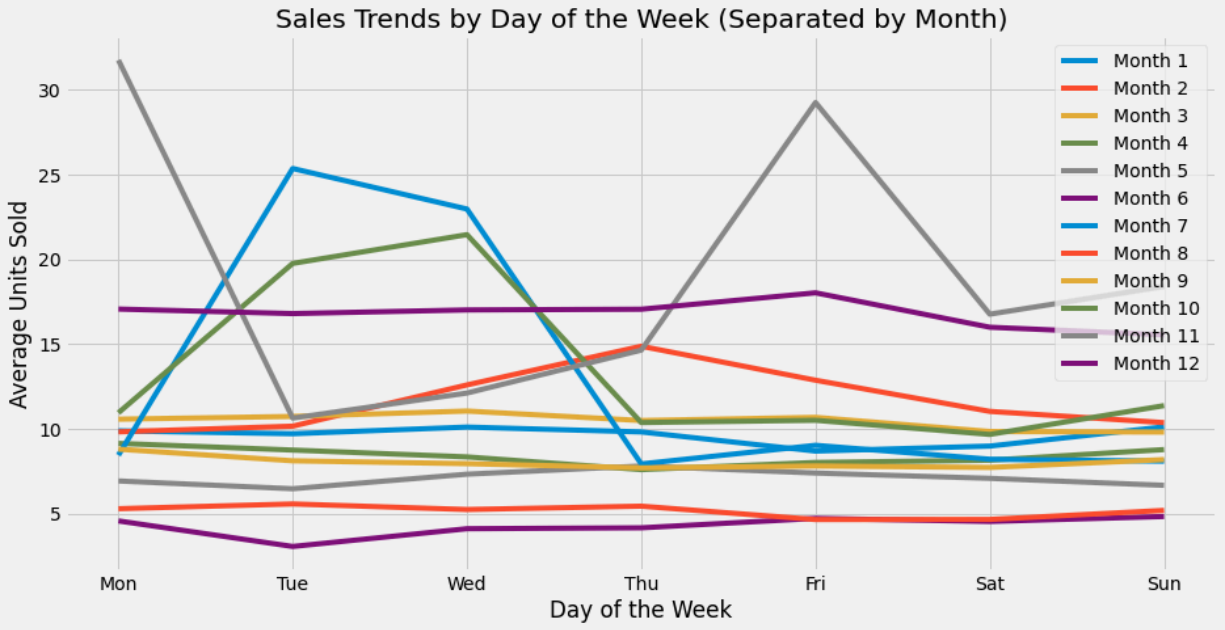
In [42]:

```
data['month'] = data['date'].dt.month

plt.style.use("fivethirtyeight")

fig, axs = plt.subplots(nrows=2, ncols=2, sharey=False, figsize=(15, 8))
fig.suptitle("Monthly Seasonality for Item Sales", fontsize=16)

item_ids = data['Item Id'].unique()[:4]  # Assuming there are at least 4 unique item IDs

sns.lineplot(data=data[data['Item Id'] == item_ids[0]], x='month', y='units', ax=axs[0, 0],
axs[0, 0].set_title(f'Monthly Seasonality for Item {item_ids[0]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[1]], x='month', y='units', ax=axs[0, 1],
axs[0, 1].set_title(f'Monthly Seasonality for Item {item_ids[1]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[2]], x='month', y='units', ax=axs[1, 0],
axs[1, 0].set_title(f'Monthly Seasonality for Item {item_ids[2]}')

sns.lineplot(data=data[data['Item Id'] == item_ids[3]], x='month', y='units', ax=axs[1, 1],
axs[1, 1].set_title(f'Monthly Seasonality for Item {item_ids[3]}')

# Set the style
sns.set_style("darkgrid")

# Adjust layout
fig.tight_layout(rect=[0, 0, 1, 0.96])  # Adjust layout to make room for the title
plt.show()
```

In [32]:

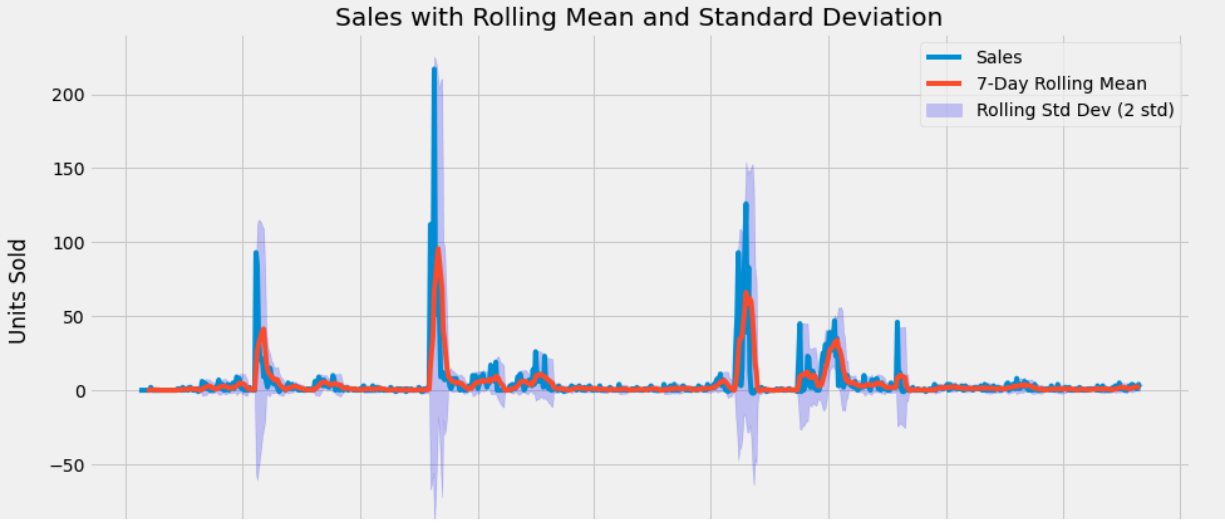
```
# EDA: Sales Trends by Day of the Week separated by Month
data['day_of_week'] = data['date'].dt.dayofweek
data['month'] = data['date'].dt.month

plt.figure(figsize=(14, 7))
for month in range(1, 13):
    monthly_data = data[data['month'] == month]
    avg_sales_by_day = monthly_data.groupby('day_of_week')['units'].mean()
    plt.plot(avg_sales_by_day.index, avg_sales_by_day.values, label=f'Month {month}')
plt.title('Sales Trends by Day of the Week (Separated by Month)')
```

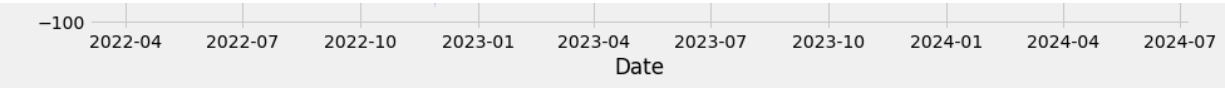
```
plt.xlabel('Day of the Week')
plt.ylabel('Average Units Sold')
plt.legend()
plt.xticks(ticks=[0, 1, 2, 3, 4, 5, 6], labels=['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'S
plt.show()
```



In [34]:

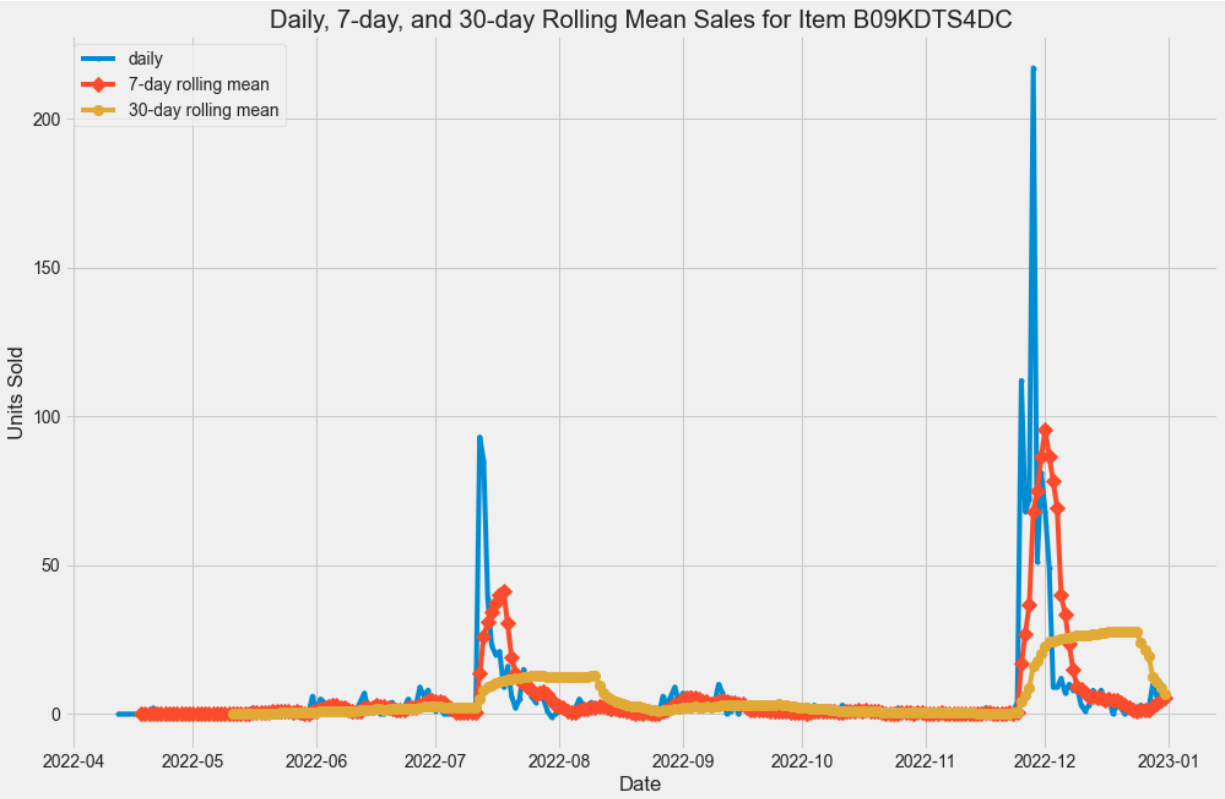
```
item_data = data[data['Item Id'] == data['Item Id'].unique()[0]]
item_data.set_index('date', inplace=True)
item_data = item_data.resample('D').sum()
item_data['rolling_mean_7'] = item_data['units'].rolling(window=7).mean()
item_data['rolling_std_7'] = item_data['units'].rolling(window=7).std()

plt.figure(figsize=(14, 7))
plt.plot(item_data.index, item_data['units'], label='Sales')
plt.plot(item_data.index, item_data['rolling_mean_7'], label='7-Day Rolling Mean')
plt.fill_between(item_data.index,
                 item_data['rolling_mean_7'] - 2 * item_data['rolling_std_7'],
                 item_data['rolling_mean_7'] + 2 * item_data['rolling_std_7'],
                 color='b', alpha=0.2, label='Rolling Std Dev (2 std)')
plt.title('Sales with Rolling Mean and Standard Deviation')
plt.xlabel('Date')
plt.ylabel('Units Sold')
plt.legend()
plt.show()
```





In [49]:

```
data['date'] = pd.to_datetime(data['date'])

# Set the item ID to analyze
item_id = data['Item Id'].unique()[0]  # Change to the specific item ID you want to analyze

item_data = data[data['Item Id'] == item_id]

item_data.set_index('date', inplace=True)

item_data['7_day_rolling'] = item_data['units'].rolling(window=7).mean()
item_data['30_day_rolling'] = item_data['units'].rolling(window=30).mean()

start, end = "2022-01-01", "2022-12-31"  # Adjust dates as needed

plt.style.use("fivethirtyeight")
fig, ax = plt.subplots(figsize=(15, 10))

ax.plot(item_data.loc[start:end].index, item_data.loc[start:end, 'units'], marker=".", lines
ax.plot(item_data.loc[start:end].index, item_data.loc[start:end, '7_day_rolling'], marker="D
ax.plot(item_data.loc[start:end].index, item_data.loc[start:end, '30_day_rolling'], marker="

ax.set_ylabel("Units Sold")
ax.set_xlabel("Date")
ax.set_title(f"Daily, 7-day, and 30-day Rolling Mean Sales for Item {item_id}")
ax.legend()
plt.show()
```



In [ ]:

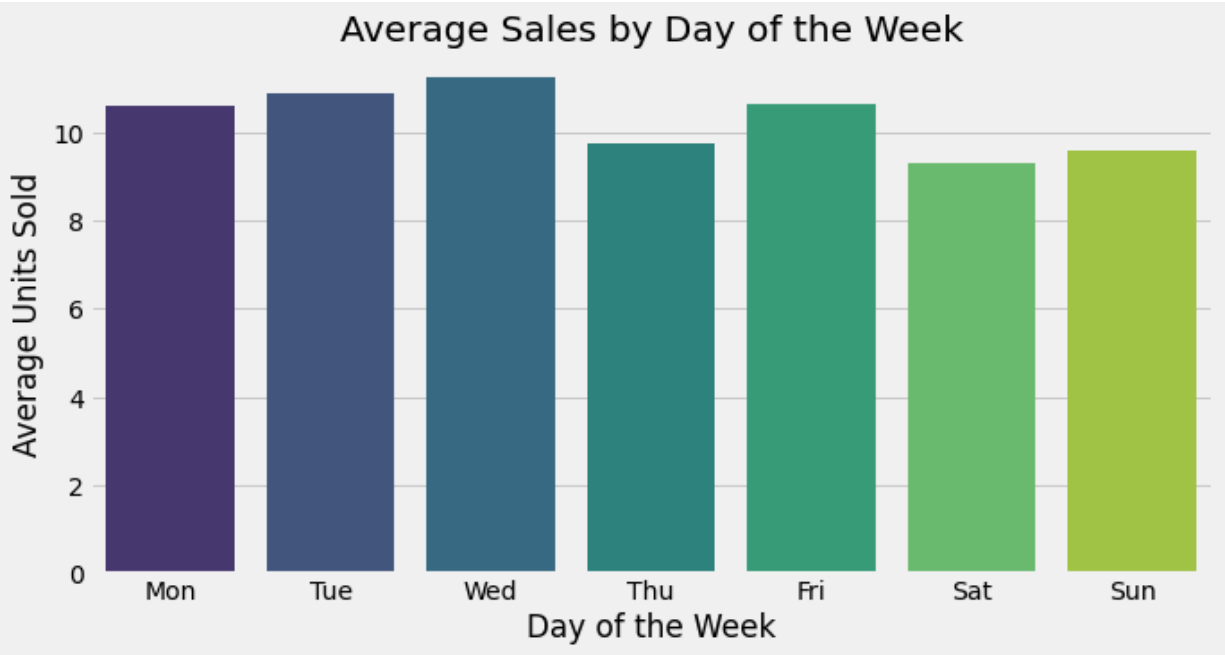
In [28]:

```
# Boxplot of sales
plt.subplot(1, 2, 2)
```

```
sns.boxplot(data['units'].dropna())
plt.title('Boxplot of Sales Units')
plt.xlabel('Units Sold')
plt.show()
```

In [30]:

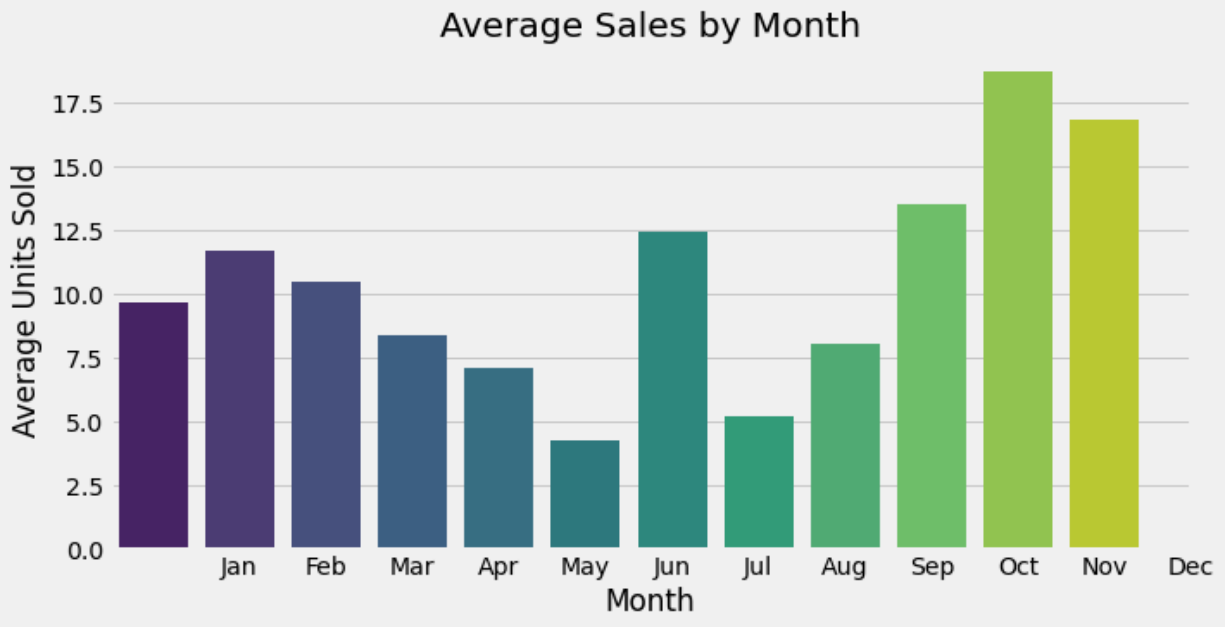
```
data['day_of_week'] = data['date'].dt.dayofweek
avg_sales_by_day = data.groupby('day_of_week')['units'].mean()

plt.figure(figsize=(10, 5))
sns.barplot(x=avg_sales_by_day.index, y=avg_sales_by_day.values, palette='viridis')
plt.title('Average Sales by Day of the Week')
plt.xlabel('Day of the Week')
plt.ylabel('Average Units Sold')
plt.xticks(ticks=[0, 1, 2, 3, 4, 5, 6], labels=['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'S
plt.show()
```



In [31]:

```
# EDA: Sales trends by month
data['month'] = data['date'].dt.month
avg_sales_by_month = data.groupby('month')['units'].mean()

plt.figure(figsize=(10, 5))
```

```
sns.barplot(x=avg_sales_by_month.index, y=avg_sales_by_month.values, palette='viridis')
plt.title('Average Sales by Month')
plt.xlabel('Month')
plt.ylabel('Average Units Sold')
plt.xticks(ticks=range(1, 13), labels=['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug
plt.show()
```



Feature Engineering

In [51]:
```
data['day_of_week'] = data['date'].dt.dayofweek
data['month'] = data['date'].dt.month
data['year'] = data['date'].dt.year
```

In [17]:
```
# Create lag features and rolling statistics for the first item
item_data = data[data['Item Id'] == unique_item_ids[0]]
item_data.set_index('date', inplace=True)
item_data = item_data.resample('D').sum()
```

In [19]:
```
# Lag features
for lag in range(1, 8):
    item_data[f'lag_{lag}'] = item_data['units'].shift(lag)

# Rolling statistics
item_data['rolling_mean_7'] = item_data['units'].rolling(window=7).mean()
item_data['rolling_std_7'] = item_data['units'].rolling(window=7).std()

item_data = item_data.dropna()

# Display the engineered features
item_data.head()
```

Out[19]:

date	ad_spend	units	unit_price	day_of_week	month	year	lag_1	lag_2	lag_3	lag_4	lag_5	lag
2022-04-26	0.0	0.0	0.0	1	4	2022	0.0	0.0	0.0	0.0	2.0	0

2022-04-27	0.0	0.0	0.0	2	4	2022	0.0	0.0	0.0	0.0	0.0	2
2022-04-28	0.0	0.0	0.0	3	4	2022	0.0	0.0	0.0	0.0	0.0	0
2022-04-29	0.0	0.0	0.0	4	4	2022	0.0	0.0	0.0	0.0	0.0	0
2022-04-30	0.0	0.0	0.0	5	4	2022	0.0	0.0	0.0	0.0	0.0	0

Time Series Forcasting

In [55]:
```
from prophet import Prophet
df_model= data.reset_index()
df_model.head(1)
```

Out[55]:

	index	ID	date	Item Id	Item Name	ad_spend	anarix_id	units	unit_price	da
0	0	2022-04-12_B09KDTS4DC	2022-04-12	B09KDTS4DC	NapQueen Elizabeth 8" Gel Memory Foam Mattress...	NaN	NAPQUEEN	0.0	0.0	

In [77]:
```
df = pd.DataFrame()
df_model["ds"] = pd.to_datetime(df_model["date"])
df_model["y"] = df_model["unit_price"]
```

In [78]:
```
# model forcasting for 10 years
m = Prophet()
m.fit(df_model)
future = m.make_future_dataframe(periods=12 * 10,
freq="M")
```

```
15:22:53 - cmdstanpy - INFO - Chain [1] start processing
15:23:13 - cmdstanpy - INFO - Chain [1] done processing
```

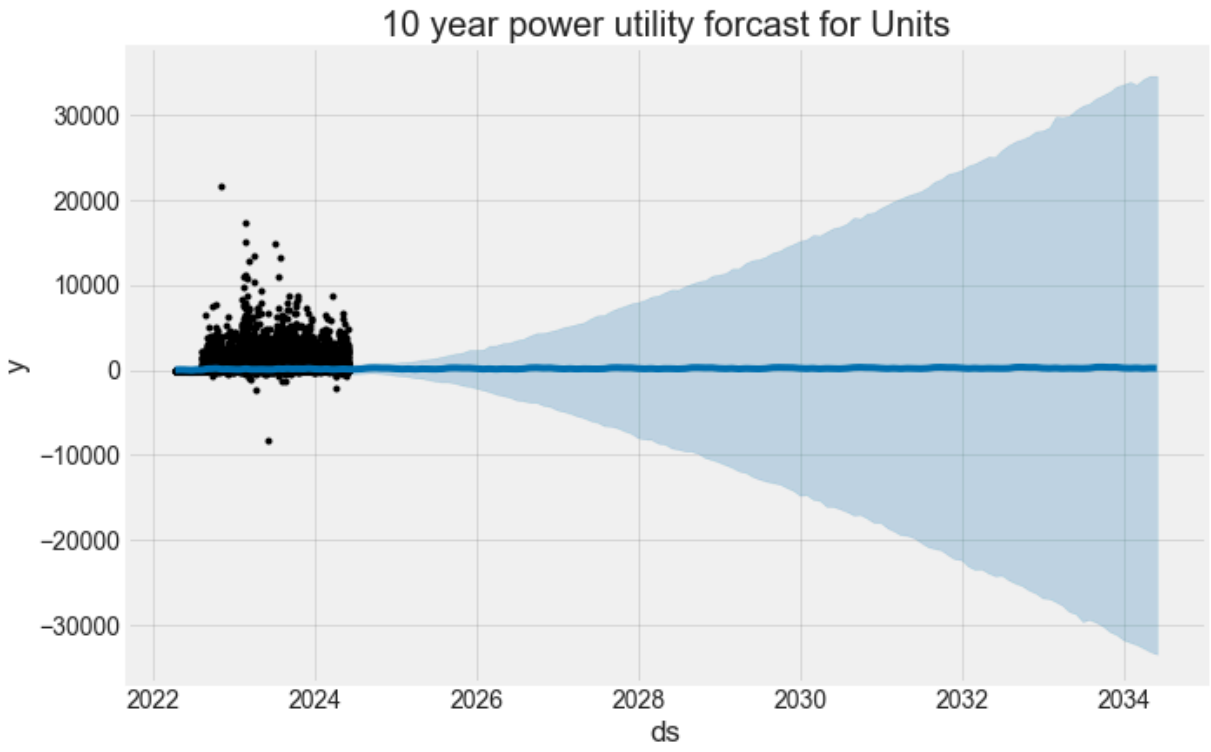
In [79]:
```
# creating future forcasting
forecast = m.predict(future)
forecast[["ds", "yhat", "yhat_lower",
"yhat_upper", "trend",
"trend_lower", "trend_upper"]].tail()
```

Out[79]:

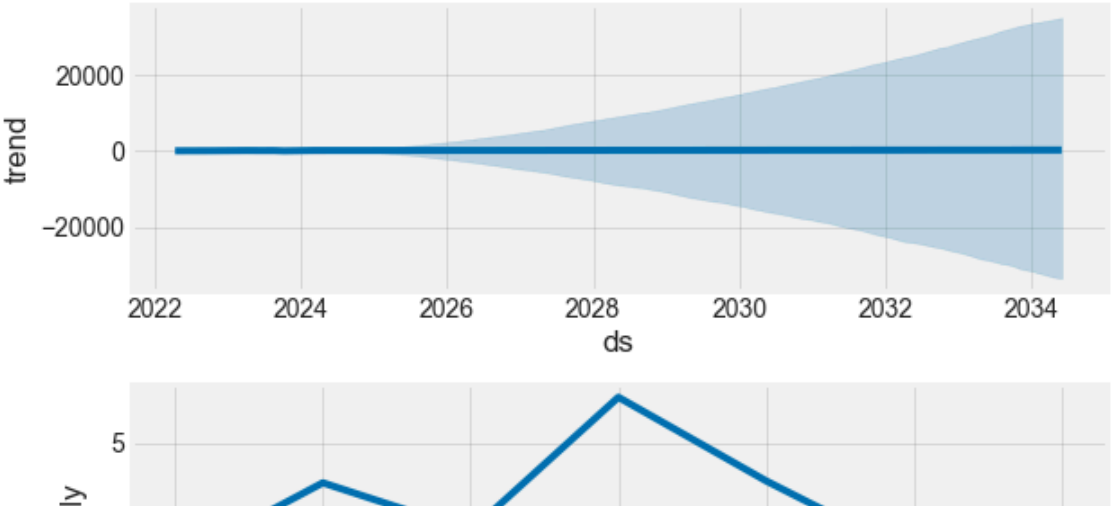
	ds	yhat	yhat_lower	yhat_upper	trend	trend_lower	trend_upper
896	2034-01-31	201.306925	-32037.143456	33917.155052	251.039153	-32048.231346	33897.296463
897	2034-02-28	236.422988	-32281.762584	33565.559773	251.877361	-32426.732575	34181.466876
898	2034-03-31	181.823288	-32680.310326	34231.835588	252.805378	-32899.203590	34419.466891

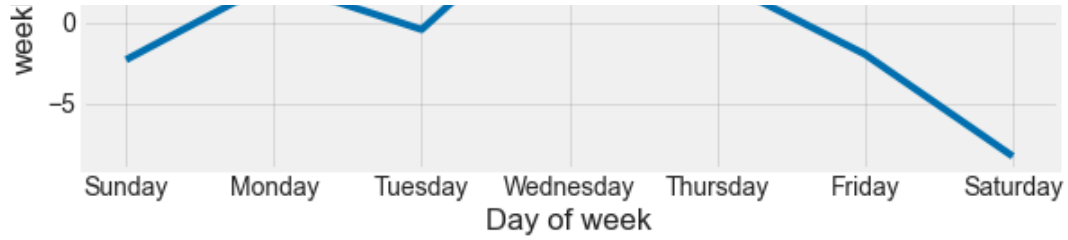
899	2034-04-30	223.283012	-33103.710029	34629.874256	253.703459	-33264.371680	34778.594450
900	2034-05-31	219.668465	-33426.457736	34607.701728	254.631476	-33520.535030	35109.410961

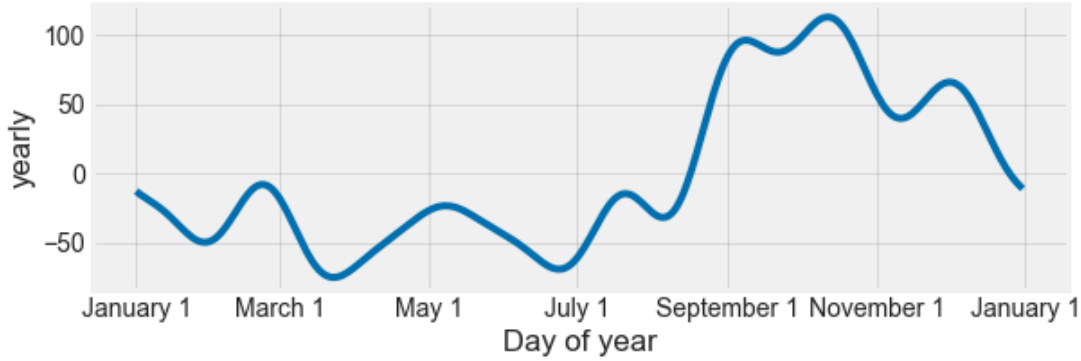
In [80]:
```
# plot style
style.use("fivethirtyeight")
# show plot
fig1 = m.plot(forecast)
plt.title("10 year power utility forcast for Units")
plt.show()
```



In [81]:
```
style.use("fivethirtyeight")
fig2 = m.plot_components(forecast)
# show plot
fig2=plt.show()
fig2
```

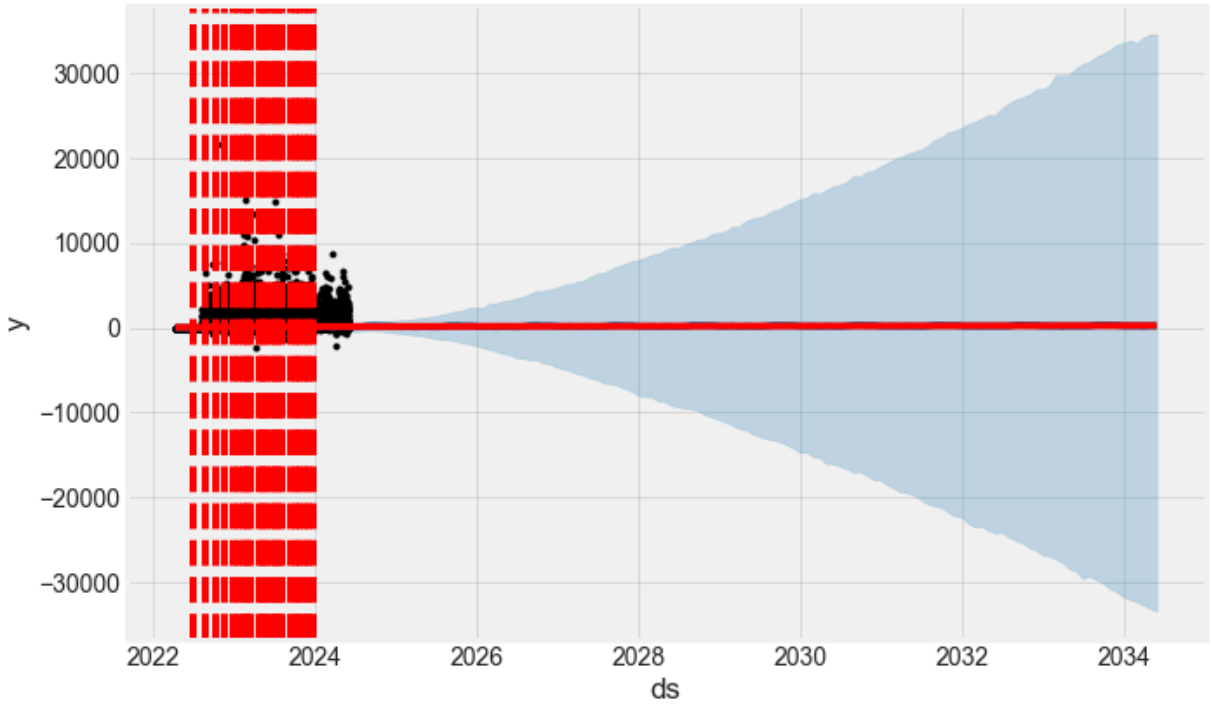






In [82]:

```
style.use("fivethirtyeight")
from prophet.plot import add_changepoints_to_plot
fig = m.plot(forecast)
a = add_changepoints_to_plot(fig.gca(),
m, forecast)
plt.show()
```



Time Series Prediction

In [20]:

```
# Model Selection and Evaluation
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
from sklearn.linear_model import LinearRegression
```

In [21]:

```
# Prepare the data for modeling
```

```
# Prepare the data for modeling
X = item_data.drop(columns=['units'])
y = item_data['units']

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

In [22]:
```
# Train a s Linear Regression model
model = LinearRegression()
model.fit(X_train, y_train)
```

Out[22]: LinearRegression()

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.

On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [25]:
```
y_pred = model.predict(X_test)

# Evaluate the model
mse = mean_squared_error(y_test, y_pred)
print(f'Mean Squared Error: {mse}')
```

```
Mean Squared Error: 1.7595508496744427e-24
```

In [85]:
```
from statsmodels.tsa.arima.model import ARIMA
from sklearn.metrics import mean_squared_error
import numpy as np

item_id = data['Item Id'].unique()[0]  # Change to the specific item ID you want to analyze

item_data = data[data['Item Id'] == item_id]

item_data.set_index('date', inplace=True)

train = item_data.iloc[:-30]
test = item_data.iloc[-30:]

train_units = train['units']
test_units = test['units']
```

Fit the ARIMA model

In [86]:
```
# Fit the ARIMA model
model = ARIMA(train_units, order=(5, 1, 0))  # Adjust order (p, d, q) as necessary
model_fit = model.fit()
```

```
C:\Users\Lenovo\anaconda3\lib\site-packages\statsmodels\tsa\base\tsa_model.py:471: ValueWarnin
g: No frequency information was provided, so inferred frequency D will be used.
  self._init_dates(dates, freq)
C:\Users\Lenovo\anaconda3\lib\site-packages\statsmodels\tsa\base\tsa_model.py:471: ValueWarnin
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C:\Users\Lenovo\anaconda3\lib\site-packages\statsmodels\tsa\base\tsa_model.py:471: ValueWarnin
g: No frequency information was provided, so inferred frequency D will be used.
  self._init_dates(dates, freq)
```

In [87]:
```
predictions = model_fit.forecast(steps=len(test_units))
```

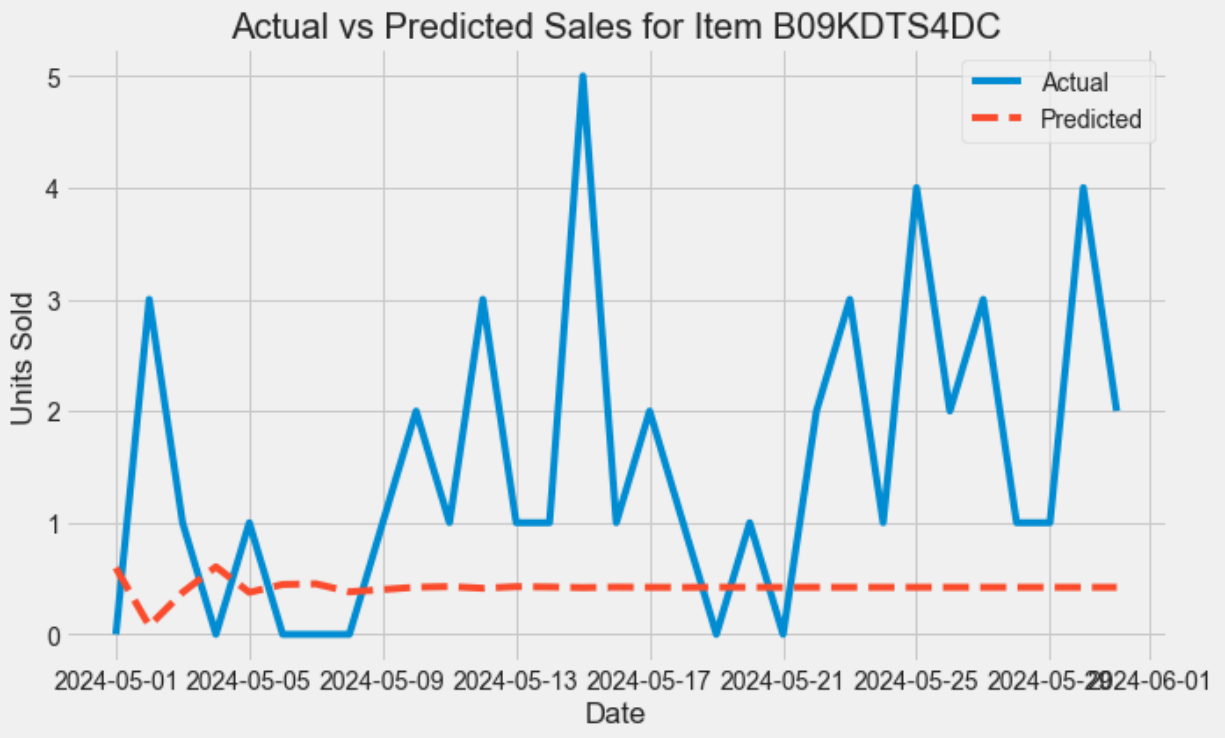
In [88]:

```
mse = mean_squared_error(test_units, predictions)
print(f'Mean Squared Error: {mse}')
```

```
Mean Squared Error: 3.0997320449515633
```

In [89]:

```
plt.figure(figsize=(10, 6))
plt.plot(test_units.index, test_units, label='Actual')
plt.plot(test_units.index, predictions, label='Predicted', linestyle='--')
plt.xlabel('Date')
plt.ylabel('Units Sold')
plt.title(f'Actual vs Predicted Sales for Item {item_id}')
plt.legend()
plt.show()
```



Prophet Model

In [90]:

```
from prophet import Prophet
from sklearn.metrics import mean_squared_error
```

In [100…

```
data['date'] = pd.to_datetime(data['date'])

item_id = data['Item Id'].unique()[0]  # Change to the specific item ID you want to analyze

item_data = data[data['Item Id'] == item_id]

item_data = item_data[['date', 'units']].rename(columns={'date': 'ds', 'units': 'y'})

train = item_data.iloc[:-30]
test = item_data.iloc[-30:]
```

In [101…

```
model = Prophet()
model.fit(train)
```

```
15:38:22 - cmdstanpy - INFO - Chain [1] start processing
15:38:23 - cmdstanpy - INFO - Chain [1] done processing
```