Axiomatizability by sentences of the form $\forall \exists! \wedge p = q$

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Given an equational class $\mathcal{V}$, several important subclasses of $\mathcal{V}$ can be defined by sentences of the form $\forall \exists! \wedge p = q$. For example, if $\mathcal{V}$ is the class of all semigroups with unit, then the subclass of all groups can be defined in this way, and if $\mathcal{V}$ is the class of all bounded distributive lattices, then the subclass of all Boolean lattices is also axiomatizable in this way. We consider the following general problem:

Problem: Given a variety $\mathcal{V}$ characterize the subclasses of $\mathcal{V}$ which can be axiomatized by a set of sentences of the form $\forall \exists! \wedge p = q$.

We will present a solution to this problem for certain varieties of distributive lattice expansions.